# Blossom Valley Habitat Conservation Area

# Post-fire Monitoring and Management Strategy

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*Prepared for:*

Center for Natural Lands Management
425 E. Alvarado Street, Ste. H
Fallbrook, CA 92028-2960
*Point of Contact: Markus Spiegelberg*

*Prepared by:*

TIERRA DATA INCORPORATED

Tierra Data Inc.
10110 W. Lilac Road
Escondido, California 92026
*Author: Elizabeth M. Kellogg*

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# Post-fire Monitoring and Management Strategy for Blossom Valley Habitat Conservation Area

Center for Natural Lands Management

# 1.0 Background and Purpose of Fire Monitoring Plan

The 286-acre Blossom Valley Habitat Conservation Area (HCA) burned during the Cedar Fire of 2003. Pre-fire, the HCA contained roughly 180 acres of coastal sage scrub, 58 acres of oak woodland and 50 acres of southern mixed chaparral. The Center for Natural Lands Management (CNLM) took title to the property in July of 2004. This Plan fulfills CNLM's intent to develop a monitoring program that allows preserve managers to determine along what kind of trajectory the HCA is recovering.

*Very broadly, the intent of this monitoring program is to inform CNLM management about ecological condition and trend (trajectory), about the nature of the issues facing them, and to support management decisions to reverse trends that are harmful. Management cues require the ability to separate natural disturbance from anthropogenic stress on the target species and natural communities and processes that we value. The monitoring program should assess management progress in relation to ambient conditions, reference conditions, baseline, and expected ecological trajectories over time (recovery after fire or plant community conversions).*

The biological and conservation goals of the HCA are to:

- Conserve the full range of vegetation communities native to the property.
- Conserve areas of habitat capable of supporting management focus species in perpetuity.
- Maintain functional biological cores (large patch sizes).
- Maintain functional wildlife corridors and habitat linkages within the region, including linkages that connect gnatcatcher populations and movement corridors for large mammals.
- Minimize the impacts of exotic species invasions, both plant and animal, on the HCA.
- Apply a "no net loss" policy to the conservation of oak woodland habitats.
- Conserve and enhance narrow endemic species and populations of management focus species.

Fire is one of several major ecological stressors on plant and wildlife communities throughout southern California. While these communities evolved with fire, they are resilient to only a certain range of fire regimes. The presence of rare plant communities and species in a modern urban matrix makes it important to understand this resilience when it comes to achieving conservation goals, because reserves are often isolated from other open space lands. As habitat patches decrease in size and increase in isolation, it becomes less possible for a species as a whole to survive local extirpations.

Other disturbance agents and stressors include invasive species, climate change, flood-drought cycles, pollution, and land uses such as recreation and grazing. Fire works cumulatively with these other disturbances either towards or away from conservation goals.

Conservation reserves can provide a unique contribution to understanding fire ecology and maintaining fire as a natural ecosystem process. The challenge for monitoring is to derive as much information and power to support management decisions as possible in the context of budget constraints and small acreages.

This Fire Monitoring Plan attempts to address this challenge through a systematic framework of:

- Refining the statements of management goals into more specific management objectives.
- Identifying conceptual models of how fire affects (can stress or benefit) plant communities and species.
- Pairing each management objective that is influenced by fire regime to at least one fire monitoring objective with a measurable attribute.
- Identifying potential plant community or species metrics that can function as indicators of ecological health, both in relation to conservation goals and to fire regime.
- Establishing a framework of monitoring protocols that can be applied at several scales and within varying budgetary constraints.
- Identifying an adaptive management strategy to refine the monitoring program.

Monitoring objectives differ from management objectives in that management objectives describe the target, threshold, or change in the condition desired, while monitoring objectives describe how to monitor progress toward that condition or change. Also, monitoring objectives, when possible, contain explicit statements about the certainty of monitoring results.

# 2.0 Design Criteria for the Monitoring Plan, Post-fire Management Questions, and Monitoring Objectives

The consequences of a poorly designed monitoring program are all bad: lost time and money, undetected resource deterioration, poor or inappropriate management response, and reduced credibility to management audiences.

This section discusses five design criteria for this monitoring plan:

1. A clear link should be established between monitoring and management objectives and questions that relate to fire as an integral ecological process and a potential stressor on plant communities and species.
2. The monitoring plan is linked to explicit conceptual models of fire effects, and includes indicators identified in the context of these conceptual models.
3. Management focus species should be stressor- or threat-based.
4. The monitoring approach is applicable across a range of budgets and spatial scales, including species, community, and landscape.
5. The approach should be structured for small acreages by linking it to other programs to improve its predictive power.

## 2.1 Linking Monitoring and Management Objectives and Fire-related Questions

For every management objective, there should be a monitoring objective in this Plan if the management objective is affected by fire. It is best if at least one measurable attribute is monitored to a chosen level of certainty for every management objective. In addition, fire-related management questions will emerge, and the monitoring plan should anticipate these. Table 2-1 presents suggested management objectives and questions that relate to the management goals for the Blossom Valley property, and that are potentially related to fire regime and the above-described conceptual models of how fire regime functions at Blossom Valley. The monitoring proposed in this Plan addresses the management objectives and questions presented in Table 2-1. CNLM staff should look for opportunities to test specific hypotheses that can address some of the questions raised as monitoring results reveal the condition and trend of Blossom Valley lands.

*Table 2-1. Suggested management objectives and questions that relate to the management goals for the Blossom Valley property, and that are potentially related to fire regime and conceptual models of how fire regime functions at Blossom Valley.*

| Management Goal | Management Objectives/Questions |
|---|---|
| Conserve the full range of vegetation communities native to the property. | *What is the current condition of plant communities* in relation to a stressed condition or desired condition (such as low numbers of exotics, presence of diverse structural and compositional elements, or condition that supports management focus species). Separate trends that are related to management versus natural variation.<br>*Are boundary shifts occurring?* Characterize and monitor plant community boundaries in relation to their expected location and fire history, the presence/abundance of invasives, and other disturbance processes.Is the distribution of coastal sage scrub versus chaparral: correlated with steeper slopes (thinner soils, drier), aspect, or topographic position? Are species dominance shifts within plant communities correlated with fire history, patch edges, or topographic position?<br>*What is the "trajectory" over time of recovery or plant community shifts?* Is succession proceeding in the predicted way–leguminous forbs, perennial grass resprouts, sprouting species, etc.? Are native annuals following a trajectory associated with canopy closure or simply responding to year-to-year rainfall variation? Are exotic annuals increasing or simply varying with rainfall? Are shrublands following a trajectory to pre-fire boundaries or are plant communities shifting to shorter-lived species, to more annuals, to more exotics, to more sprouting shrubs versus seeders, or more wind-dispersed (coastal sage) species? Is the shift potentially a result of too-short fire intervals?. Why do some sites recover with post-fire herbs and others do not? Is the community supporting only broadly fire-adapted plants and wildlife? Is the plant community shifting to taller canopy dominants?<br>*Is each plant community and specialized habitat for management focus species showing it is within the range of resilience to stressors and threats?* Are we at risk of a type conversion or loss of species support functions? Is the coastal sage scrub type stable over time or is it successional to chaparral? Do we have both sprouters and obligate seeders present on the property? Is the chaparral dominated by sprouting versus seeding species, or a mix? Is there a similar post-fire herbaceous flora in the coastal sage scrub and chaparral communities? Is the chaparral composition showing overlap with coastal sage species early post-fire and late post-fire? Maintain a fire regime that is within the range of resilience for these communities. Are populations of species at risk of decline due to the synergy of altered fire and other disturbance regimes present? Are their numbers stable? Is oak tree and obligate-seeding shrub recruitment self-sustaining? Can we increase the mean percent cover of native grasses?<br>*What is the hydrologic condition?* Is rilling, gullying, or sheet flow present in drainages? Is the hydroperiod or hydrologic connectivity changing?<br>*What is the fuel condition?* Maintain fuel loads within the natural range of variation within this administrative boundary or in concert with partners in other management areas. This means that fire intervals should not be less than ___ years in chaparral, and 20? years in coastal sage scrub (depending on when canopy closure occurs. maintain sufficient information on fuel condition to be able to communicate to local residents in the wildland-urban interface about fuel condition. |
| Conserve areas of habitat capable of supporting management focus species in perpetuity. | What is the condition of the property for supporting orange-throated whiptail and for deer and mountain lion to access to the conservation area? Is this condition changing? Has fire regime affected the abundance, species richness, and relative abundance of herpetofauna relate to patch size, canopy cover, elevation or aspect? Has habitat actually burned? Has fire affected the abundance, distribution, and species richness of herpetofauna? What is the abiotic patch richness (such as rock outcrops) for herpetofauna at Blossom Valley? Is the population of orange-throated whiptail shifting spatially due to fire? |
| Maintain functional biological cores (large patch sizes). | Do weed boundaries change without any management intervention? Are coastal sage scrub/grassland/oak/chaparral boundaries shifting? Has fire affected patch edges and consequently the need for fencing, cowbird trapping, domestic pet control, landscaping restrictions, and controlling nonnative ant species (stormwater runoff)? Has the fire history resulted in additional fragmentation? Has fire affected biotic patch richness, vertical structure, interspersion and zonation? |
| Maintain functional wildlife corridors and habitat linkages within the region. | Has fire affected biological connectivity? Are there functional corridors for large mammals to move around? Has fire affected this preserve as a stepping stones of the preserve system that will work for birds to maintain genetic and demographic connectivity? is the Presence/absence of covered large mammals correlated with fire (for example, deer use)? |
| Minimize the impacts of exotic species invasions, both plant and animal, on the conservation area. | Reduce target noxious weed populations to zero. Minimize the impact of more pervasive exotic species, especially in the shrubland communities, and favor native grasses and forbs of shrub interspaces and understory. Detect exotic animals as soon as practicable, focusing on those that pose the most threat. Are black rats, opossum, cats, dogs present? What is their trend? Are invasive plants present and what is their distribution? How do covered species respond to control or removal of nonnative plants?. How effective are specific management actions in controlling invasions and removing nonnative species? Are we detecting exotics in time to apply cost-effective treatments? Is human disturbance facilitating invasion by exotic plants? Where is exotic plant eradication most beneficial to natives?<br>Are exotic ants present? Does the fire result in an increase in nonnative ant invasion and prey base for orange-throated whiptail? Does fire favor exotic ants or deter them? How far into the preserve do the ants penetrate from urban edges? What is the relationship between presence or abundance of covered species and presence of exotic ants? How does the distribution of exotic ants change over time (i.e. where do they occur in the preserve, next to the edges of the preserve or in the interior, and is their presence becoming more widespread over time)? What factors, identified a priori (e.g. edges, soil moisture), are associated with this change? How effective are specific management actions in controlling invasions? |

*Table 2-1. Suggested management objectives and questions that relate to the management goals for the Blossom Valley property, and that are potentially related to fire regime and conceptual models of how fire regime functions at Blossom Valley. (Continued)*

| Management Goal | Management Objectives/Questions |
|---|---|
| Achieve "no net loss" to the conservation of oak woodlands | Monitor canopy cover and recruitment in oak woodlands to determine if the stand is self-sustaining in relation to fire regime. Ensure oaks are reproducing, and that the age structure, structural diversity, understory composition, and cover of individual oak stands are within the desired range of natural variability for the community. |
| Conserve and enhance narrow endemic species and populations of management focus species. | Identify habitat conditions and species that are most at risk of decline due to altered fire regime or fire in combination with other disturbance, and monitor their presence and abundance. Are rare plants finding the physical structural conditions they need to thrive with respect to fire? Are we sustaining species diversity? Are species most vulnerable to altered fire regime present?. What is their trend? Examples are obligate seeders, dispersal-limited species, canopy-dependent and sedentary birds or butterflies, habitat-specialist versus opportunistic mammals, and cavity nesting birds. Are species that depend on a mature habitat condition present or are they returning (thrasher, dusky-footed woodrat)? Has fire affected the ability of the Preserve to provide adequate suitable habitat for pollinators and seed dispersal of covered plants, even though specific pollinators are not known?<br>How does the abundance of coastal sage scrub/oak woodland/chaparral bird species vary across the preserve, and how does it change over time with fire recovery? What is the species richness in the preserve and how does it change over time with fire recovery? Are species resilient to the current fire regime–first, are species present that are sensitive to a narrowly specific fire regime or cover condition? Are they present in sufficient abundance to be self-sustaining? |

## 2.2 Link to Conceptual Models of Fire Effects

Section 3.0 describes some preliminary, literature-based conceptual models about fire effects in the plant communities represented at Blossom Valley. In addition, a description of how plants may be grouped by their fire response ability is presented. It is intended that these models be regularly updated and refined with new information. Also, they can be used to help define desired vegetation conditions at Blossom Valley in order to meet all of management's goals.

## 2.3 Monitoring Indicators and Management Focus Species are Stressor- or Threat-based

This Fire Monitoring Plan identifies plant community and species metrics that can function as indicators of ecological health, both in relation to conservation goals and to fire regime. It is helpful and efficient in terms of the monitoring requirement and the need to make interpretations for management to select species to monitor that are affected by stresses, threats, or specific habitat conditions such as closed canopy or edges.The stressor-based selection of management focus species forces the conservation program to have a working conceptual model about how the ecosystem functions, and this is a helpful way to ensure monitoring is focused on the manager's needs. It helps ensure that monitoring is logically consistent with management objectives and understanding of the mechanisms involved on the property.

Most programs choose a hierarchical suite of indicators to measure progress. Some translate these into a simpler "report card" to demonstrate performance to the public. In all cases the indicators are underlain by a clear expression of the goals of the program and conceptual models guiding how those goals will be achieved.

It is important that species be selected to monitor that are not necessarily rare, threatened, or endangered. "Efforts to conserve bird and small mammal biodiversity in coastal sage scrub should not focus exclusively on rare species or on locations with the highest species richness, but instead should focus on a diverse suite of species that are representative of the range of variation in communities found in coastal sage scrub habitats" (Chase et al. 2000). For example, the simple presence or absence of wildlife species matters that prefer large patch sizes with little edge, closed canopy versus open canopy, pioneer species versus canopy dominants, forbs versus shrubs, long-lived versus short-lived, or are sedentary and dispersal-limited.

## 2.4 Applicability Across a Range of Budgets and Spatial Scales

For cost efficiency and to ensure the work gets accomplished in the long term, one of the criteria that should be used to design a monitoring program is the identification of the smallest number of metrics that can predict the patterns that matter to the manager. An effective suite or hierarchy of indicators will cross scales and will be programmed in a modular or hierarchical (tiered) way. In this way, the program can be adapted based on budgets and be tiered up to regional programs or down to species-level analyses. Integrated groups, or portfolios, of measurements are needed in a modular or tiered framework that targets the smallest number of measurable variables that can predict the patterns that matter to CNLM (See Section 4.0).

## 2.5 Increased Power Through Links to Other Programs

Any monitoring framework will improve its predictive power and efficiency by establishing consistency with methods used by other fire or vegetation monitoring programs. This will improve CNLM's ability to interpret both Blossom Valley conditions and to scale up to other parcels, other landowners, and broader regional questions. The benefits of incorporating uniformly-gathered data consistent with other programs facilitates information exchange among these programs, supports historical program documentation, and can perhaps provide reference sites or control sites at other locations. CNLM can also benefit as management attempts to interpret data (are the observations made unique to Blossom Valley or are they evident across the region?).

We use a modified U.S. Department of Interior (USDI) Fire Monitoring Program approach, being especially consistent with how plots are laid out. We include and integrate into our modified USDI approach, attributes or metrics used locally by others (San Diego Natural History Museum Bird Atlas program, Multiple Species Conservation Program). The USDI approach is the most standardized and broadly used that we know of, so has the greatest chance of sharing data for mutual benefit with CNLM.

We reviewed the following programs for potential integration into this one:

1. *USDI "FIREMON" from the Fire Management Program Center, National Interagency Fire Center Monitoring Handbook*. This program has a plot-level sampling system designed to characterize changes in ecosystem components over time, before and after a prescribed burn treatment. It can also be used for fire effects monitoring after burns that were not prescribed. It includes a set of sampling manuals, database, field forms, and analysis programs. The sampling intensity is keyed to available resources, such as people, time, expertise, and funding and not some statistical parameter, such as variance. Most managers are constrained by project resources so this is important. Uses point-intercept method, three shrub age classes: Seedling (a shrub that is too imma-

ture to flower); Mature (able to produce flowers and seeds that year); and Resprout (resprout after top-killing by fire or some other disturbance).

2. *U.S Geological Survey Biological Resources Division post-2003 monitoring protocols*. This program was undertaken to monitor recovery of vegetation after the huge, autumn of 2003 wildfires. Insufficient information on methods was available to evaluate this effort.
3. *Ecological Score Cards (CalFed Program, The Nature Conservancy)*. Currently under development by The Nature Conservancy (TNC) at their Consumnes and Sacramento River projects to measure ecosystem responses to restoration measures. The scorecard targets these processes: water flow, erosion/deposition, lateral channel migration, ecological succession. The future goals is to use this score card to measure habitat and species responses to restoration measures.
4. *The Nature Conservancy's Fire Management and Research Program*. TNC through this program oversees fire management on its preserves nationwide, fosters fire ecology research, and promotes the judicious use of prescribed fire to meet biodiversity conservation needs through publications, information exchange, and fire policy reviews. The Fire Program publishes a technical newsletter, Rx Fire Notes, and has been active on the National Commission of Wildfire Disasters and the Federal Wildland Fire Policy and Program Review. No specific fire monitoring protocols are applied throughout TNC preserves.
5. *San Diego Natural History Museum (SDNHM) Bird, Mammal and Plant Atlas programs*. To improve documentation of mammals, birds, and the flora of San Diego County, the SDNHM trained volunteers both how to conduct bird surveys and collect voucher specimens of native and naturalized plants throughout the county. For plants, the end product is an internet-accessible, database and plant atlas based upon vouchered specimens based on grids throughout the county that are 3 miles by 3 miles. The Bird Atlas of San Diego County was a six-year project, and is now in the final publication phase for distribution maps and interpretive text plus a web-accessible database. Twenty percent of the county's surface burned in 2002 and 2003, making the atlas a basis for assessing the effects of these firestorms. The atlases are intended to serve as the basis for evaluating the effectiveness of the Multiple Species Conservation Plan and similar land-management programs underway throughout the county. The San Diego Mammal Atlas Team and the San Diego Mammal Atlas was founded in 1999 as a companion to the San Diego Bird Atlas. The Mammal Atlas team is a collaboration of over 25 mammalogists and conservationists currently working with the museum to study the effects of fire severity on mammalian community post-fire recovery.
6. *Pollard Walks, Step-Points and Other "Boot Count" methods*. Systematic walks that are laid out with specific observational information to obtain can be focused on vegetation, rare plants, ground cover, butterflies, or other attributes. They can be an efficient means for managers to get a general sense of annual variation in conditions and species abundance, and a rough assessment of trend if repeated over time.
7. *California Native Plant Society (CNPS) Rapid Assessment Protocol* (Appendix A). This method is becoming more and more widely adopted and is useful for the initial description of a stand, and for occasional repeating as recovery progresses after fire. The rapid assessment protocol is a non-statistical,

reconnaissance-level, relevé-style method of vegetation and habitat sampling. It may be used to quickly assess and map the extent of all vegetation types in relatively large, ecologically defined regions. CNPS has adopted this method to verify locations of known vegetation types, to gain information about new types, and to acquire general information about their composition, habitat, and site quality. Other agencies, such as California State Parks, the Department of Fish and Game, and the U.S. Forest Service, are also adopting this method for documenting vegetation patterns. By using such a widely implemented method, managers can gain a broader ecological perspective, as the full range in ecological variation across broad landscapes can be reflected in the vegetation assessments. Changes in environmental elements (such as geology, aspect, topographic position) or physical processes (fire, flooding, erosion, and other natural or human-made disturbances) can influence the distribution of plants or patterning of vegetation, which are documented in the rapid assessments. The first key indicator in analyzing a stand's ecological condition is delineating its structure. The protocol's foundation is the use of a definition of "stand" (CNPS 2001) that calls for separating assessment units into units that are compositionally and structurally similar, i.e., if the mix of all species within the stand has structural and compositional integrity, it meets this stand definition. This delineation of structure should establish not only the presence and condition of age cohorts but also establish the relationship of those cohorts to any significant factors affecting stand viability.

8. *California Rapid Assessment Method (CRAM) for wetlands*. Funded by EPA and intended for wide adoption, the conceptual framework of this approach has three tiers: inventory (based on Cowardin); condition; and intensive monitoring and research at selected wetland sites. It integrates the CNPS Rapid Assessment protocol. It incorporates a a stressor index using a presence/absence checklist. It assesses four condition attributes: buffer and landscape context, hydrology, physical structure, and biotic structure. The CRAM attribute and Metrics summary is as follows:

    *Buffer and Landscape Attribute:* connectivity (for landscape context), percent of wetland assessment area with buffer, average buffer width, and buffer condition.

    *Hydrology Attribute:* hydroperiod, hydrologic connectivity.

    *Physical Structure Attribute:* abiotic patch richness (such as rock outcrops at Blossom Valley), topographic complexity (uses schematics to aid interpretation).

    *Biotic Structure Attribute:* organic matter accumulation, biotic patch richness, vertical structure, absolute vegetation cover and relative cover (using the 50/20 rule), plant interspersion and zonation, percent invasive plant species based on species list, native plant species richness based on species list.

# 3.0 Ecological Models Relating Fire to Communities and Species Populations

The fire regime can have significant effects on biota either through the lack of significant fire over an extended period or from fires that occur in a way to which the biological communities or individual species have not adapted. A fire regime works at many scales and has many components, as well as synergism with other disturbances. Frequency, return interval, size, patch pattern, seasonality, and intensity are each fire attributes that affect natural resources differently. A change in one component, such as frequency, could potentially either enhance or deteriorate a system. Because the modern environment is altered by many irreversible changes, the site-specific resilience of plant communities and species to today's fire regime may be different than they were under the fire regime of a few hundred years ago. The modern fire regime at Blossom Valley probably has no historic precedent based on the matrix of existing plant communities and likely ignition sources and their seasonality, so predictions and models are necessary about what to expect.

Specific predictions with respect to fire and other stressors for plant communities and species would consider:

1. Fire intervals outside the resilience of particular plant communities such that type conversion is possible. Fire size that creates a uniform fire regime across the reserve over many decades. Fire intensity that kills seeds or resprouting capability, or low intensity that does not germinate heat- or smoke-germinated seeds. Fire season which has a differential effect on the herbaceous layer.
2. Invasives that can outcompete natives and prevent the normal sequence of post-fire conditions from proceeding.
3. Erosion due to extreme fire regime.
4. Land use such as livestock grazing that is not managed to protect vulnerable species.
5. Wildland-urban interface issues. For example, stormwater runoff, or recreational activities that affect reproductive activity or that result in soil erosion.
6. Extreme events such as drought combined with other stressors.

## 3.1 Vegetation Communities and Wildlife Habitat

Adopting one model or another related to fire ecology is really over-simplistic and does not focus on what we need: meeting our objectives in the context of a synergistic set of disturbance processes that includes fire. In the following sections, conceptual models are developed in the form of a literature review regarding fire effects.

### Diegan Coastal Sage Scrub

This community of drought-deciduous sub-shrubs, is the predominant vegetation at Blossom Valley. In general, at higher elevations it intergrades with chaparral, but it tends to occupy a place lower on the moisture gradient and higher on the temperature gradient than chaparral. The coastal sage scrub community can either be "preclimax" to chaparral or a stable climax community, depending on soil parent material, aspect, and disturbance history. The spatial patterning of chaparral versus coastal sage scrub can often be related to soil moisture (Hanes 1977). As moisture-holding capacity of the soil types can vary, soil type can have a significant effect on the distribution of plant species (Westman 1981). Nitrogen has been shown to be a limiting factor for chaparral plants, and soils vary with respect to the availability of nutrients (Westman 1981)."

It also contrasts with chaparral by its drought-coping strategy of shedding foliage, while chaparral plants tend to tolerate water loss by adaptations such as thick, waxy leaves that resist dessication. Coastal sage scrub has lower shrub cover, higher volatile oil content, greater cover by herbaceous (or understory) species, shorter duration of nitrogen-fixing species, and more marked variation in post-fire sprouting patterns than chaparral (Westman 1981). Typically, coastal sage scrub has much less standing biomass and litter accumulation.

The long-term absence of fire in sage scrub stands is expected to result in a structural simplification of the community as shrubs age and canopy cover diminishes recruitment, an overall reduction in above-ground stand diversity (Westman 1981, Westman 1982, O'Leary 1989, Malanson and O'Leary 1982, De Simone and Zedler 1999), low numbers of above ground annuals (though they may still be present in the seed bank), and a general absence of nitrogen-fixing organisms (Westman 1982, DeBano and Dunn 1982). Mature stands are typically highly dominated by one or very few species, due at least in part to the shade intolerance of the herbaceous understory and to reduced levels of soil nitrogen (Westman 1981). With the exception of a few scattered herbaceous individuals, the understory is barren. It is not uncommon to find areas of one hectare or more dominated by one or two shrub species. The dominant shrubs often die within 25–35 years on sites which have not burned in 60 years or more. At 40 years, the stand diversity is much reduced, and annuals have completely disappeared, though they may remain viable within the seed bank. Animals with sedentary life cycles that are dependent on herbaceous or suffrutescent shrubs of a more open habitat condition could be at risk from prolonged absence of fire as the shrub canopy fills in.

Herbaceous species (plus seedlings) tend to occupy gaps in the shrub canopy where they can sometimes occur at high densities (F. Davis et al. 1989, Rice 1993, Tyler 1995 in Keeley 2000). However, the highest densities of herbaceous annuals appear in the first growing season following a fire, with a secondary immigration of less abundant or less readily dispersed herb species to the site over time. Within 20 years post-fire the cover of legumes and vines has all but disappeared. Symbiotic nitrogen-fixing organisms are virtually absent from stands which have not burned in 20 years or more (Westman 1981).

Constituent shrub species are capable of continual reproduction by seed, unlike chaparral species. Many coastal sage scrub species are considered to be "pioneer species," which are present in early successional stages following disturbances (Mooney 1977, Zedler et al. 1983). Resprouting shrubs recruit seedlings immediately after fire but also recruit in gaps of unburned stands. Gap-creating agents vary (including shallow soils, steep slopes), but animals, especially small mammals, can be important in creating and maintaining gaps (DeSimone and Zedler 1999). In coastal areas, most sage scrub species resprout from below ground root crowns, although there can be substantial seedling germination (White 1995). This is not the case in inland areas where there is little or no regeneration from sprouting and virtually all recovery is dependent upon seed germination. Low-intensity fires stimulate sprouting of dominants, but hot fires suppress crown-sprouting, and consequently promote the herbaceous flora (Westman 1981).

Many of the dominant coastal sage scrub shrubs are highly combustible because of a high proportion of fine fuels and volatile secondary plant chemicals, and are often highly tolerant of fire. Fuelbed characteristics of coastal sage-scrub differ from mixed evergreen chaparral both in terms of fuel loading and fuel arrangement. The volatile oil concentrations of coastal sage-scrub species are considerably higher than mixed chaparral, which creates a higher reaction intensity per unit of fuel during pyrolysis.

Fuel moisture is lower in coastal sage scrub than chaparral in the summer, but the fuel is less continuous, has lower canopy volume, and lower tissue density (Mooney 1977). Prevailing summer onshore winds and coastal fog provide higher relative humidities that mitigate some of these qualities. California sagebrush leaves are considered to be highly flammable under dry conditions. Fine fuels such as leaves of California buckwheat contribute to flammability of this plant community, and are most responsive to changes in fire weather. Under hotter, drier, windier conditions (late September–November), coastal sage scrub can create fast spreading and high-intensity wildfires. Once the fine fuels (1-hour and 10-hour time lag fuels) dry out, they can sustain very explosive wildfires (Andrews 1986, 1989; Montague, pers. comm.). A time lag in fuels terminology refers to a National Fire Danger System ratings class regarding dead fuel (dead plant material). Subclasses are assigned based on the speed, or time lag, with which they lose their moisture (Biswell 1989), which is roughly related to stem diameter and density. In such fuels, moisture content is controlled primarily by precipitation, relative humidity, and temperature.

Regionally, problems have been reported associated with high fire frequencies and short fire return intervals for much of southern California. Coastal sage scrub probably tolerates a wide range of fire intervals, from 2–40 years, judging by the mix of resprouting and seeding capabilities of the component species (Malanson 1984). A single premature fire can transform vegetation composition or even type-convert shrublands. O'Leary (1995) estimated that fire return intervals of five to ten years can result in chaparral replacement by coastal sage scrub. Despite the apparently greater resilience of coastal sage scrub (compared to chaparral) to short fire return intervals, conversion to annual grasses has been widely reported at fire intervals of 5-10 years, particularly at drier inland locations (Timbrook et al. 1982, Callaway and Davis 1993, Riggan et al. 1994, Minnich and Dezzani 1998, O'Leary 1995b). This may be due to interaction with other disturbance types such as grazing or drought or the ready establishment of exotic annual herbs which can often support high fire frequencies (Minnich and Dezzani 1998).

In past years national forests in southern California have called for short-rotation burning to frequently rejuvenate coastal sage stands (Stephenson and Calcarone 1999) on the order of 17-year rotations in the Cleveland National Forest, and 12-year rotations in the Angeles National Forest. However, retention of older stands may be necessary to support all desired species of the community, and fire-free intervals of 25 years or longer to allow the type to reach full structural maturity and remain there for some time is currently targeted (Stephenson and Calcarone 1999). Strategic prescribed fire on at least a 25-year interval may be desirable, while maintaining a range of age classes to fully accommodate the needs of all component species. Since in such a prescribed burn rotation a maximum of 50% of the vegetation cover actually burns, this means that some of the plant community will continue to attain an age of 40–60 years.

Life form largely dictates the mode of post-fire regeneration. Herbaceous perennials are all obligate resprouters. Suffrutescents, with slightly woody bases above ground are killed by fire and regenerate from an abundant seed bank e.g. deerweed and peak rush-rose *(Helianthemum scoparium)*. Among the subshrubs, most are obligate resprouters.Two species, white sage *(Salvia apiana)* and ashyleaf buckwheat *(Eriogonum cinereum),* form distinct basal burls (Keeley 1998). Sprouting may be a necessary form of regeneration because it appears that the seeds of most coastal sage-scrub species are killed by the intense heat of a fire. However, three species of subshrubs are facultative seeders: California sagebrush, California buckwheat, and black sage. In these species first-year seedlings are common but resprouting is variable and there may be complete mortality at some sites. Post-fire resprouting in coastal sage scrub subshrubs tends to be more successful in younger, rather than in older shrubs and at coastal rather than inland sites (Keeley 1998).

### Southern Chaparral

Throughout its range, chaparral occurs in a matrix of coastal sage scrub and oak woodland. Herbaceous species are restricted to canopy openings and as a result are uncommon in mature chaparral but can dominate after a fire. Post-fire emergence of these species is largely from dormant seeds in the soil, as well as from bulbs, rhizomes, and tubers. A second pulse of annual herbs often occurs within five years of a fire (S. Keeley 1977), probably corresponding to the first above-average annual rainfall. As the community ages, it becomes increasingly dominated by a few species of tall, vigorous crown sprouters (Lloret and Zedler 1991, Van Dyke et al. 2001). In areas where oaks or other tree species are located in proximity to mature chaparral, the chaparral shrubs can act as "nurse plants" for tree seedlings which may eventually overtop and kill their hosts (Callaway and D'Antonio 1991).

Fire interacts with processes of drought-mediated canopy development, production, and mortality to affect stability of community composition (Riggan et al. 2003). Chaparral is generally believed to be resilient to fire return intervals ranging from between 20 to 150 years, with average natural return intervals of 50 to 70 years at least in inland situations (Minnich 1983, Davis and Michaelson 1995, Conard and Weise 1998, Mensing et al. 1999). The degree to which fire can influence community structure in Mediterranean shrublands depends most strongly upon the fire interval (Hobbs and Huenneke 1992, Keeley 2001, Zedler et al. 1983). The natural fire interval of southern California chaparral is believed to be greater than twenty years (Keeley 2001).

Keeley (2001) observed that chaparral is particularly immune to alien invasions because exotic herbaceous growth forms cannot establish under the closed canopies of native shrubs. Non-native species are not common in intact chaparral stands, but shallow soils, erosion or other disturbance can provide them with a foothold. A fire-aided invasion process has been documented by Minnich (Minnich and Dezzani 1998), who examined aerial photographs of the mountains in western Riverside County taken between 1931 and 1995. In this area – which burned more frequently than the county-wide average – the images showed that chaparral and sage scrub were gradually displaced by alien grasses as the fire rotation interval fell from 30 years to eight years. Minnich noted that chaparral coverage in the study area dropped from 1,137 acres to 109 acres – "mostly fragments fortuitously skipped by fire," – while coastal sage scrub habitat fell from 2,577 acres to 1,137 acres.

Fire intensity can also affect stand composition because of the diverse cues through which vegetation may respond to fire, blazes of different intensities or degrees of smoke production may result in different plants dominating the post-fire recovery. In intact chaparral, most wildfires are naturally high intensity and these fires facilitate the regeneration of the natural stand. In areas where chaparral is disturbed from high fire frequency, low-intensity burns can fail to produce the heat needed to destroy seeds of some no n-native annuals when their water content and carbohydrate storage condition make them most vulnerable (Moreno and Oechel 1991). Nitrogen oxides, which are also important components of air pollution, are the chemicals in smoke responsible for germination of some chaparral species.

Species that resprout vigorously and also produce seedlings after fire are the most widespread life history in chaparral, but seedlings seldom contribute substantial numbers of individuals that become members of the mature community (Hanes 1977, Zedler 1995). The primary advantage of root crown sprouting is that the large, well-developed root systems allow these shrubs to gain competitive dominance of the site within a few years after a fire. The resprouts will eventually outcompete the seedlings for light, moisture, and nutrients as the canopies of the resprouts expand, causing the gradual elimination of seedlings (Horton and Krabel 1955, Hanes 1971, Vogl 1981, Keeley 1981).

Despite the advantages of resprouting following a fire, certain chaparral shrubs reproduce exclusively by seeds and lack the capability to resprout. Other species that have well developed capabilities for resprouting still produce millions of seeds annually, which would seem wasteful from the standpoint of a plant's allocation of energy. There appear to be certain environmental situations within the chaparral community in which the capability to reproduce by seed becomes important. For example, seed reproduction becomes essential through periods of extreme environmental stress, such as extended droughts, landslides, and in colonizing areas devoid of resprouting individuals (Vogl 1981). Keeley and Zedler (1978) hypothesized about evolutionary selection pressures under both short and long fire-free periods that favor dominance by different species groups. During a short fire cycle, there are fewer dead shrubs prior to the fire, thus more potential resprouts. Subsequent fires are less intense, so there is less fire-induced mortality, and fewer openings for seedlings to become established. The result is low selection pressure for obligate-seeder life histories, or plants that depend on fire for regeneration by seed and do not recover by sprouting. Sprouting species are at a disadvantage during long fire-free periods. The intensity of a fire produced by the accumulated fuel load will reduce the number of individuals that can successfully resprout. Also, there are fewer resprouts after a burn because more shrubs were already dead prior to the burn. The result is larger openings for seedlings and high selection pressure for the obligate-seeding strategy. The successful species will be the one with the most seeds per unit area in the soil seed bank when the eventual fire does occur.

Under the scenario of pre-historic fire regimes, the obligate seeding strategy becomes extremely advantageous. Obligate seeding species will gradually become eliminated under high fire frequency or short return-interval scenarios. Certain species of Ceanothus, for example, may be eradicated because the post-fire population requires at least seven years to produce seed, and multiple years or even decades to establish enough seed in the soil seed bank that original population levels will be replaced after fire. With some fire-free periods of 150 years or more, the limits of obligate seeders' and other organisms' resilience is unknown. The length of time that seeds remain viable is unknown for most chaparral species (Tyler and Odion 1996). Further study of seed bank longevity is needed to understand the risk to species of concern.

Under long-term absence of fire, chaparral composition will shift towards taller canopy dominants which are in the vigorous crown sprouter group (such as oak and toyon), and loss of ceanothus and other obligate seeders. Van Dyke et al. (2001) found that more than half of the herbs growing above ground were absent in samplings 25 years apart in maritime chaparral of Monterey County. The remaining herbs were restricted to the few remaining canopy gaps, and the understory was bare except for litter and seedlings of trees, which need shade to germinate, then a canopy opening to establish new individuals. In general, herbs are expected to be low in number and restricted to canopy openings where dominant species die from aging, or on shallower or finer-textured soil types that restrict shrub growth. If fire parameters do not favor regeneration of obligate seeders, or if seedlings emerge under adverse environmental conditions after fire and die from drought or competition, stand dominance may shift to chamise. Animals with sedentary life cycles that are dependent on herbaceous - or suffrutescent shrubs of a more open habitat condition may be at risk.

### Riparian Woodlands

Despite their relatively small area, a great diversity of wildlife depend on this plant community. It provides habitat and forage for migratory and resident birds as well as natural wildlife corridors for movement of other species, linking habitat types. Other functions are also performed by drainages that extend beyond their limited area, such as filtering of sediment and contaminants for water quality protection, and groundwater recharge. Riparian dominants almost universally resprout after fire (Zedler 1995), except those of extreme intensity.

While the community itself is resistant to ignition, once a fire starts it can become intense and difficult to suppress. While fire intensities may approach high levels in riparian fuels, resistance to both ignition and suppression is quite high. Firefighter access to these fuels is limited, and fuel continuity and arrangement is very dense. Long-term, smoldering fires are common and can become a nuisance to wildlife and firefighters. This, along with the high natural resource values, requires fire management planning for such areas. Fire often top-kills many of the broad leaved trees in these woodlands, and they may recover very slowly (Davis et al.1988). Full tree canopy recovery following fires in riparian areas may take many decades (Davis et al.1988). Fire impacts to woodlands depend on the nature of the particular fire, the fuels available, and the season of burn as it affects the plants and wildlife residing there. Cool ground fires that clear out dead material and underbrush can be beneficial to management objectives. The disturbance caused by fire might also favor invasion by exotic species such as giant reed.

### Oak Woodlands

Coast live oak woodlands occur on north facing slopes, on upper terrace floodplains, near rock outcrops, and in shaded ravines where there is ample moisture. Engelmann oaks require less soil moisture, and thus tend to be found in more upland conditions.

Post-fire survival of oaks is facilitated by fire-resistant, thick bark, and massive root systems that allow fast regeneration of lost canopy (Plumb 1980), even with crown fire. Mature coast live oaks recover rapidly from moderate-severity fire, and light-severity fire has little effect on them. Basal sprouting is common (Tietje et al. 2001, Pavlik 1991, and Paysen 1993). After the hot Old Topanga fire of 1993, the majority of oaks in the study recovered 80 percent of their canopy in two years (Dagit 2002). As the canopy regenerated in oak saplings after this fire, the diameter of trunks also increased (Dagit 2002), apparently benefiting from the post-fire nutrient flush after high-intensity fire (Boerner et al.1988). However, coast live oak seedlings and saplings less than 3 inches (7.6 cm) in diameter may be top-killed by low- to moderate-severity fire, and severe fire kills trees of this size (Dougherty and Riggan 1982, Plumb 1980, Plumb and Gomez 1983). Trees greater than 6 to 8 inches in diameter resist top-kill. The most common fire damage to the trunk is a basal wound resulting in potential cambium death. Large trees may need up to three growing seasons to basal sprout (Plumb and Gomez 1983).

Mortality of oaks from fire is greater when there is a shrub understory or adjacent chaparral. Use of fire is frequently recommended for managing this understory. When oaks grow in dispersed stands of low density and low percentages of canopy closure, the associated vegetation is primarily annual and perennial grasses, and this presents little danger to the trees in terms of fuel loading. Grassland fires tend to be fast moving and consequently oaks are not exposed to high temperatures of any duration during wildfires. These open oak woodlands can provide fire suppression control points. In stands with dense brush, domestic goat grazing (at a rate of 240 goats/acre for one day), in conjunction with prescribed fire, has been used to reduce fuel loading and continuity in dense coast live oak chaparral near housing developments (for example, see Tsiouvaras et al.1989).

Engelmann oak is relatively rare compared to coast live oak, and its very limited range in southern California makes protection a high priority. It has a reduced ability to recruit seedlings and saplings compared to coast live oak. The research on seedlings and saplings at Camp Pendleton indicates a higher susceptibility of Engelmann oaks to fire than coast live oaks to recruitment impacts, and that these are more susceptible to mortality following spring fires than fall fires (Lawson et al.1997). Since controlled burns are normally conducted in the spring, consideration needs to be paid towards this sensitivity. Mortality of seedlings and saplings occurs differentially according to their height and position in relation to the mature oak canopy. This was observed on Camp Pendleton by Lawson and others (1997), who documented mortality from low- to moderate-severity fire of small-diameter coast live oaks and Engelmann oaks over five years. Fire mortality of Engelmann oak and coast live oak (in a woodland with herbaceous and coastal sage scrub species in the understory) was studied for trees less than 3.9 inches (10 cm) in diameter: of 1,214 small trees surveyed, 531 survived 5 years after fire. Both species survived at about the same rate. In the same location on Camp Pendleton, a light- to moderate-severity fire in an Engelmann oak/coast live oak stand enhanced coast live oak seedling establishment. In the two years preceding fire there was no establishment; in 5 postfire years 1,118 oak seedlings established, of which 1,025 were coast live oak. In contrast, following a severe fire in Ventura County, severely-burned sites supported no coast live oak germination from acorns the following spring, while adjacent unburned areas produced new seedlings (Davis et al.1989).

Many studies have shown oak survival to be inhibited by rodent populations in savannas and grasslands. Acorns are cached by wildlife around rock outcrops. Many native wildlife (such as deer and rodents) eat acorns or seedlings, and their abundance may affect recruitment. Others (scrub jays and ground squirrels) can facilitate by moving acorns from under mature trees and caching them in areas suitable for germination. In Serrano Canyon in San Luis Obispo County, rodent abundance was found to be a symptom of the conversion from native perennial grasses and forbs to introduced annuals. Overall seed production in the area increased with the annual species. This allowed the population of seed-eating rodents to increase proportionately. While perennials produce seed over a relatively longer period each year (well into summer), annuals produce only one crop of seeds each year mostly in one short season (late spring, early summer). When annuals dominate a savanna, acorns, which mature when annual seed is long gone, become an important food crop for the rodents, and the recruitment of oaks suffers. (http://polyland.lib.calpoly.edu/overview/Archives/derome/grasslands.html)

### Grasslands

The local grasslands are mostly composed of non-native annual species, as is typical of grasslands throughout California. California grasslands are believed to have been largely converted from native perennial grasses to non-native, European annuals. Early historical accounts are used along with knowledge of microfossil presence and current grassland composition and distribution to ascertain what the native grasslands were. Certain exotic species probably preceded arrival of the Spanish to Alta California, spreading from Baja California northward. Early examples of adobe bricks reported by Heady (1977) contained seeds of *Hordeum leporinum, Lolium multiflorum, Poa annua,* and *Erodium cicutarium.* Remnant stands of native perennials are most common in areas where soils retain moisture later into spring and early summer, such as in valley bottoms and lower foothills.

Both throughout California and locally in San Diego County, the most intensive sheep and cattle grazing ended by the turn of the 20th Century, and the end of the grazing era was coupled with a devastating drought which likely set into permanence the conversion of native perennial grasslands to dominance by exotic annuals. The replacement of native perennial grasses probably occurred in phases between the 1850s and 1900, resulting from their competitive ability combined with a complex of factors such as drought, overgrazing, altered fire regime, and changed rodent activity (Burcham 1956, 1957, Robbins 1940, Heady 1977, White 1967, Wright and Bailey 1982). Also, ranchers commonly used fire to open up California sagebrush to grazing (Burcham 1956). With removal of livestock, some previously-grazed areas have recovered to shrublands and others have not.

Kellogg & Kellogg (1990) observed, from 1938 aerial photos and other records, that many areas on MCB Camp Pendleton currently dominated by annual grasslands were dry-farmed to grain in the late 1800s to late 1930s. The only site factor examined that correlated to the absence of perennial grasses on Camp Pendleton was historic cultivation.

Fire is well-recognized as beneficial to native grasslands as a whole and many of its component species (Biswell 1989, for example), which have developed physical characteristics that make them resilient to frequent fire. Most grasslands appear dependent on fire to recycle nutrients, which are used up rapidly by grasses (Mutch 1970). The annual growth of above ground biomass in grasslands dies back during the dry season and decomposition sets in that ties up nutrients needed for productivity, and fires support the recycling process. Grasslands need the continual and frequent infusion of nutrients that fire provides. Long between-fire intervals favors the expansion or recolonization of coastal sage scrub into grasslands.

The dominant native California perennial bunchgrass, *Nassella pulchra,* has been shown to benefit from fire due to removal of thatch that obstructs light from the grass bunches, increasing tillering and increasing seed weight (Menke 1992). Perennial bunch grasses differ from annual grasses in that they put much of their energy during their first several years into establishing a well-developed root system that would sustain them through regular summer drought. Their roots penetrate deeply into the soil, providing nutrients and water and holding soil particles firmly in place. This decreases the erosive effects of wind and water. Unlike annual grasses, they do not produce seeds the first year, but as the years continue, produce an abundance of seed at maturity. These seeds drop close to the tufted parent plant, and generally, expansion of remnant stands is limited by the limited dispersal capability of these seeds (E. Kellogg, pers. obs.).

Bell (no date) reviewed the effect of burrowing pocket gophers (Thomomys bottae) on maintaining grassland soils in southern California. he noted their ability to support plant species diversity, reduce runoff erosion, increase water infiltration through soil aeration, mix nutrients (Spencer et al.1985), and rotate seed banks including that of needlegrass and native forbs (Hobbs and Mooney 1985, Reichman and Smith 1985, Anderson 1987) Gopher activity supports pioneer patch dynamics for native forbs. Bell describes gopher diggings as approaching 30 percent of the needlegrass prairie on the Santa Rosa Plateau, and that these diggings can bring up to the surface from five to 50 tons per acre of soil each year (Cox and Allen 1987, Spencer et al.1985). An individual gopher may bring two tons per acre of soil to the surface each year (Downhower and Hall 1966).

Cattle grazing affected different life history guilds in different ways on the California coastal prairie, and this suggests that grazing can be a valuable management tool to conserve native annual forbs (Hayes and Holl, In Press). Many of these forbs are of conservation concern throughout California, and locally some provide forage for the federally listed butterflies. In this study which used paired, grazed and ungrazed plots, native annual forb species richness and cover were higher in grazed sites as mulch and litter layers were opened up, but exotic annual grasses and forbs were higher in grazed sites. Native grass cover did not differ between grazed and ungrazed sites, but cover and richness of native perennial forbs was higher in ungrazed sites. The authors conclude that land managers should focus on a matrix of disturbance regimes to maintain the suite of species native to grasslands.

## 3.2 Plant Populations In Relation to Fire

Focal species should be stressor-based, meaning they should be selected to be the ones most at risk from an altered fire regime, especially in combination with drought, invasives, and other disturbance processes. In order to identify at risk species, plants may be grouped as to their expected response to fire by life history traits. Response to variation in the fire regime varies with regeneration strategies.The groupings below with examples from the Blossom Valley species list were conceived to function as a resource for future fire management decision-making. Information for dominant shrubs was derived from the USFS Fire Effects

Information System (USFS FEIS at http://www.fs.fed.us/database/feis/plants/). The breakdown of life histories used for shrubs and trees is based on Zedler (1977, 1995). Classification of herbaceous species is based on Zedler (1995), Keeley and Keeley (1984), and Keeley *et al*. (1985). Lichens are also considered in the herbaceous species table.

***Obligate Shrub Seeders.*** Primary period of population expansion is post fire. Mature plants killed by fire, recruitment mostly from soil seed bank. Fire-dependent, shallower roots, higher tolerance of water stress, and greater post-fire seedling survivorship than obligate sprouters. Obligate seeders can be lost with a single premature burn. For non-sprouting species 7-15 years are needed for seedlings to mature enough to replenish the population, depending on weather and other factors. These shrubs have only limited dispersal ability and once lost from an area, recolonization from other established populations can be extremely slow (Zedler and Zammit 1989). Obligate seeders can disappear after a long fire-free period, but still remain in the soil seed bank.

- Absence at Blossom Valley may be an indicator of too-short interval or insufficiently hot fires in the fire history.

***Obligate Shrub/Tree Sprouters.*** Seeds killed by fire, regeneration by vegetative resprouting. Sprouts between fires but may need fire to create gaps for saplings to recruit to the canopy and for population expansion; more resilient to short return intervals for fires (Zedler et al. 1993, Fabritius and Davis 2000), but nevertheless may be severely impacted by sustained high-frequency fire regimes. Successful germination and recruitment of new individuals is correlated with the cooler, moister, low light conditions and increased litter depth associated with mature closed-canopy chaparral that develops over fire-free intervals of 40 years or more (Lloret and Zedler 1991, Keeley 1992a and b, DeSimone 1995). S. Keeley et al. (1981) investigated seedlings of obligate sprouters: Seedlings are established primarily in mature chaparral in gaps resulting from the death of senescing, shorter-lived species. Seedling establishment is often episodic and coincides with periods of above-normal rainfall. Although initial establishment may occur in burned or unburned stands during very wet years, continued survival is favored beneath mature stands on sites that are relatively mesic (north slopes) and which possess a well-developed litter layer. Long-term survival beneath mature chaparral is rare; seedlings are subjected to herbivory by small mammals. Seedlings are most common in very old stands (60 to 100+ years) where long fire free intervals allow for the build-up of seedling populations.

- *Quercus berberidifolia* (scrub oak). Scrub oak's prolific sprouting ability makes it a prominent component of the early postfire community. It is exceptionally persistent with or without fire (Minnich and Howard 1984, Keeley et al. 1986). Seedlings likely establish in unusually moist years but need litter, so this only happens in very old stands (Zedler 1977) This species is expected to be stable with or without fire. May increase cover without fire due to its height and ability to dominate the canopy.
- *Rhamnus crocea* (spiny redberry). Maintains itself primarily through sprouting. Little or no seedling establishment has been noted immediately following fire. Seedling establishment is never very abundant and is restricted to stands of mature chaparral, probably in gaps created by senescence of shorter-lived shrubs (Keeley 1981, 1986, 1987). Species is expected to be stable or increase with extended fire-free period. Con-

tinued existence of this species would not be expected to be jeopardized by fire. Considered fire resistant in horticultural setting.

- *Rhus integrifolia* (lemonade berry). Tall canopy dominant, moderately vigorous resprouter. Expanding on SCI. Seedling recruitment occurs under fire-free conditions (Lloret and Zedler 1991) and after fire but survivorship after fire has not been determined (Keeley 1998). Species is expected to continue to increase with extended fire-free period due to height and ability to dominate the canopy, as well as ability to recruit seedlings.

***Facultative Shrub/Tree Seeders/Sprouters (mixed seedling recruitment and vegetative resprouting).*** Mortality of the lignotuber (a woody swelling below or just above the ground, containing buds from which new shoots develop if the top of the plant is cut or burnt) can be very high if fire returns prematurely (Zedler et al. 1983, Haidinger and Keeley 1993). Since a premature fire also kills seedlings that germinated in response to the previous fire, facultative seeders show only limited ability to persist under repeated disturbance.

- *Malosma laurina* (laurel sumac). Vigorously resprouts and produces abundant seed following fire. However, this extremely deep-rooted species apparently has low tolerance to water stress. In the Santa Monica Mountains most seedlings die (99%) in the first summer following a fire (Davis et al. 1998). The species behaves as an obligate resprouter. However, it appears to expand and even dominate coastal sage scrub with short-interval fire from both seedlings and resprouts in San Diego County (E. Kellogg, pers. obs.). Perhaps these conflicting observations are due to rainfall year when seedling observations were made.
- *Adenostoma fasciculatum* (chamise). Chamise resprouts from dormant buds on the lignotuber following fire. The seed germinates at high rates only after fire, and seedling recruitment and population expansion are fire dependent (Keeley 1986). Different fire severities can shift the competitive balance between chamise and other potential dominants such as ceanothus (Howe 1976). Chamise has fuel characteristics which result in intense, fast-spreading, potentially large fires. May be eliminated from sites with late spring or early summer prescribed burns and replaced with Eriogonum fasciculatum.
- *Xylococcus bicolor* (mission manzanita). A vigorous sprouter, rarely establishes seedlings, does not seem to be able to exploit closed canopy conditions (Zedler 1977). Short fire return interval can result in substantial mortality (Zedler et al. 1983). A facultative resprouter but shrub is known to require fire for seed germination–it has a very hard seed coat that benefits from scarification by fire. Moderate-to high-intensity fire may result in population expansion. Further seed bank or seed germination studies would be useful.
- *Malacothamnus fasciculatus (chaparral mallow).* Winter-deciduous shrub common after fires, on disturbed sites, and roadsides in chaparral. Vigorous sprouter from rhizomes, extremely clonal. Abundant postfire seedling recruitment. Benefits from post-fire canopy opening and probably from nutrient flush. Primary period of population expansion is postfire and it is a recognized fire follower. Common in southern California.

***Subshrubs (Coastal Sage Scrub).*** Intermediate- to long-lived dominant and canopy species which tolerate fire, but do not require it for establishment; they are sensitive to fire intensity because it affects sprouting ability (Zedler in Kalen et al. 1995). The ability of surviving shrubs to seed in the first year after fire appears to allow coastal sage scrub to persist under fire frequencies that eliminate chaparral (O'Leary 1995).

- *Artemisia californica* (California sagebrush). Can produce some seedlings in closed canopy conditions between fire events and in adjacent open areas if the soil is not disrupted, but the primary period of reproduction and population expansion is early post fire by seed (Zedler 1977). Low-intensity fires stimulate sprouting, but severe fires cause widespread plant mortality and destruction of shallow buried seed (Malanson and O'Leary 1985). Recovery optimal under low severity conditions (USFS 1994). May benefit from some low-intensity prescribed fire. Short-interval fire will eliminate it. Severe, long-interval fires may be destructive to re-establishment.
- *Eriogonum fasciculatum* ssp. *fasciculatum* (California buckwheat). Evergreen but only moderately sclerophyllous. The woody, branched roots penetrate to under 1.5 m (Kummerow et al. 1977). Plants are vulnerable to hot fires so resprout success is low and most regeneration is from seeds (Keeley 1998). Frequent fires deplete the seed bank, making populations vulnerable to local extinction. California buckwheat does well on rocky road cuts and in shallow soils that are inhospitable to annual grasses.
- *Salvia apiana (*white sage). Similar to California sagebrush, but higher intensity fires may favor the germination and repopulation by seed of white sage over Artemisia due to the more abundant postfire seeding of white sage.

***Suffrutescents.*** Smaller, short-lived shrubs with slightly woody above ground stem that is killed by fire with no ability to resprout. Fire-stimulated seedling establishment. Obligate seeders following fire but will respond to other disturbances. Mostly absent in older communities or persist in gaps. No special dispersal mechanism. Germination is heat or charate stimulated, with a portion germinating without treatment (Keeley et al. 1985).

- *Eriophyllum confertiflorum* (golden yarrow).
- *Lotus scoparius* (deerweed). Will decline as canopy closes. Resident with fire-stimulated establishment, but also the ability to respond to other disturbances. Maintains a large, dormant seed bank.
- *Helianthemum scoparium* (peak rush-rose). Will decline as canopy closes. Seeds germinate without treatment but germination nearly doubles with some heat treatment.

***Herbaceous Perennials.*** Underground storage structures such as a bulb, tuber, rhizome, or large tap root; these plants are normally dormant when a fire passes through, so are not directly affected, but benefit from nutrient flush, canopy opening, and other aspects of altered competitive status. Obligate resprouters.

- *Bloomeria crocea* (common goldenstar).
- *Delphinium parryi* (blue larkspur).
- *Paeonia californica* (California peony).

***Herbaceous Perennials Dependent on Seed for Propagation.*** Generally germinate well without treatment, but high temperatures are lethal (Keeley et al. 1985)

- *Dicentra chrysantha* (golden eardrops). Requires both extended seed burial with dessication and smoke for germination (Keeley and Fotheringham 2003). Although it has a stout taproot, this species is often not seen during the inter-fire period. Dry gravelly hillsides, gullies, and disturbed areas, often invading after fire. The seeds usually do not germinate unless desiccated or seared by fire.

***Stem Succulents and Cacti.*** Somewhat fire resistant due to succulence and low fuel loads associated with typically open habitats. No soil seed bank, so population recovery is slow if plants are killed by fire. Variability in different species ability to survive or resprout following fire. Most have some ability to resprout, but most also suffer some degree of mortality if fire is moderate or severe.

- *Dudleya pulverulenta* (dudleya). Leaf succulence and habitat preference for rocky, shallow soils and open habitats limits fuel in proximity to plants and generally allows this genus to tolerate fire well. Canopy closure detrimental. Resprouts after fire. Rely on resprouting ability to survive wildfire.
- *Yucca whipplei* (Our Lord's candle). Fire resistant. No postfire seeding recruitment; resprouts after fire, but most yucca species experience some degree of mortality. Shade intolerant, canopy closure detrimental. Persistent, long-lived, establishment independent of large-scale disturbance

***Opportunistic Native Annuals (Zedler 1995).*** Usually found in canopy openings in shrublands. Fire can benefit by opening up canopy cover, but will seed with or without fire.

- *Chorizanthe fimbriata* (fringed spineflower).
- *Eschscholzia californica* (California poppy).
- *Mimulus brevipes (*hillside monkey-flower).
- *Camissonia bistorta* (California sun cup).

***Pyrophyte Annuals (Keeley and Keeley 1984).*** Considered fire followers because seeds stored in the soil seed bank are stimulated to germinate following fire by heat, smoke, or charate (ashy burned material). Fire eliminates canopy cover of competing species. No special dispersal mechanisms, largely disappear by third year after fire. Seed is long-lived.

- *Emmenanthe penduliflora* (whispering bells). Germination of seed is fire-dependent. Likely to have had little reproduction during the interfire period.
- *Lotus salsuginosus* (alkali lotus or humble lotus). Unlikely to appear during the interfire period. Seeds respond to heat stimulation (Keeley and Keeley 1982). Population likely to appear following either prescribed fire or wildfire.
- *Phacelia* spp. Species in these genera are generally considered pyrophytic. Population expansion likely following either prescribed fire or wildfire, but these are fairly common species that appear able to maintain themselves at low levels without fire.

- *Chaenactis artemisiifolia* (white pincushion). Smoke-induced germination.
- *Caulanthus heterophyllus* var. *heterophyllus* (slender-pod jewel flower). Smoke-induced germination
- *Antirrhinum kelloggii, A. nuttallianum* (snapdragons). Smoke-induced germination.

***Lichens.*** Foliose lichens of rocks, bark, and shrubs are highly flammable because they desiccate when relative humidity drops (Brodo et al. 2001). At least some stands should be protected so they can get as old as possible, to act as refugia and sites of inocula to perpetuate lichens (Bowler and Riefner 2003).

## 3.3 Wildlife Populations and Fire Effects

Continuing to identify which species are at risk from an altered fire regime as in the previous sections, we attempt to group wildlife as to expected fire effects. These effects can be direct, but many are quite indirect and less predictable compared to plants. Direct effects include injury and mortality due to direct exposure to the fire. Indirect effects are caused by the alteration or destruction of habitat utilized by wildlife within the perimeter of the fire (Walter 1977). Most animals are able to escape the lethal effects of fire by selecting an insulated micro environment (burrows, riparian areas) or by rapidly emigrating from the area of the fire. Therefore the majority of the effects upon wildlife species is indirect, a result of alterations in the vegetation structure and temporary loss of habitat. These alterations include the removal of favorable nesting sites, the disappearance of host and forage plants, and loss of protective vegetation cover. Additionally, the loss of vegetation also results in changes in the biophysical milieu, altering temperature, wind, incident radiation, and soil moisture among other parameters that make up a microhabitat. The following passages discuss the effects of fire upon key species and species groups of interest.

### Terrestrial Mammals

The degree to which mammals are successful at surviving wildfire depends both on their mobility and the uniformity, severity, size, and duration of the fire (Wright and Baley 1982). Small mammals usually attempt to escape wildfire by using subterranean shelters. Seed-eating rodents generally do well after fire, since they benefit from an open condition and bare mineral soil. Above-ground lagomorphs are more impacted by fire. Those with surface nests, such as the dusky-footed woodrat with its stick house and the California parasitic mouse which lives in woodrat nests, depend on a mature habitat condition.

More mobile, opportunistic large mammals such as carnivores do well, such as foxes and coyotes. They can benefit from increased levels of prey during the recovery phase. Ungulates must find sanctuary in unburned patches or along the periphery of the fire. Large mammal death is generally rare, but possible when fronts are fast moving, wide, and actively crowning with thick ground smoke (Smith 2000).

Depending on the uniformity and severity of a wildland fire, mammals can experience different indirect effects. Given a patchy burn, small rodents, such as woodrats, can recover quickly and exceed pre-burn levels (Schwilk and Keeley 1998 as referenced in Smith 2000). Mule deer *(Odocoileus hemionus)* generally prefer to forage in recovering burned vegetation as opposed to unburned areas

(USFS 2003). This is most likely due to an increase in the soil nutrient availability, and thus an increase in the nutritional value of forage within burned sites. In one study, mule deer were estimated to have densities of 25 per square mile in unburned chaparral, while burned areas that had experienced a stand replacing fire had densities of 56 per square mile (Smith 2000).

### Birds

Shrubland bird populations are generally known to decline as an immediate response to wildfires (Smith 2000). This can result from emigration to unburned patches and direct fatalities as result of overexposure to the fire. If the fire disrupts nesting this can also directly affect population levels. If burns are patchy the initial losses related to the fire itself are often counter-balanced by population increases during the vegetation recovery in subsequent years. Research in chaparral after the first year of a stand-replacing fire suggests that avian species richness in the burn was 70% to 90% of that in the unburned adjacent sites (Moriarty *et al.*1985).

Patch size has been shown to be the single most important predictor of native plant species richness (Alberts et al. 1993). It follows that patch size dynamics of burns and the availability of unburned islands greatly influences the use of unburned sites by shrub-dependent bird species, such as in burned coastal sage scrub (Beyers and Wirtz 1997). Researchers have found a negative correlation between a number of species and the proximity of urban edges or level of fragmentation of a habitat (Alberts et al. 1993, Andren et al. 1985, Andren and Angelstam 1988, Santos and Telleria 1992). Bolger (1997) found that the abundance of edge- or fragmentation-reduced species appears to be depressed within 650 to 1650 ft from an edge, and the abundance of edge/fragmentation enhanced species is elevated up to 3,280 ft from an edge, depending on the species.

Sage sparrows, wrentits, black-throated sparrows, bushtits, mountain chickadee, acorn woodpeckers, white-headed woodpeckers, other sapsuckers, screech owl, sawwhet owl are canopy-dependent species which would decline post-fire. Canopy species may have severe short-term *and* long-term effects because of possible type conversion in some habitats. Wrentits, California thrashers are very sedentary and were probably killed by the fires. California gnatcatchers (*Polioptila californica*) prefer the cover and structure provided by mature unburned coastal sage scrub. Likewise the California thrasher *(Toxostoma redivivum)* will recolonize burned sites four to five years after a burn, and do not reach maximum densities until twenty years post-fire (Cody 1998).

In contrast, the lazuli bunting feeds on the first annuals after fire, and is considered a fire follower species. It was *never* detected at locations during the five-year San Diego Natural History Museum (SDNHM 2004) Atlas period, but was observed in the first post-fire year. Also, Lawrence's goldfinch, mountain quail, wild turkey increased. A 2000% increase in black-chinned sparrows was observed, and swallows, swifts, sparrows, and flycatchers were more abundant in burned chaparral in the first post-fire year. Finally, the SDNHM notes that this rebound effect was especially dramatic on Costa's hummingbird (*Calypte costae).* This results from heightened levels of poodle-dog bush *(Turricula parryi),* beardtongue *(Penstemon spectabilis),* and woolly blue-curls (*Trichostema lanatum)* that promote feeding and nesting.

It is unusual for raptors to suffer mortality due to a direct impact of fire (USFS 2003). Adults individuals can escape fire, however fire could directly reduce raptor populations if it impacts nesting trees. Low-intensity fires probably have little effect on raptors. Most raptors are unaffected or benefitted when occupying burned habitat. Burned areas provide little cover for prey species and raptors can take advantage of this vulnerability. Additionally, because prey species often increase after fire, raptors can also benefit. Coopers hawk (*Accipiter cooperii*) populations have been documented to benefit from fire (Dodd 1988 as referenced in Smith 2000). Nonetheless, fires that destroy potential nesting trees could impede reproduction of raptors when alternative nesting sites are scarce (USFS 2003).

### Reptiles and Amphibians

The direct impact of fire depends heavily on the severity and extent of the fire, and mobility of the species in question. Reptiles and amphibians must find respite in subterranean burrows, ponds, insulated rocks, etc. (Smith 2000). Due to their limited mobility they cannot escape a fast moving fire front. Significant mortality was observed as a result of the 2003 Cedar Fire (Tierra Data, pers. obs. 2003).

Undoubtedly, changes in the vegetation due to fire can indirectly impact reptile and amphibian species. A study by Simovich (1979, as referenced in Smith 2000) found that lizards were more abundant in chaparral after a wildland fire when compared to mature stands of chaparral.

### Terrestrial Invertebrates

The direct mortality of insects caused by wildland fires is significant. However, many species are able to escape fire by taking flight, or finding sanctuary in protected micro-sites such as soil burrows, unaffected trees, or rock outcroppings. In contrast, some species are attracted to fires, in search of suitable dead wood in which to lay eggs (Smith 2000).

Given that generally insect populations suffer heavily from wildland fires, recolonization and insect diversity of the burned site increases as vegetation is released from dormancy and regenerates. Insect diversity can shift as fire-following plants that were absent prior to the fire can provide new niches. Additionally, relative abundance of species can change as insects that take advantage of decaying wood become more abundant.

Some butterfly species are dependent on plants typically found in shrubland gaps, and may be at a greater risk of extinction than the plants themselves. For example, the Palos Verdes blue butterfly *(Glaucopsyche lygdamus palosverdesensis)* was thought to be extinct on the Palos Verdes peninsula in coastal Los Angeles County, but was rediscovered in 1994. Like many moths and butterflies, the Palos Verdes blue is restricted in the host plants it can utilize. It has a shorter life span than the plant species it depends upon; California locoweed (*Astragalus trichopodes* var. *lonchus)* and deerweed. Both plants are known to be fire followers in a landscape that is essentially lacking in wildland fire. This places the butterfly at risk because the host plants usually occur at low densities, depending on localized disturbances such as landslides or animal trails. For organisms with extremely sedentary demographics, such as this butterfly, long fire-free intervals combined with habitat loss and drought have been catastrophic.

# 4.0 Sampling Approach

This sampling approach uses a tiered or modular framework, in order to be flexible with available budgets. Each of the four monitoring levels builds on the one below it. For example, *Level IV* monitoring assumes that each level below it is implemented. The approach laid out below also implements the basic framework, outlined in Section 1.0, of fitting a monitoring program to a goal, then conceptual model, then mechanisms or actions. Finally, each monitoring Level incorporates multiple scales, from species to community to landscape level.

At all levels, the sampling frequency should be decided by the HCA Manager based on the rate of change of the variable of interest, management objectives, risk assessments, and resource constraints.

The methods proposed incorporate those used for fire monitoring by the U.S. Department of Interior such that data can be compared to that collected on their public lands. They also incorporate at certain Levels the use of descriptive relevés for vegetation consistent with the California Native Plant Society's methods for describing California vegetation such that CNLM can support the statewide effort to improve vegetation mapping. These methods are also consistent with an interagency Memorandum of Understanding for Cooperative Vegetation and Habitat Mapping and Classification (May 24, 2000) that standardizes an approach to vegetation mapping in California (see http://cnps.org/archives/).

*Level I:* Ambient environmental baseline conditions and presence/absence lists, organized different ways related to how the conceptual models predict community and habitat values.

*Level II:* Monitoring of vegetation and short-term fire recovery using stratified random approach, primarily for trend rather than statistical description of attributes and variables. Not as statistically robust as higher levels. Try to identify a reference site with little to no fire history or one with lots of fire history. Still mostly habitat-based, using cover and frequency as primary metrics.

*Level III:* Monitoring of short-term change in populations, recruitment, or habitat conditions for covered or management focus species, with effort to get at abundance trends to a defined statistical certainty. Abundance- and trend-focused rather than presence/absence. Adds density as a metric in plant communities to get better information on rare plants and recruitment/mortality. Adds a metric for monitoring landscape mosaics.

*Level IV:* Monitoring long-term change by adding *repeated* measures to those at lower levels. Adds a definition of minimum detectable change. Adds other environmental attributes and species groups, spatial studies, and objective-based monitoring for prescribed burns–did we achieve prescribed burn objectives?

## 4.1 Stratification, Monitoring Schedule, and Selection of Reference Sites

**Landscape Stratification.** To improve the power of any data collected to make predictions related to fire effects, the property should be divided into units that are expected to demonstrate a similar response to fire. There is a record of five fires on the Blossom Valley property between 1918 and the Cedar Fire of 2003. An additional four fires are recorded nearby (see Fire History map in

Appendix B). Some areas have only one recorded fire (2003), while others have burned three times. Fire intervals on the property range from very long (some areas appear to have no fire record since the Cedar Fire), to as short as 16 years. Other fire intervals are 33, 41, 43, 49, and 74 years. The flora and fauna of Blossom Valley may be impacted by short-interval and frequent fire in the shrublands. It may be experiencing a type conversion from chaparral to coastal sage scrub, or its plant community boundaries may be stable and more related to topographic factors.

In order the sort out fire effects, it is important that monitoring strategies be stratified by fire history, or be designed to specifically cover the range of fire histories (depending on the sampling objective) in shrublands or woodlands. Since it is most likely that fire intervals have more direct effect on community composition than frequency (except in grasslands), it is recommended that the property be stratified in shrubland or woodland communities by fire interval based on the fire history map in Appendix B. If sampling is organized in a stratified random manner based on plant community and fire history, specific questions could be asked about trend related to fire. For instance, we could ask if there were any difference in seral community composition of coastal sage scrub versus chaparral, and does it seem to be related to fire? Is diversity sustained in long-interval versus short-interval phases of the communities. Is there a difference in dominant plants?

**Monitoring Schedule.** Sample should be conducted during the phenological peak of the season (flowering, as opposed to green-up, transition, or dormant) when biomass is greatest. This could occur twice in a year in areas with summer “monsoons” (USDI “FIREMON” Monitoring Handbook).

**Need for Reference Sites.** Reference sites improve the ability to make predictions based on small data sets, and this is one of the primary reasons that methods are selected for Blossom Valley that are consistent with that used by others, to improve the chance that an offsite reference site might be located. Reference plots are also helpful and necessary to evaluate whether specific management objectives are met. (The California Rapid Assessment Program is designed to evaluate the condition of wetlands through the use of reference sites, for example.) Depending on objectives, it may be important to look for opportunities on adjacent preserved lands, or join with another programs to compare data in the same community type and same region, for fire effects and for management effects. If an unburned area on the property could be used as a control, this would improve the predictive power of the sampling program.

Establishing control plots for evaluating long-term change is helpful for testing specific hypotheses comparing non-treatment effects (areas not treated with prescribed fire) with treatment-plus-time effects.

*If the decision is made not to install reference plots, the manager should be especially conscientious to maintain updated conceptual models of fire effects in order to help interpret the data collected.*

## 4.2 Level I: Ambient Environmental Baseline Conditions and Presence/Absence Lists

*Level I: Ambient environmental baseline conditions and presence/absence lists, organized different ways related to how the conceptual models predict community and habitat values.*

The following list of monitoring elements incorporates a list of environmental baseline conditions that should be collected each year or in the event of a fire or prescribed burn. It includes some of our own approaches, SDNHM Atlas program methods, CNPS vegetation monitoring protocols, and some from the USDI "FIREMON" Monitoring Handbook.

- Weather including rainfall (monthly, long-term average); other weather such as wind speeds, direction, relative humidities (nearest Remote Automated Weather Station (RAWS) or National Oceanic and Atmospheric Administration [NOAA] site) with metadata regarding elevation, location, equipment type, calibration, etc. Depict rainfall in relation to trend (such as compared to long-term average, graph of timing/seasonality, palmer drought severity index).
- Fuel Conditions using Fire Behavior Prediction System fuel models 1-13 (Anderson 1982) or custom models using BEHAVE (Burgen and Rothermel 1984). Fuel type and load (based on maps, surveys, aerial photos, digital data). Fuel height on edge near development.
- Make sure wildfire or prescribed fire is well documented, such as the fire location and size (labelled and dated map with coordinates, fire name and number assigned by Dispatcher), fire perimeter, aspect, slope, landform, legal or local descriptor of location, path, point of origin, ignition source, weather conditions at the time, fire severity, return interval, including beyond boundaries of the property. Absolute cover (percent bare ground) after the burn using a step-point transect (see below). Track fire history on a subbasin or watershed basis, if possible.
- Map unburned islands. Map after-burn condition (severity) using the National Park Service Severity Rating system (Table 4-1).

*Table 4-1. Fire severity classes and definitions, adapted from National Park Service.*

| FIRE SEVERITY CLASS | Effects on Litter/Duff | Effects on Herbs/Grasses | Effects on Shrubs | Effects on Trees |
|---|---|---|---|---|
| 1<br>Completely Burned | Burned to ash | Burned to ash | Burned to ash, few resprouts | Burned to ash or killed by fire |
| 2<br>Heavily Burned | Burned to ash | Burned to ash | Burned to ash, some resprouts | Killed by fire or severely stressed |
| 3<br>Moderately Burned | Burned to ash | Burned to ash | Burned to singed, some resprouts | Crown damage only to smaller trees |
| 4<br>Lightly Burned | Blackened, but not evenly converted to ash | Burned to ash, some resprouting | Singed/stressed, many resprout/recover | No effect on mature trees, may kill seedlings/saplings |
| 5<br>Scorched | Blackened | Singed/stressed, many resprout/recover | Not affected, slight stress | No effect on trees |
| 6<br>Unburned | Unburned inclusions within a fire should be marked as 6 | | | |

- Presence/absence from a standardized Stressor Checklist developed for the site. For example, presence/absence of:
    - Stormwater runoff (fosters erosion, Argentine ant invasion)
    - Point-source erosion
    - Drought severity (Palmer Drought Severity Index or other) from NOAA, http://www.drought.noaa.gov/index.html)

- Invasives on Target Weeds list: *Ricinus comunis* (castor bean*), Salsola iberica* (Russian thistle), *Brassica geniculata* (perennial mustard), *Centaurea melitensis* (tocalote), *Eucalyptus, Xanthium strumarium* (cocklebur), *Tamarix* sp., *Carduus pycnocphalus* (Italian thistle), *Foeniculum vulgare* (fennel), *Nicotiana glauca* (tobacco weed), *Brassica nigra* (black mustard).
- Are Argentine ants present? If so, where in relation to factors that foster introduction of their increase?
- Recreational use outside of defined rules or conservation goals for the site.
- Fire regime outside of the resilience of desired plant communities or management focus species.

□ Implement a means to evaluate displacement of focus management wildlife species.

- Determine presence and use areas of target Multiple Species Conservation Program (MSCP) species: mountain lion, mule deer, orange-throated whiptail.
- Determine presence/ absence of presence/absence of other management focus species that are sensitive to fire regime such as canopy condition, too short interval, too long interval, or fires not hot enough for seed germination. For example: interior versus edge wildlife; understory versus tall canopy dominants; those with narrow canopy condition requirements; percent exotics on plant list; native species richness in each plant community. Continue to develop the plant species list by way of annual wandering transects. What is the native plant species richness based on species list and is it changing? Is there a diverse native understory in coastal sage scrub? What is the ratio of sprouters/seeders and is it changing? Is the ratio of natives to exotics on the species list changing?

□ Do a descriptive relevé of each plant community. This approach is used by CNPS as an intensive version of the Rapid Assessment protocol for plant communities, and for statewide vegetation mapping as a standardized procedure for describing plant communities using the Sawyer/Keeler-Wolf method. It is not intended to be repeatable, only descriptive (not statistical). This approach is selected to support that statewide program and also, if wetlands occur on the property, to support the California Rapid Assessment Method for wetlands. This plot will provide a baseline community description, including relative cover of dominants (using the 50:20 rule for determining dominance–see Appendix C).

□ Use the locations of the above relevés to also conduct bird point counts according to methods of the SDNHM Bird Atlas Program. Post-fire bird atlas surveys are seven times per year, four in the breeding season and three in winter. Try to relate presence/absence of birds to vegetation condition.through the use of the same size and style of relevé as recommended in the CNPS Relevé Protocol (see Appendix A).

□ Conduct step-points on open grassland-type communities to get an annual condition estimate for natives/exotics/weeds. Step-point method (Evans and Love 1957, Owensby 1973) uses a vertical pin placed at a mark or notch at the toe of the boot. It provides an objective way to determine species composition and total ground cover. These step-point "boot counts" could be conducted along an established transect walk-through each year to get comparative data over time. They could be established to get a representative view of the community or located to detect problem areas, such as along trails or ditches, the housing interface. The method records bare soil, rock, gravel, litter, and plant species encountered under certain points selected by pacing a site. The technique has been used to monitor the effects of grazing treatments, prescribed burns, fertilizer, and seeding projects, etc. The method allows large areas to be sampled quickly for analysis of management practices. The procedure involves selecting a random transect through a representative part of a range site. A transect often consists of 100 paces, resulting in 100 points sampled. The observer establishes a step-point by lowering a sampling pin to the ground, guided by a definite notch in the toe of the boot. At each step-point the observer places the boot at a 300 angle to the ground to avoid disturbing plants in the immediate area and lowers the pin perpendicularly to the sole of the boot until it either hits a herbaceous plant or the ground. The first plant hit by the point of the pin near the ground is recorded. If no plant is hit, the pin is pushed to the ground and a hit on bare soil, rock, gravel, or litter is recorded. in addition, if no plant is hit, the nearest plant to the pin is recorded. Nearest plants are determined in a forward direction (1800 arc) going from left to right. For relative species composition the number of hits plus the number of nearest plant occurrence for a particular species or species group are divided by the total number of points sampled. (http://californiarangeland.ucdavis.edu/Factsheets_pdf/Monitoring %20Series% 20Aug%2003/ MS6% 20binder.pdf)

- Conduct a regular wandering transect for reptiles. Relate results to topographic complexity or abiotic patch richness such as rock outcrops. Is physical diversity contributing to species diversity? Do species abundance or location change with vegetation recovery?
- Are butterflies present in diversity and abundance in each habitat and does this change with habitat condition, with weather, or with the presence of understory host plants? Establish a Pollard walk-style (Pollard 1977, Royer et al. 1998) transect for monitoring butterfly populations each year. For example, from a specific window of time when butterflies are expected to be active, such as 11:00 to 13:00, walk within established transects (400m long and 5m wide). Surveyors walk back and forth along the transect and generate species lists and numbers for each species. Each transect contains vegetative habitat that is essentially homogenous. Butterflies are collected using a net and brought to the lab for identification. Butterflies that evade capture were recorded and identified as closely as possible in the field by sight. Temperature, wind, cloud cover, and plant species in flower were recorded. Each transect is sampled twice. Relate results to habitat condition and weather.
- Changes in landscape (matrix-level) boundaries. Focus on ecotones because some changes will be evident there first. Are community, ecotone, or invasive species infestation borders changing?
- What percent of habitat patches are buffered from land use activities that may degrade it? Percent of assessment area with buffer; average buffer width, and buffer condition. Are patches fragmented? (See CRAM Manual for details.)
- Prescribed fire planning should consider concerns and values to be protected for prescribed fires: identify concerns, constraints, threat models to values at risk including infrastructure/improvements, endangered and sen-

sitive species habitat, species of concern, non-native plant and animal distributions, areas of high erosion potential, watersheds, and riparian areas; public perception, cooperator relations, potential impacts on staff, visitors, and neighbors; cultural resources; monitoring research locations; viewsheds; smoke management concerns including non-attainment zones, smoke-sensitive sites, and recommended road visibility standards.

- For a prescribed fire, monitor wetlands pre- and post-burn treatment for details and timing of water manipulation, such as the duration of drying out/draw-down and of winter flooding in days.

## 4.3 Level II Vegetation and Short-term Fire Recovery, Fire Observation Monitoring

*Level II: Monitoring of vegetation and short-term fire recovery using stratified random approach, primarily for trend rather than statistical description of attributes and variables. Not as statistically robust as higher levels. Try to identify a reference site with little to no fire history or one with lots of fire history. Still mostly habitat-based, using cover and frequency as primary metrics.*

### 4.3.1 Monitoring Variables Portfolio

Cover and frequency are the primary metrics used in Level II monitoring.

**Cover.** Point intercept is the best method for determining cover of the more dominant species. It is better than line intercept for herbaceous species; however, it is more difficult in tall vegetation types.

**Frequency** is the percentage of all sampling units for which the canopy of a species is present. best measured by nested plots because is very sensitive to plant size, dispersal patterns and density. Frequency *is very sensitive to invasions by undesirable species, and very sensitive to relative change over time for key species.*

### 4.3.2 Plot/Transect Layout and Installation

A single plot should be located in each monitoring type, meaning each major landscape unit based on the stratification scheme described above. At Blossom Valley, this would be either by plant community alone or by plant community plus fire interval. The primary data collection method is point intercept. Grass and shrub plots use a 30-meter (m) plot, whereas woodland plots are 50 m in length.

The following descriptions of plot layouts recommended for Blossom Valley come directly from the USDI FIREMON Monitoring Handbook (2003).

Plot layout and installation methods vary with plot type; here, each method is presented separately. Two monitors are recommended for grassland, and three for brush plot installation. A minimum of two monitors are needed for woodland plot installation, but a third and even fourth monitor will make it go more than twice as fast where vegetation is dense.

After generating a plot origin point and having marked this point by installing an origin stake, from this origin stake, select a random azimuth. Lay out a 30 m+ tape from the origin stake along this azimuth. Suspend the transect line, defined by the tape, above the vegetation (brush plots may require special techniques—see tips below). This may require construction of two tripod scaffolds—one for each end of the tape. The entire 30 m line and 5 m on either side of it must lie within the identified monitoring type.

#### 4.3.2.1 Marking the Plot

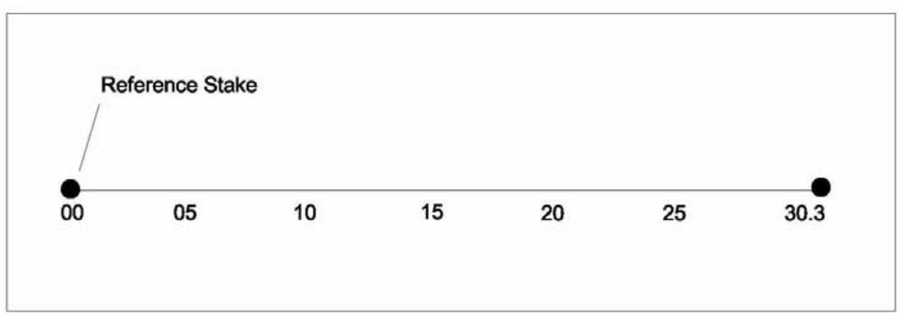
Mark the transect dimensions by installing two 0.5 in diameter rebar (rebar is recommended throughout the text, but other materials may be used) stakes at 0 and 30.3 m. Installing a stake at 30.3 m (30P) minimizes stake interference in the point intercept transect at the 30 m data point. Stake height above the ground should allow easy relocation of the stakes. Stakes should be installed deep enough to provide adequate basal stability relative to the height necessary to bring the stake into view. Suggested stake lengths are 0.5 to 1 m for grassland transects, and 2 m or more for brush transects. It is generally best to overestimate the stake heights needed, to compensate for snow creep and vegetation growth. Burial of the origin stake (0 point) is recommended, especially in areas subject to vandalism or disturbance.

A metal detector (or magnetic locator) can be used later to relocate the plot if all of the above-ground stakes are lost. In high-use areas it may be necessary to partially camouflage stakes, or to mark beginning and end points with buried metal markers that can be relocated with a metal detector (or a magnetic locator). Electronic Marker Systems, or "cyberstakes," may be useful under these circumstances.

Color code plot beginning and ending stakes (orange for 0P, blue for the 30P) with heat-resistant paints, such as automotive engine paint. Place a piece of cardboard behind the stake while painting it to protect the surrounding vegetation. Repaint the stakes after each burn. Install permanent plot identification tags on each stake.

#### 4.3.2.2 Grassland Plots

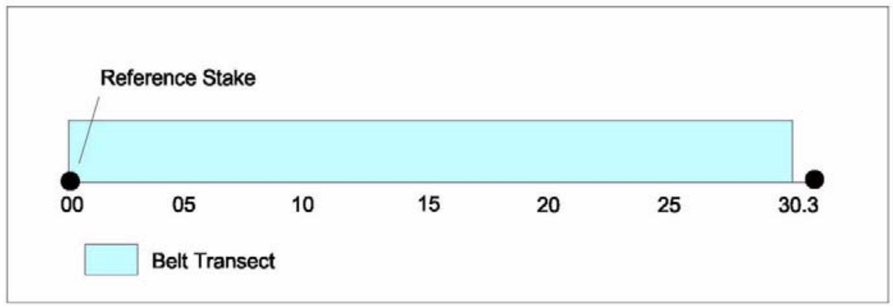
This is the suggested default layout for a grass transect. Measure the herbaceous layer on the first 30 meters of the transect using the point-intercept method. Gather burn severity data either every 5 meters or every 3 decimeters (NPS Fire Monitoring Program, see Section 4.2, above).




#### 4.3.2.3 Shrubland Plots

This is the suggested default layout for a shrub plot. This plot includes the herbaceous layer and the burn severity data collected in the grassland transect, and adds the measurement of brush density in the belt shown (30 meters long by a variable width), which we place either on the upslope side (to avoid trampling), or the right side of the transect (when facing 30 m) in flat terrain (to avoid bias); the width of the brush belt is usually modified following a period of pilot sampling. This modification is based upon the average density of shrub spp. Use three age classes for shrub species: Seedling (a shrub that is too immature to flower), Mature (a shrub that is able to produce flowers and seeds that year), and Resprout (a shrub that has resprouted after being top-killed by fire or some other disturbance). (NPS Fire Monitoring Program)

Place a stake at each point (marked with a black circle (•) in the Figure). Note that the endpoint is installed 0.3 m past the endpoint of the transect to minimize interference.




Shrubland types can be very difficult (and sometimes painful) to navigate in, make straight lines through and photograph. Here are some tips to aid intrepid shrubland monitors.

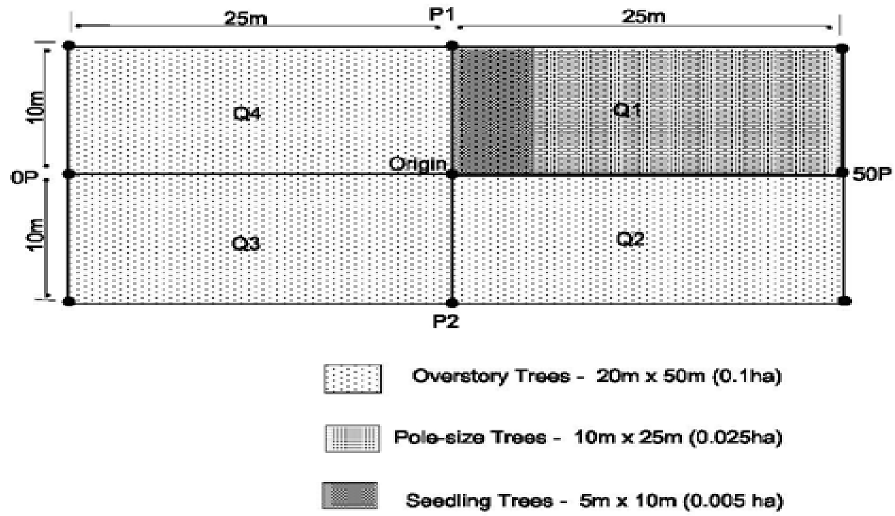
- The best way to string a straight tape in a shrubland depends on the height, density and pliability of the species concerned. If the average height of the shrubs is <1.5 m, pound the rebar to within a decimeter or two of the average height (use rebar long enough for you to bury a third to half of the stake), and string the tape over the top of the vegetation. If the shrubs are >1.5 m and have a relatively open understory, run the tape along the ground. However, if these tall shrubs are fairly continuous, you may be better off trying to string the tape right through the stems. No matter how you string the tape, record where you string it, so future monitors can replicate your work.
- Three may be the best number of monitors for installing brush plots, with two people setting up the transect and the third mapping and photographing. When re-reading the plot, two people can collect transect data and the third can collect density data and photograph the plot.
- When on slopes, approach the plot from above. You will find it easier to move, toss equipment, and sight from above than below. Examine where your plot might go, and plan out your sampling strategy to minimize movement from one end of the plot to the other.
- Play leapfrog to navigate to the plot, or when stringing the tape along the azimuth. The first person sights along the azimuth while the second person moves through the brush to the farthest point at which she or he can still see the first person. **Note:** Rather than trampling directly down the actual transect line, take a circuitous route. Two monitors will sight on each other trading the compass and the tape. Then the first person works his or her way around past the second person to the next point where a line of sight can still be maintained. They sight on each other once again and toss the tape, and continue until the destination is reached.

- Use a tall, collapsible, brightly painted sampling rod and include it in your photos. This will make the opposite stake (0 or 30P) more visible in the photos, and will let your fellow monitors know where you are.
- Wear a brightly colored shirt, hat or vest. Flag the sampling rod. Flag your glasses. Flag your hat. Do whatever you have to do to be seen.
- In addition to using a GPS unit to record the plot location, make the plot easier to find by installing reference stakes or tagging reference trees, and locating at least three other highly visible reference features. Take bearings to three of these features, so that returning monitors can locate the plot by triangulation.
- You may find it useful to set up a photo point from an adjacent ridge to get a community-wide view of change over time.

#### 4.3.2.4 Woodland Plots

Successful recruitment of trees is a surrogate for key attributes in a riparian or oak woodland. The principal objective of woodland monitoring is to determine whether the age class, structural diversity, composition, and cover of individual stands within the desired range of natural variability for the vegetative community. The range of naturally viable, fully functional woodland ecosystems does not express itself in any single simple form. They express themselves through their reproduction processes; clones generating suckers off lateral roots; responses to natural environmental events; shade intolerance; growth hormonal balance mechanism; and disturbance dependency (Schier et al. 1985); and also the historic and current land management factors that have affected their natural viability (Bartos 2001). In order to see how historic and current factors may have affected the current viability of individual stands, a woodland protocol focuses on three key indicators of stand condition: overall stand structure, unique stand management issues, and a ranking of factors that might be putting stands at risk.

For woodland plots, the origin point, marked by a stake, serves as your plot center (see following Figure ). Use this origin to lay out a rectangular plot. Select a random azimuth and measure a 50 m line along this azimuth, using the origin point as its center. The centerline is defined by a tape measure laid as straight as possible. To lay out this 50 m tape, stand at the plot origin and run the 0 end of the tape toward the 0P point (along the back azimuth) and the 50 m end of the tape to the 50P. Record the plot azimuth on the woodland plot data sheet (example is FMH-7).




**Establish the Plot Boundaries.** Laying out the tape to define the plot boundaries requires at least two monitors—one for each end. The monitors must take time to lay out the plot as a true rectangle. These plots are large and one monitor could lose sight of the other, making it difficult to "square" the plot corners (90° angles). A few helpful hints to accomplish this task are provided here.

- Lay out the plot centerline as straight as possible. Next, lay out three 20 m (or 30 m) tapes perpendicular to the centerline, also as straight as possible, and such that the tapes intersect at right angles. Start with either line P1–P2 or Q4–Q3. To accomplish this use the principle of the 3, 4, 5 triangle. For every right angle, measure 3 m along the 20 m tape where it intersects the centerline; mark the measurement. Measure 4 m along the centerline; mark the measurement. The hypotenuse of the resulting triangle should be 5 m (as illustrated in the Figure). If the hypotenuse is not 5 m, adjust the 20 m tape so that it is. In sparsely vegetated forest types you may be able to triangulate using larger triangles. For example, in the Figure the hypotenuse of the triangle from the centerline 0P to point P1 is 26.92 m. Lay out the endline and midline tapes, making sure that the "0" end of each tape starts at the same end of the plot. If the plot encompasses variable slopes, such as a ravine (and this does not cause you to reject it), lay out the tapes so that you are measuring slope distance rather than horizontal distance—FMH.EXE software will correct for this. In such a case, it will be impossible to perfectly square the plot, but this allows for the most true representation of the area on the ground.
- Squaring a plot can be tedious and time-consuming. Keep in mind that the variables affected by this process are density of overstory, pole-size and possibly seedling trees. The degree to which the plot should be perfectly square depends on the density of trees, particularly if there are any trees right on the boundary in question. If trees are dense and there are one or more trees on the boundary, it is important to get the corners as square as possible. A good guideline is that the 3, 4, 5 triangle be no more than 1 dm off on each side. If trees are sparse and there are no trees on the boundary, squareness is less crit-

ical and an error of 30 dm may be acceptable. **Accuracy Standards:** ± 0.5 m for the length, and ± 0.2 m for the width, of a woodland plot.

**Orient the Plot Quarters.** Once your plot is squared, divide the plot into quarters and assign numbers according to the following protocol. If you stand at the plot origin, with both feet on the centerline and the 0 point (0P) on your left, Quarter 1 (Q1) is to your forward-right. Quarters 2, 3, and 4 are numbered clockwise from Q1 as shown in the Figure.

**Mark the Plot.** Define the plot, quarters, and fuel inventory lines as shown in the Figure with rebar stakes (rebar is recommended, but other materials may be used). Bury a 0.5 in diameter rebar stake (the origin stake) at the plot center or origin. Install rebar stakes at each of the four corners of the 20 m × 50 m plot (Q1, Q2, Q3, and Q4). Place a stake at either end of the center line (points 0P and 50P), and a stake at either end of the short axis midline (points P1 and P2). Stake height above the ground should be sufficient to allow easy relocation of the stakes. Install the stakes deep enough to provide adequate basal stability relative to the height necessary to bring the stake into view. Suggested stake lengths are: 0.5 m–1 m for woodland plots, or taller if undergrowth is tall and thick. It is generally best to overestimate the stake heights needed, to compensate for snow creep and vegetation growth. Burial of the plot reference or origin (center) stake is recommended, especially in areas subject to vandalism or disturbance. The other key stakes (Q1, Q2, Q3, Q4, 0P, and 50P) may also be considered for burial, but only as a last choice, as buried stakes can be difficult to install, locate, and remove. Buried stakes can be relocated with a metal detector (or a magnetic locator). Color-code the plot beginning and ending stakes (orange for 0P, blue for the 50P) using heat-resistant paints, such as automotive engine paint. Repaint the stakes after each burn. The FIREMON handbook calls for the placement of seventeen 0.5 in diameter rebar stakes for each woodland plot. These markers are important for the relocation of plots and transects. In some situations, however, these rebar stakes may be hazardous, destructive to cultural resources, or visually or philosophically intrusive. Plastic caps placed on the top of the stakes may prevent injuries and can increase stake visibility (and in some places are required by law). At an absolute minimum, the origin stake and the four corner stakes (Q1, Q2, Q3, and Q4) must be installed. These stakes can be camouflaged by paint or by total or partial burial. You may also consider using “cyberstakes.” Any innovations or deviations from the above should be well documented. Plots are distinguishable from one another through identification codes etched onto metal tags which attach to the rebar stakes.

## 4.4 Level III Population Monitoring of Covered and Focal Species

*Level III: Monitoring of short-term change in populations, recruitment, or habitat conditions for covered or management focus species, with effort to get at abundance trends to a defined statistical certainty. Abundance- and trend-focused rather than presence/absence. Adds density as a metric in plant communities to get better information on rare plants and recruitment/mortality. Adds a metric for monitoring landscape mosaics.*

At Level III this monitoring framework adds plots to improve the statistical power of the established plots in the stratified random approach. It also moves from habitat-based to population monitoring of species that are targeted for management, using appropriately specialized detection techniques for each species.

For example, whereas at Level I we could answer the question of whether the ratio of natives to exotics on the species list is changing, at Level III we can answer whether the *abundance* of natives to exotics is changing to a specified level of certainty? For rare plants, since they are usually non-randomly located, randomly-placed plots would not likely provide sufficient information to detect their trend. Counts or density approaches are used where the rare plants are found to document abundance, recruitment, and mortality.

Finally, Level III adds an approach for monitoring spatial mosaics, also derived for FIREMON that was specially adapted for use at National Wildlife Refuges.

### 4.4.1 Selecting a Desired Statistical Power and Minimum Detectable Change

This approach adds plots to improve statistical power. To do this, the manager will need to calculate sample size needed to detect a change to a chosen level of significance. The manager decides, usually based on budget and the precision necessary to decide on a management adjustment, what level of certainty is acceptable.

The following example is derived from the FIREMON Handbook. For example, the manager wants to determine whether a change in the population of interest has taken place between two time periods (for example, between preburn and year-1 postburn). These will be used to calculate sample size. For change-related management objectives, the monitoring objective will specify:

- the minimum detectable change (MDC) desired
- a chosen level of power
- a chosen significance level (alpha)

****Use the FIREMON Handbook to suggest a Minimum Detectable Change goal for various species, the power, significance level, decisions about variability and certainty.****

**Minimum Detectable Change.** This is the size or amount of change that you want to be able to detect between two time periods. How much of a change is biologically meaningful for the population of interest? Is a 10% change meaningful? 30%? 50%? 80%? The management objectives should provide the specific quantifiable levels of change desired. Looking at these objectives, use the low endolfa range of values for your MDC. For example, if your management objective states that you want to see a 50-80% change, use 50% as the MDC.

The initial level of MDC, set during the design phase, can be modified once monitoring or new research provides new information about the size and rate of flux of the population. For example, the manager may discover that the 10% decrease in the mean percent cover of the “nonnative” species you choose was not biologically significant. This information might have come from recent research that found the percent cover of this species can fluctuate by more than 30% a year based on weather conditions alone.

The precision selected should be related to the need to have very close estimates of the true population mean. General guidelines for choosing the desired precision are as follows:

- Choose 25% of precision for most objective variables when the exact values are not critical; if small changes are not of a concern, then being within 25% of the true mean is probably sufficient.

- Choose 5-20% precision if the estimated mean must be within a small percentage of the true population mean (e.g. if a population's survival depends on only slight changes).

Managers must decide on the precision of the estimate. The precision of a sample statistic is the closeness with which it estimates the true population value (Zar 1996). Do not confuse it with the precision of a measurement, which is the closeness of repeated measurements to each other (the maximum acceptable confidence interval).

Managers might choose a wider confidence interval for areas unoccupied by endangered species than areas that are occupied with the constituent elements of their habitat.

Characterize each existing plant community baseline such that trend in ___ can be detected with 75% certainty alpha = 0.20 in ____ time frame? This means we want to be 75% certain of detecting a 25% increase in population status. We are also willing to accept a 25% chance of saying a 25% change took place when it did not. Here, power = 75%; MDC = +25%; and alpha = 25% (0.20).

**Confidence Interval.** This means the precision of the mean (standard error) with a stated level of confidence. While standard error is an estimate of the precision of the sample mean, confidence intervals provide added information about variability by using the standard error along with a stated level of confidence. The confidence interval is a range of values for a variable which has a stated probability of including the true population mean. To calculate the confidence interval, you need the following inputs:

- mean of the sample
- standard error
- desired confidence level (80*, 90% or 95%)
- critical value of the test statistic student's t (two-tailed), based on the selected confidence level and the degrees of freedom (number of plots -1)

**Pilot sampling**. Install ten plots using the restricted sampling method on page..... Analyze data. If density of key species is high, make the plot smaller. If density is low for objective variables, make the plot bigger *(just use a variable area for density because the appropriate size plot will vary with species)*. Calculate coefficient of variation for each variable (not just your objective variable[s]).

Restricted random sampling is a variant of stratified random sampling that helps ensure that your plots are distributed throughout your monitoring type. Use an n=10 for number of plots if area is small and when variability of your objective is low. Divide monitoring type into n portions. You will then choose at least 3-5, depending on the likelihood of initial plot rejection, plot location points per portion. Then establish a monitoring plot within each of these portions (i.e. generate a set of possible locations that will eventually be reduced to one.) Verify plot suitability.

**Caution–Pseudoreplication.** Pseudoreplication is the use of inferential statistics to test for treatment effects with data where treatments are not replicated (though observations may be) or replicates are not statistically independent (Hurlbert 1984). Pseudoreplication occurs, for example, when all of the plots for a particular monitoring type are located in one burn unit, and inferences about the burn program in general (i.e. a treatment effect), rather than the effects of one particular fire, were made from the data. See Irwin and Stevens (1996) for a good overview of this concept.

**Caution–Autocorrelation.** All monitoring programs need to address autocorrelation during the sampling design period. Data that are auto correlated are not independent over space or time and therefore are more difficult to analyze. For example, spatial autocorrelation can occur if plots are placed too close together such that the plots tend to record similar information. In this situation, the data may have an artificially low amount of variation. The fire monitoring program addresses spatial autocorrelation by using a restricted random sampling design to minimize the chance that plots would be placed in close proximity to one another.

Temporal autocorrelation occurs when the same plots are repeatedly measured over time, such as when permanent plots are used. The data from one year to the next are not completely independent of the data in preceding years.

**Interpreting long-term change results when results are not statistically significant (see Elzinga et al. 1998).** If a change does not meet significance criteria and you want to determine if an important change really has taken place, conduct a power analysis by either 1) solving for MDC using n, s, power, and confidence level; or 2) solve for power using n, s, MDC and confidence level. If MDC is acceptable or power is high, don't worry! the change probably did not take place. If MDC is unacceptable or the Power is low, then this should be a warning! An important change may have taken place.

### 4.4.2 Recommended Monitoring Variables for Levels III and IV

Level III includes Cover and Frequency as in Level II. It also adds **density** as a metric in shrublands and for rare plants in grasslands. Density is good for monitoring sensitive species because it samples the number of individuals per unit area, which is necessary to know about recruitment or mortality.

### 4.4.3 Qualitative Monitoring of Mosaics

These methods are derived from the FIREMON Handbook as adapted for National Wildlife Refuges.

Creating and managing for habitat variation is an important goal on some conservation area. Accordingly, prescribed fire is often used as a management tool to create vegetation or habitat "mosaics." Or, sometimes mosaics are already in existence due to fire history. For example, a a general objective could be to create enough mosaic of burned to unburned patches that early- and late-seral sagebrush dependent wildlife species remain in a treatment area, and a more specific fire objective would be to use mosaic burning to reduce sagebrush stand density by 50%.

A fire-created mosaic can be characterized generally as the spatial variation in burned and unburned vegetation in a treatment area, or the proportion of the treatment area that is burned or unburned. The degree to which a mosaic is created by prescribed burning, and whether an objective to achieve a mosaic is achieved, generally depends on a combination of several variables such as the proportion of vegetation burned, the number and distribution of patches or stands following the burn, patch shape and size, and the amount of habitat edge and contrast created by the burn. For example, a treatment area that is 50% burned with several burned/unburned patches that are well-distributed would be considered a highly variable mosaic. Also, an area that is 50% burned overall, with very few patches but a big amount of edge contrast could also be considered a highly variable mosaic.

Several methods are available for evaluating existing or post-burn spatial variation. Quantitative approached to measuring mosaics include using landscape metrics such as post-burn patch density, average patch size, variation in patch size, and perimeter-to-area ratios, or a multivariate combination of several variables. However, success criteria for most mosaic objectives may not be quantitative or based on thresholds in these types of metrics. As a minimum standard, we recommend implementing the following qualitative approach, which is efficient to implement and should provide enough information to characterize most post-burn mosaics. If mosaic objectives specify quantitative targets not adequately addressed by this approach, additional measurements will be required.

**Methods.** Conduct a post-burn walkthrough by walking through the treatment area. On a standardized data form, visually estimate and record the amount (%) of the treatment area that was burned. This will provide general information about the potential for post-burn vegetation. For example, 0% or 100% burned indicates no variation or mosaic within the treatment area. Values other than 0% or 100% indicate variation. On the data form, sketch the distribution of burned and unburned vegetation. This will provide spatial information about post-burn variation, as well as the type and amount of mosaic created. At a minimum, attempt to show the following: number and relative size of burned and unburned patches, patch shapes, and treatment area boundaries.

Take one or more representative photographs from suitable vantage points. Repeat the above methods at each plot location: visually estimate and record the amount (%) of the treatment area that was burned within the 100-meter distance from the plot. Also record the number of burned/unburned interfaces that bisect this sample area–this will provide a simple index of interspersion and patch scale.

## 4.5 Level IV Monitoring Long-term Change, Other Environmental Attributes and Species Groups, Spatial Studies, Objective-based Monitoring

*Level IV:* Monitoring long-term change after prescribed fire or wildfire. Adds *repeated* measures to those at lower levels. Adds a definition of minimum detectable change. Adds other environmental attributes and species groups, spatial studies, and objective-based monitoring for prescribed burns–did we achieve prescribed burn objectives?

# 5.0 Adaptive Management: Refining the Models, Updating the Protocols

Intended to be a starting point for adaptive decision-making, this Fire Monitoring Plan will require revision to remain current and relevant. Updating would be appropriate, for example, when new scientific findings, with new management policies, or when results of monitoring reveal new insights and indicate a change in strategy. If conceptual models are updated, so might how we design the sampling strategy. Management success criteria will be adjusted based on past accomplishments, new risks and hazards, new biological information, and changes in policy. So might the sampling strategy.

Adaptive management is not trial and error. It is a committed process of evaluating objectives and actions, in part to ensure that too much money is not spent.

Any sampling program needs an adaptive management element. In order to do that, the program has to track how management decisions are made, and how feedback loops to management function. Priority resources need to be defined, as well as who the stakeholders are for the HCA, what is understood about how fire interacts with this landscape and what assumptions we are working with (the conceptual or threat models), and how monitoring is connected to the Preserve Management Plan.

The key to adaptive management is explicit objectives. The idea behind objectives is for different people with different backgrounds to be able to all agree upon and understand the intent of the management actions. What are we trying to achieve programmatically? Without true objectives, the public is denied the ability to understand what we are trying to do. Further, management's intentions are muddied for those that follow as personnel change.

The Pressure-State-Response model of adaptive management (Holling 1978, Bormann et al. 1994) states that human operations such as agriculture, urbanization, recreation, and the commercial harvest of natural resources can be sources of stress or pressure affecting the overall function of a system. When managers understand these effects, they can adjust to mediate the threat. The Conceptual Models described in Section 3.0 describe what is understood about the relationship between community stress, functional state, and management actions.

This flexibility of this Plan's framework (goal, conceptual model, then process or action) in terms of spatial scale and system hierarchy makes it a useful structure for organizing the long list of potential indicators and metrics proposed by previous efforts to develop a performance monitoring system. Most, if not all, of the disagreements about the proper indicators to select can be resolved by explicitly assigning them to the goal, model, or mechanism level of measurement at different spatial scales. In addition, the framework proposed here, when used as an evaluation template, can help prioritize efforts to improve measurement technologies, enhance coordination among the parties collecting measurements, or conduct model validation.

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# 7.0 Appendices

A. CNPS Rapid Assessment or Relevé Methods

B. Fire History Map

C. Protocol for 50:20 Rule

D. Plant List with life form/preliminary grouping as to fire response

E. Equipment Checklist

F. Field Survey Forms

# Appendix A: California Native Plant Society Rapid Assessment or Relevé Methods

CALIFORNIA NATIVE PLANT SOCIETY –
VEGETATION RAPID ASSESSMENT PROTOCOL
CNPS VEGETATION COMMITTEE
(November 5, 2001, Revised September 20, 2004)

## Introduction

The rapid assessment protocol is a reconnaissance-level method of vegetation and habitat sampling. It may be used to quickly assess and map the extent of all vegetation types in relatively large, ecologically defined regions. The California Native Plant Society (CNPS) has adopted this method to verify locations of known vegetation types, to gain information about new types, and to acquire general information about their composition, habitat, and site quality. Other agencies, such as California State Parks, the Department of Fish and Game, and the U.S. Forest Service, are also adopting this method for documenting vegetation patterns.

By using this method, biologists and resource managers can gain a broad ecological perspective, as the full range in ecological variation across broad landscapes can be reflected in the vegetation assessments. For example, changes in environmental elements (such as geology, aspect, topographic position) or physical processes (fire, flooding, erosion, and other natural or human-made disturbances) can influence the distribution of plants or patterning of vegetation, which are documented in the rapid assessments. In turn, these vegetation patterns can influence the distribution of animals across the landscape.

The quantitative vegetation data recorded in the rapid assessments can be described with standard classification techniques and descriptions, and they can be depicted in maps across any landscape. Additional information recorded in the assessments, such as disturbance history and anthropogenic impacts, can serve to define habitat quality and integrity for plant and animal distributions. Because this method provides an important means for representing the full array of biological diversity as well as habitat integrity in an area, it can also be an effective and efficient tool for conducting natural resource planning.

## Purpose

The Vegetation Program has adopted the rapid assessment method to update the location, distribution, species composition, and disturbance information of vegetation types as identified in the first edition of *A Manual of California Vegetation* (MCV), a CNPS publication. The release of the MCV heralded a new statewide perspective on vegetation classification. The premise of the book – all vegetation can be quantified based on cover, constancy, and composition of plant species, yielding uniform defensible definitions of vegetation units – has proven to be very useful throughout California and the rest of the nation. The MCV has become the standard reference on California vegetation and has been adopted by many agencies such as California Department of Fish and Game, the National Park Service, California State Parks, and the U.S. Forest Service as the standard approach to classify vegetation statewide.

One of the most important purposes of rapid assessments is to verify the locations of each vegetation type because much about the geography of vegetation remains uncertain in this state.

To obtain a more accurate understanding of the location and distribution of the vegetation types, nothing short of systematic inventory will suffice. Using the rapid assessment method, CNPS Chapters and other organizations can work together in selected ecological regions to gather vegetation data over a short time period in a broad area. This geographic inventory of vegetation types can greatly advance the current distribution understanding of vegetation.

In addition, California is working with a new vegetation classification, and its parameters are largely untested. The rapid assessment method will be used to gather additional information on species composition, distribution, disturbance effects, and environmental influences of vegetation. Thus, this method will provide modifications to the existing vegetation classifications and information on new types.

This protocol can also be used in tandem with other resource assessment protocols such as wildlife assessments or aquatic/stream assessments. For example, the California Wildlife Habitat Relationships (CWHR) protocols have been used in conjunction with the vegetation assessment protocol to obtain detailed records on habitat quality and suitability for vertebrate animals in terrestrial habitats. The CWHR protocols can also help test the relationships between the vegetation type and habitat of various animals and thereby refine the understanding and predictability of the distribution of animals. A portion of the CWHR protocols is incorporated into the rapid assessment method to obtain suitability information for vertebrate species.

While people can quickly obtain information on the variety of vegetation types using this method, some of the vegetation types recorded in the rapid assessment process may be poorly defined in the current classification system. These poorly understood or unknown types will be identified and located and then will be prioritized for more detailed assessment using the CNPS relevé protocol. Thus, the rapid assessment method will be used in conjunction with the relevé method to provide large quantities of valuable data on the distribution and the definition of vegetation. These data will be entered into existing databases for summarizing and archiving, and they will be used to modify and improve statewide vegetation classification and conservation information.

<u>Why do we need to know about the composition and distribution of vegetation?</u>

- to have a more accurate understanding of the commonness and rarity of different forms of vegetation throughout the state
- to link the distribution of various rare and threatened plant species with the vegetation units
- to provide a clearer picture of relationships between vegetation types
- to help prioritize community-based land conservation goals based on the local representation of unique types, high diversity areas, etc.
- to do the same for regional vegetation throughout the state and the nation.
- to broaden the vegetation knowledge base for California
- to motivate people to do more to help identify, protect, and conserve vegetation in their area
- to link vegetation types with habitat for animals

**<u>Selecting stands to sample:</u>**

To start the rapid assessment method, stands of vegetation needs to be defined.
A stand is the basic physical unit of vegetation in a landscape. It has no set size. Some vegetation stands are very small, such as alpine meadow or tundra types, and some may be several square kilometers in size, such as desert or forest types. A stand is defined by two main unifying characteristics:

1) It has <u>compositional</u> integrity. Throughout the site, the combination of species is similar. The stand is differentiated from adjacent stands by a discernable boundary that may be abrupt or indistinct.
2) It has <u>structural</u> integrity. It has a similar history or environmental setting that affords relatively similar horizontal and vertical spacing of plant species. For example, a hillside forest originally dominated by the same species that burned on the upper part of the slopes, but not the lower, would be divided into two stands. Likewise, a sparse woodland occupying a slope with very shallow rocky soils would be considered a different stand from an adjacent slope with deeper, moister soil and a denser woodland or forest of the same species.

The structural and compositional features of a stand are often combined into a term called <u>homogeneity</u>. For an area of vegetated ground to meet the requirements of a stand, it must be homogeneous.

Stands to be sampled may be selected by evaluation prior to a site visit (*e.g.* delineated from aerial photos or satellite images), or they may be selected on site (during reconnaissance to determine extent and boundaries, location of other similar stands, etc.).

Depending on the project goals, you may want to select just one or a few representative stands of each homogeneous vegetation type for sampling (*e.g.* for developing a classification for a vegetation mapping project), or you may want to sample all of them (*e.g.* to define a rare vegetation type and/or compare site quality between the few remaining stands).

## Definitions of fields in the protocol

### LOCATIONAL/ENVIRONMENTAL DESCRIPTION

**Polygon/Stand #:** Number assigned either in the field or in the office prior to sampling. It is usually denoted with an abbreviation of the sampling location and then a sequential number of that locale (*e.g.* CRRA-001 for Coyote Ridge rapid assessment number 1).

**Air photo #:** The number given to the aerial photo in a vegetation-mapping project, for which photo interpreters have already done photo interpretation and delineations of polygons. If the sample site has not been photo-interpreted, leave blank.

**Date:** Date of the sampling.

**Name(s) of surveyors:** The full names of each person assisting should be provided for the first rapid assessment. In successive assessments, initials of each person assisting can be recorded. Please note: The person recording the data on the form should circle their name/initials.

**GPS waypoint #:** The waypoint number assigned by a Global Positioning System (GPS) unit when marking and storing a waypoint for the stand location. These waypoints can be downloaded from the GPS into a computer Geographic Information System to depict sample points accurately on a map.

**GPS name:** The name personally assigned to each GPS unit (especially useful if more than one GPS unit is used to mark waypoints for the project).

**GPS datum: (NAD 27)** The map datum that is chosen for GPS unit to document location coordinates. The default datum for CNPS projects is NAD 27. However, other agencies and organizations may prefer another datum. Please circle NAD27 or write in the appropriate datum.

**Is GPS within stand? Yes / No** Circle"Yes" to denote that the GPS waypoint was taken directly within or at the edge of the stand being assessed, or circle "No" to denoted the waypoint was taken at a distance from the stand (such as with a binocular view of the stand).

**If No cite distance (note ft/m), bearing and view from point to stand:** An estimate of the number of feet or meters (please circle appropriate), the compass bearing from the waypoint of GPS to the stand, and the method of view used to verify the plot (*e.g*. binoculars, aerial photo).

**Error: ±** The accuracy of the GPS location, when taking the UTM field reading. Please denote feet (ft) or meters (m). It is typical for all commercial GPS units to be accurate to within 5 m (or 16 ft.) of the actual location, because the military's intentional imprecision (known as "selective availability") has been "turned off" as of July 2000. Please become familiar with your GPS unit's method of determining error. Some of the lower cost models do not have this ability. If using one of those, insert N/A in this field.

**UTM field reading:** Easting (UTME) and northing (UTMN) location coordinates using the Universal Transverse Mercator (UTM) grid. Record using a GPS unit or USGS topographic map.

**UTM zone:** Universal Transverse Mercator zone. Zone 10S for California west of the 120$^{th}$ longitude; zone 11S for California east of 120$^{th}$ longitude.

**Elevation:** Recorded from the GPS unit or USGS topographic map. Please denote feet (ft) or meters (m), and note if reading is from GPS unit or map. (Please note: Readings taken from a GPS unit can be hundreds of feet off.)

**Photograph #'s:** Note the roll number, frame number, direction, and the name of the person whose camera is being used. Take at least two photographs from different directions, and describe the location and view direction from compass bearings for each frame. Additional photographs of the stand may also be helpful. (Also, if using a digital camera or scanning the image into a computer, positions relative to the polygon/stand number can be recorded digitally.)

**Topography:** Check two of the provided features, characterizing both the local relief and the broad topographic position of the area. First assess the minor topographic features or the lay of the area (*e.g.* surface is flat, concave, etc.). Then assess the broad topographic feature or general position of the area (*e.g.* stand is at the bottom, lower (1/3 of slope), middle (1/3 of slope), upper (1/3 of slope), or top).

**Geology:** Geological parent material of site. If exact type is unknown, use a more general category (*e.g.* igneous, metamorphic, sedimentary). *See code list for types.*

**Soil:** Record soil texture or series that is characteristic of the site (*e.g.* sand, silt, clay, coarse loamy sand, sandy clay loam, saline, et.). *See soil texture key and code list for types.*

**Rock: %Large** (optional): Estimate the percent surface cover of large rocks (e.g. stones, boulders, bedrock) that are beyond 25 cm in size.

**Rock:%Small** (optional): Estimate the percent surface cover of small rocks (e.g. gravel, cobbles) that are greater than 2 mm and less than 25 cm in size.

**%Bare/Fines** (optional): Estimate the percent surface cover of bare ground and fine sediment (e.g. dirt) that is 2 mm or less in size.

**%Litter** (optional): Estimate the percent surface cover of litter, duff, or wood on the ground.

**%BA Stems** (optional): Estimate the percent surface cover of the plant basal area, i.e., the basal area of stems at the ground surface.

**General slope exposure** (circle one and enter actual º): Read degree aspect from a compass or clinometer (or estimate). Make sure to average the reading across entire stand. "Variable" may be selected if the same, homogenous stand of vegetation occurs across a varied range of slope exposures.

**General slope steepness** (circle one and enter actual º): Read degree slope from compass (or estimate), using degrees from true north (adjusting for declination). Average the reading over entire stand.

**Upland or Wetland/Riparian** (circle one): Indicate if the stand is in an upland or a wetland; note that a site need not be officially delineated as a wetland to qualify as such in this context (*e.g.* seasonally wet meadow).

**Site history, stand age, and comments**: Briefly describe the stand age/seral stage, disturbance history, nature and extent of land use, and other site environmental and vegetation factors. Examples of disturbance history: fire, landslides, avalanching, drought, flood, animal burrowing, or pest outbreak. Also, try to estimate year or frequency of disturbance. Examples of land use: grazing, timber harvest, or mining. Examples of other site factors: exposed rocks, soil with fine-textured sediments, high litter/duff build-up, multi-storied vegetation structure, or other stand dynamics.

**Type / level of disturbance** (use codes): List codes for potential or existing impacts on the stability of the plant community. Characterize each impact each as L (=Light), M (=Moderate), or H (=Heavy). *See code list for impacts.*

## VEGETATION DESCRIPTION

### *Basic alliance and stand description*

**Field-assessed vegetation alliance name:** Name of alliance (series) or habitat following the CNPS classification system (Sawyer and Keeler-Wolf 1995). Please use binomial nomenclature, *e.g. Quercus agrifolia* forest. An alliance is based on the dominant (or diagnostic) species of the stand, and is usually of the uppermost and/or dominant height stratum. A dominant species covers the greatest area (and a diagnostic is consistently found in some vegetation types but not others).

Please note: The field-assessed alliance name may not exist in present classification, in which you can provide a new alliance name in this field. If this is the case, also make sure to denote and explain this in the "Cannot identify alliance based on MCV classification" of the "**Problems with Interpretation**" section below.

**Field-assessed association name** (optional): Name of the species in the alliance and additional dominant/diagnostic species from any strata, as according to CNPS classification. In following naming conventions, species in differing strata are separated with a slash, and species in the uppermost stratum are listed first (*e.g. Quercus agrifolia/Toxicodendron diversilobum*). Species in the same stratum are separated with a dash (*e.g. Quercus agrifolia-Quercus kelloggii).*

Please note: The field-assessed association name may not exist in present classification, in which you can provide a new association name in this field.

**Size of stand:** Estimate the size of the entire stand in which the rapid assessment is taken. As a measure, one acre is about 0.4 hectares or about 4000 square meters.

**Adjacent Alliances:** Identify other vegetation types that are directly adjacent to the stand being assessed. Specifically, list up to three alliances (or associations or mapping units) by noting the dominant species; also note the distance away in meters from the GPS waypoint and the direction in degrees aspect that the adjacent alliance is found
(e.g. Abies concolor-Pinus ponderosa 50m, 360°/N Arctostaphylos patula 100m, 110° ).

***Habitat classification per California Wildlife-Habitat Relationships (CWHR)***
For CWHR, identify the size/height class of the stand using the following tree, shrub, and/or herbaceous categories. These categories are based on functional life forms.

**Tree:** Circle one of the tree size classes provided when the tree canopy closure exceeds 10 percent of the total cover (except in desert types), or if young tree density indicates imminent tree dominance. Size class is based on the average dbh (diameter of trunk at breast height). In choosing a size class, make sure to estimate the mean diameter of all trees over the entire stand. Circle the size class 6 multi-layered tree if there is a size class 5 of trees over a distinct layer of size class either 3 or 4 (*i.e.* distinct height class separation between different tree species) and the total tree canopy exceeds 60%.

**If tree, list 1-3 dominant overstory species:** If tree canopy cover exceeds 10 percent (except in desert types), please list the dominant species that occur in the overstory canopy.

**Shrub:** Circle one of the shrub size classes provided when shrub canopy closure exceeds 10 percent (except in desert types). Size class is based on the average amount of crown decadence (dead standing vegetation on live shrubs when looking across the crowns of the shrubs).

**Herbaceous:** Circle one of the herb height classes provided when herbaceous cover exceeds 2 percent. This height class is based on the average plant height at maturity.

**Desert Palm/Joshua Tree:** Circle one of the palm or Joshua tree size classes by averaging all the stem-base diameters (*i.e.* mean diameter of all stem-base sizes). Diameter is measured at the plant's base above the bulge near the ground.

**Desert Riparian Tree/Shrub:** Circle one of the size classes by measuring mean stem height (whether tree and/or shrub stand).

**Overall cover of vegetation**
Provide an ocular estimate of cover for the following categories (based on functional life forms). Record a specific number for the total aerial cover or "bird's-eye view" looking from above for each category, estimating cover for the living plants only. Litter/duff should not be included in these estimates.

To come up with a specific number estimate for percent cover, first use to the following CWHR cover intervals as a reference aid to get a generalized cover estimate: <2%, 2-9%, 10-24%, 25-39%, 40-59%, 60-100%. While keeping these intervals in mind, you can then refine your estimate to a specific percentage for each category below.

**%Overstory Conifer/Hardwood Tree cover:** The total aerial cover (canopy closure) of all live tree species that are specifically in the overstory or are emerging, disregarding overlap of individual trees. Estimate conifer and hardwood covers separately. Please note: These cover values should not include the coverage of suppressed understory trees.

**Shrub cover:** The total aerial cover (canopy closure) of all live shrub species, disregarding overlap of individual shrubs.

**Ground cover:** The total aerial cover (canopy closure) of all herbaceous species, disregarding overlap of individual herbs.

**Total Veg cover:** The total aerial cover of all vegetation. This is an estimate of the absolute vegetation cover, disregarding overlap of the various tree, shrub, and/or herbaceous layers.

***Modal height for conifer/hardwood tree, shrub, and herbaceous categories*** (optional)
If height values are important in your vegetation survey project, provide an ocular estimate of height for each category listed. Record an average height value, estimating the modal height for each group. Use the following height intervals and record a height class: 01=<1/2m, 02=1/2-1m, 03=1-2m, 04=2-5m, 05=5-10m, 06=10-15m, 07=15-20m, 08=20-35m, 09=35-50m, 10=>50m.

***Species list and coverage***
**Species (List up to 12 major species), Stratum, and Approximate % cover:** (Jepson Manual nomenclature please)
List the species that are dominant or that are characteristically consistent throughout the stand.

When different layers of vegetation occur in the stand, make sure to list species from each stratum. As a general guide, make sure to list at least 1-2 of the most abundant species per stratum. Provide a stratum code for each species listed, based on height, where T (=Tall) is >5 m in height, M (=Medium) is between 0.5 and 5 m in height, and L (=Low) is <0.5 m in height.

Also, provide a numerical ocular estimate of aerial coverage for each species. When estimating, it is often helpful to think of coverage in terms of the cover intervals from the CNPS relevé form at first (*e.g.* <1%, 1-5%, >5-15%, >15-25%, >25-50%, >50-75%, >75%). Keeping these classes in mind, then refine your estimate to a specific percentage (*e.g* the cover of species "x" is somewhere between 25 and 50 percent, but I think it is actually around 30%). Please note: All estimates are to be reported as absolute cover (not relative cover), and all the species percent covers may total over 100% when added up because of overlap.

**Major non-native species in stand (with % cover):** All exotic species occurring in the stand should be listed in this space provided (or they can be recorded in the above Species list). Make sure to give each exotic species an absolute coverage estimate.

**Unusual species:** List species that are either locally or regionally rare, endangered, or atypical (*e.g.* range extension or range limit) within the stand. This species list will be useful to the Program for obtaining data on regionally or locally significant populations of plants.

## PROBLEMS WITH INTERPRETATION

**Confidence in Identification: (L, M, H)** With respect to the "field-assessed alliance name", note whether you have L (=Low), M (=Moderate), or H (=High) confidence in the interpretation of this alliance name. Low confidence can occur from such things as a poor view of the stand, an unusual mix of species that does not meet the criteria of any described alliance, or a low confidence in your ability to identify species that are significant members of the stand.

**Explain:** Please elaborate if your "Confidence in Identification" is low or moderate. Similarly, if the field-assessed alliance name is not defined by CNPS's present Manual of California Vegetation (MCV) classification, note this in the space and describe why. In some instances for specific projects, there may be the benefit of more detailed classifications than what is presented in the first edition of the MCV. If this is the case, be sure to substitute the most appropriate and detailed classification.

**Other identification problems (describe):** Discuss any further problems with the identification of the assessment (*e.g.* stand is observed with an oblique view using binoculars, so the species list may be incomplete, or the cover percentages may be imperfect).

**Polygon is more than one type (Yes, No)** (Note: type with greatest coverage in polygon should be entered in above section) This is relevant to areas that have been delineated as polygons on aerial photographs for a vegetation-mapping project. In most cases the polygon delineated is intended to represent a single stand, however mapping conventions and the constraints and interpretability of remote images will alter the ability to map actual stands on the ground. "Yes" is noted when the polygon delineated contains the field-assessed alliance and other vegetation type(s), as based on species composition and structure. "No" is noted when the polygon is primarily representative of the field-assessed alliance.

**Other types:** If "Yes" above, then list the other subordinate vegetation alliances that are included within the polygon. List them in order of their amount of the polygon covered.

**Has the vegetation changed since air photo taken? (Yes, No)** If an aerial photograph is being used for reference, evaluate if the stand of the field-assessed alliance has changed as a result of disturbance or other historic change since the photograph was taken.

**If Yes, how? What has changed** (write N/A if so)**?** If the photographic signature of the vegetation has changed (*e.g.* in structure, density, or extent), please detail here.

**Simplified Key to Soil Texture** (Brewer and McCann, 1982)

Place about three teaspoons of soil in the palm of your hand. Take out any particles <2mm in size, and use the following key to figure out the soil texture (e.g. loamy sand). Then figure out the texture subclass by using the Code List attached (e.g. coarse loamy sand).

A1 Soil does not remain in a ball when squeezed.............................…..............…....... sand

A2 Soil remains in a ball when squeezed.........................................…..............…............. B

B1 Add a small amount of water. Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger. Soil makes no ribbon..................….......................……………………………………….…loamy sand

B2 Soil makes a ribbon; may be very short......................................…...............................C

C1 Ribbon extends less than 1 inch before breaking..........................................…...............D

C2 Ribbon extends 1 inch or more before breaking.............................................….............E

D1 Add excess water to small amount of soil; soil feels very gritty or at least slightly gritty ..........................................................................…..........loam or sandy loam

D2 Soil feels smooth........................................................…...............................silt loam

E1 Soil makes a ribbon that breaks when 1–2 inches long; cracks if bent into a ring...........F

E2 Soil makes a ribbon 2+ inches long; does not crack when bent into a ring....................G

F1 Add excess water to small amount of soil; soil feels very gritty or at least slightly gritty.......................................................................…sandy clay loam or clay loam

F2 Soil feels smooth...................................................................…...silty clay loam or silt

G1 Add excess water to a small amount of soil; soil feels very gritty or at least slightly gritty...........................................................................……....sandy clay or clay

G2 Soil feels smooth......................................................................…..….........silty clay

# CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ FIELD FORM CODE LIST

(revised 7/8/02)

**IMPACTS**

01 Development
02 ORV activity
03 Agriculture
04 Grazing
05 Competition from exotics
06 Logging
07 Insufficient population/stand size
08 Altered flood/tidal regime
09 Mining
10 Hybridization
11 Groundwater pumping
12 Dam/inundation
13 Other
14 Surface water diversion
15 Road/trail construction/maint.
16 Biocides
17 Pollution
18 Unknown
19 Vandalism/dumping/litter
20 Foot traffic/trampling
21 Improper burning regime
22 Over collecting/poaching
23 Erosion/runoff
24 Altered thermal regime
25 Landfill
26 Degrading water quality
27 Wood cutting
28 Military operations
29 Recreational use (non ORV)
30 Nest parasitism
31 Non-native predators
32 Rip-rap, bank protection
33 Channelization (human caused)
34 Feral pigs
35 Burros
36 Rills
37 Phytogenic mounding

**MACRO TOPOGRAPHY**

00 Bench
01 Ridge top (interfluve)
02 Upper 1/3 of slope
03 Middle 1/3 of slope
04 Lower 1/3 of slope (lowslope)
05 Toeslope (alluvial fan/bajada)
06 Bottom/plain
07 Basin/wetland
08 Draw
09 Other
10 Terrace (former shoreline or floodplain)
11 Entire slope
12 Wash (channel bed)
13 Badland (complex of draws & interfluves)
14 Mesa/plateau
15 Dune/sandfield
16 Pediment
17 Backslope (cliff)

**MICRO TOPOGRAPHY**

01 Convex or rounded
02 Linear or even
03 Concave or depression
04 Undulating pattern
05 Hummock or Swale pattern
06 Mounded
07 Other

**PARENT MATERIAL**

| | |
|---|---|
| ANDE | Andesite |
| ASHT | Ash (of any origin) |
| GRAN | Granitic (generic) |
| GREE | Greenstone |
| DIOR | Diorite |
| BASA | Basalt |
| OBSI | Obsidian |
| PUMI | Pumice |
| IGTU | Igneous (type unknown) |
| MONZ | Monzonite |
| PYFL | Pyroclastic flow |
| QUDI | Quartz diorite |
| RHYO | Rhyolite |
| VOLC | General volcanic extrusives |
| VOFL | Volcanic flow |
| VOMU | Volcanic mud |
| BLUE | Blue schist |
| CHER | Chert |
| DOLO | Dolomite |
| FRME | Franciscan melange |
| INTR | General igneous intrusives |
| GNBG | Gneiss/biotite gneiss |
| HORN | Hornfels |
| MARB | Marble |
| METU | Metamorphic (type unknown) |
| PHYL | Phyllite |
| SCHI | Schist |
| SESC | Semi-schist |
| SLAT | Slate |
| BREC | Breccia (non-volcanic) |
| CACO | Calcareous conglomerate |
| CASA | Calcareous sandstone |
| CASH | Calcareous shale |
| CASI | Calcareous siltstone |
| CONG | Conglomerate |
| FANG | Fanglomerate |
| GLTI | Glacial till, mixed origin, moraine |
| LALA | Large landslide (unconsolidated) |
| LIME | Limestone |
| SAND | Sandstone |
| SETU | Sedimentary (type unknown) |
| SHAL | Shale |
| SILT | Siltstone |
| DIAB | Diabase |
| GABB | Gabbro |
| PERI | Peridotite |
| SERP | Serpentine |
| ULTU | Ultramafic (type unknown) |
| CALU | Calcareous (origin unknown) |
| DUNE | Sand dunes |
| LOSS | Loess |
| MIIG | Mixed igneous |
| MIME | Mixed metamorphic |
| MIRT | Mix of two or more rock types |
| MISE | Mixed sedimentary |
| CLAL | Clayey alluvium |
| GRAL | Gravelly alluvium |
| MIAL | Mixed alluvium |
| SAAL | Sandy alluvium (most alluvial fans and washes) |
| SIAL | Silty alluvium |
| OTHE | Other than on list |

**SOIL TEXTURE**

| | |
|---|---|
| COSA | Coarse sand |
| MESN | Medium sand |
| FISN | Fine sand |
| COLS | Coarse, loamy sand |
| MELS | Medium to very fine, loamy sand |
| MCSL | Moderately coarse, sandy loam |
| MESA | Medium to very fine, sandy loam |
| MELO | Medium loam |
| MESL | Medium silt loam |
| MESI | Medium silt |
| MFCL | Moderately fine clay loam |
| MFSA | Moderately fine sandy clay loam |
| MFSL | Moderately fine silty clay loam |
| FISA | Fine sandy clay |
| FISC | Fine silty clay |
| FICL | Fine clay |
| SAND | Sand (class unknown) |
| LOAM | Loam (class unknown) |
| CLAY | Clay (class unknown) |
| UNKN | Unknown |
| PEAT | Peat |
| MUCK | Muck |

**DOMINANT VEGETATION GROUP**

| | |
|---|---|
| ***Trees:*** | |
| TBSE | Temperate broad-leaved seasonal evergreen forest |
| TNLE | Temperate or subpolar needle-leafed evergreen forest |
| CDF | Cold-deciduous forest |
| MNDF | Mixed needle-leafed evergreen-cold deciduous. forest |
| TBEW | Temperate broad-leaved evergreen woodland |
| TNEW | Temperate or subpolar needle-leaved evergreen woodland |
| EXEW | Extremely xeromorphic evergreen woodland |
| CDW | Cold-deciduous woodland |
| EXDW | Extremely xeromorphic deciduous woodland |
| MBED | Mixed broad-leaved evergreen-cold deciduous woodland |
| MNDW | Mixed needle-leafed evergreen-cold deciduous woodland |
| ***Shrubs:*** | |
| TBES | Temperate broad-leaved evergreen shrubland |
| NLES | Needle-leafed evergreen shrubland |
| MIES | Microphyllus evergreen shrubland |
| EXDS | Extremely xeromorphic deciduous shrubland |
| CDS | Cold-deciduous shrubland |
| MEDS | Mixed evergreen-deciduous shrubland |
| XMED | Extremely xeromorphic mixed evergreen-deciduous shrubland |
| ***Dwarf Shrubland:*** | |
| NMED | Needle-leafed or microphyllous evergreen dwarf shrubland |
| XEDS | Extremely xeromorphic evergreen dwarf shrubland |
| DDDS | Drought-deciduous dwarf shrubland |
| MEDD | Mixed evergreen cold-deciduous dwarf shrubland |
| ***Herbaceous:*** | |
| TSPG | Temperate or subpolar grassland |
| TGST | Temperate or subpolar grassland with sparse tree |
| TGSS | Temperate or subpolar grassland with sparse shrublayer |
| TGSD | Temperate or subpolar grassland with sparse dwarf shrub layer |
| TFV | Temperate or subpolar forb vegetation |
| THRV | Temperate or subpolar hydromorphic rooted vegetation |
| TAGF | Temperate or subpolar annual grassland or forb vegetation |
| ***Sparse Vegetation*:** | |
| SVSD | Sparsely vegetated sand dunes |
| SVCS | Sparsely vegetated consolidated substrates |

# CALIFORNIA NATIVE PLANT SOCIETY - VEGETATION RAPID ASSESSMENT FIELD FORM

(Revised Sept. 20, 2004)

| **For Office Use:** | **Final database #:** | **Final vegetation type name:** | **Alliance**__________ **Association**__________ |
|---|---|---|---|

## I. LOCATIONAL/ENVIRONMENTAL DESCRIPTION

| **Polygon/Stand #:** ______________ | **Air photo #:** ______________ | **Date:** ______________ | **Name(s) of surveyors:** ______________ |
|---|---|---|---|

**GPS waypoint #:** __________ **GPS name:** ________________ **GPS datum: (NAD 27)** ________ **Is GPS within stand?** <u>Yes / No</u>

**If No, cite from GPS point to stand, the distance** _______**(in meters) and bearing** _______**(in degrees)** **GPS Error:** ±______ **ft / m**

**UTM field reading:** **UTME** ___ ___ ___ ___ ___ ___ **UTMN** ___ ___ ___ ___ ___ ___ ___ **UTM zone:** ______________

**Elevation**: __________ **ft / m** **Photograph #'s**: ____________________

**Topography:** **convex**____ **flat**____ **concave**____ **undulating**____ | **top**____ **upper**____ **mid**____ **lower**____ **bottom**____

**Geology:** _______ **Soil Texture:** _______ **Rock: %Large**____ **%Small** ____ **%Bare/Fine:** ____ **%Litter:** ____ **%BA Stems:** ____

**Slope exposure** (circle one and/or enter actual °): **NE**_______ **NW**_______ **SE**_______ **SW**_______ **Flat**__ **Variable**__

**Slope steepness** (circle one and enter actual °): **0°**__ **1-5°** _____ **5-25°**_____ **> 25°**_____ **Upland** or **Wetland/Riparian** (circle one)

**Site history, stand age, and comments:** ____________________

____________________

____________________

**Type/ Level of disturbance** (*use codes*): _____/____ _____/____ _____/____ _____/____ _____/____ _____/____ _____/____ _____/____

## II. VEGETATION DESCRIPTION

**Field-assessed vegetation alliance name:** ____________________

**Field-assessed association name** (optional): ____________________

**Size of stand:** **<1 acre**___ **1-5 acres**___ **>5 acres**___ **Adjacent alliances:** ____________________ __________

____________________ __________ ____________________ __________

**Tree:** <u>T1</u> (<1" dbh), <u>T2</u> (1-6" dbh), <u>T3</u> (6-11" dbh), <u>T4</u> (11-24" dbh), <u>T5</u> (>24" dbh), <u>T6</u> multi-layered (T3 or T4 layer under T5, >60% cover)

**If Tree, list 1-3 dominant overstory spp.:** ____________________

**Shrub:** <u>S1</u> seedling (<3 yr. old), <u>S2</u> young (<1% dead), <u>S3</u> mature (1-25% dead), <u>S4</u> decadent (>25% dead)

**Herbaceous:** <u>H1</u> (<12" plant ht.), <u>H2</u> (>12" ht.) **Desert Palm/Joshua Tree:** <u>1</u> (<1.5" base diameter), <u>2</u> (1.5-6" diam.), <u>3</u> (>6" diam.)

**Desert Riparian Tree/Shrub:** <u>1</u> (<2ft. stem ht.), <u>2</u> (2-10ft. ht.), <u>3</u> (10-20ft. ht.), <u>4</u> (>20ft. ht.)

**% Overstory Conifer/Hardwood Tree cover:** _____/_____ **Shrub cover:** _____ **Herbaceous cover:** _____ **Total Veg cover:**______

**Overstory Conifer/Hardwood height:** _____/_____ **Tall Shrub/Low Shrub height:** _____/_____ **Herbaceous height:** _____

*Height classes:* 01=<1/2m 02=1/2-1m 03=1-2m 04=2-5m 05=5-10m 06=10-15m 07=15-20m 08=20-35m 09=35-50m 10=>50m

**Species (List up to 12 major species), Stratum, and Approximate % cover:** (Jepson Manual nomenclature please)

*Stratum categories*: T=tall, M=medium, L=low; *% cover intervals for reference*: <1%, 1-5%, >5-15%, >15-25%, >25-50%, >50-75%, >75%

| Strata | Species | % cover | | Strata | Species | % cover |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Major non-native species - With % cover:** ____________________

**Unusual species:** ____________________

## III. PROBLEMS WITH INTERPRETATION

**Confidence in identification: (L, M, H)** ______ **Explain** ____________________

**Other identification problems (describe):** ____________________

**Polygon is more than one type: (Yes, No)** ________ (Note: type with greatest coverage in polygon should be entered in above section)

**Other types:** ____________________ ____________________ ____________________

**Has the vegetation changed since air photo taken? (Yes, No)** _____ **If Yes, how? What has changed** (write N/A if so)**?** _______

____________________

# CALIFORNIA NATIVE PLANT SOCIETY - VEGETATION RAPID ASSESSMENT FIELD FORM

(Revised Sept. 20, 2004)

| For Office Use: | Final database #: | Final vegetation type name: | Alliance________________________________________ Association_____________________________________ |
|---|---|---|---|

**I. LOCATIONAL/ENVIRONMENTAL DESCRIPTION**

| Polygon/Stand #: | Air photo #: | Date: | Name(s) of surveyors: |
|---|---|---|---|
| _______________ | _______________ | ______________ | ______________________________________________________________ |

**GPS waypoint #:** __________ **GPS name:** ________________ **GPS datum: (NAD 27)** ________ **Is GPS within stand?** <u>**Yes / No**</u>

**If No, cite from GPS point to stand, the distance** _______**(in meters) and bearing** _______**(in degrees)** **GPS Error: ±**______ **ft / m**

**UTM field reading:** **UTME** ___ ___ ___ ___ ___ ___ **UTMN** ___ ___ ___ ___ ___ ___ ___ **UTM zone:** ______________

**Elevation**: __________ **ft / m** **Photograph #'s**: ____________________________________________________________

**Topography: convex**____ **flat**____ **concave**____ **undulating**____ | **top**____ **upper**____ **mid**____ **lower**____ **bottom**____

**Geology:** _______ **Soil Texture:** _______ **Rock: %Large**____ **%Small** ____ **%Bare/Fine:** ____ **%Litter:** ____ **%BA Stems:** ____

**Slope exposure** (circle one and/or enter actual °): **NE**_______ **NW**_______ **SE**_______ **SW**_______ **Flat**__ **Variable**__

**Slope steepness** (circle one and enter actual °): **0°**__ **1-5°** _____ **5-25°**_____ **> 25°**_____ **Upland** or **Wetland/Riparian** (circle one)

**Site history, stand age, and comments:** ___________________________________________________________________

________________________________________________________________________________________________

________________________________________________________________________________________________

**Type/ Level of disturbance** (*use codes*): _____/____ _____/____ _____/____ _____/____ _____/____ _____/____ _____/____ _____/____

**II. VEGETATION DESCRIPTION**

**Field-assessed vegetation alliance name:** _____________________________________________________________

**Field-assessed association name** (optional): ___________________________________________________________

**Size of stand: <1 acre**___ **1-5 acres**___ **>5 acres**___ **Adjacent alliances:** _________________________________ __________

_____________________________________ __________ _____________________________________ __________

**Tree:** <u>T1</u> (<1" dbh), <u>T2</u> (1-6" dbh), <u>T3</u> (6-11" dbh), <u>T4</u> (11-24" dbh), <u>T5</u> (>24" dbh), <u>T6</u> multi-layered (T3 or T4 layer under T5, >60% cover)

**If Tree, list 1-3 dominant overstory spp.:** _________________________________________________________________

**Shrub:** <u>S1</u> seedling (<3 yr. old), <u>S2</u> young (<1% dead), <u>S3</u> mature (1-25% dead), <u>S4</u> decadent (>25% dead)

**Herbaceous:** <u>H1</u> (<12" plant ht.), <u>H2</u> (>12" ht.) **Desert Palm/Joshua Tree:** <u>1</u> (<1.5" base diameter), <u>2</u> (1.5-6" diam.), <u>3</u> (>6" diam.)

**Desert Riparian Tree/Shrub:** <u>1</u> (<2ft. stem ht.), <u>2</u> (2-10ft. ht.), <u>3</u> (10-20ft. ht.), <u>4</u> (>20ft. ht.)

**% Overstory Conifer/Hardwood Tree cover:** _____/_____ **Shrub cover:** _____ **Herbaceous cover:** _____ **Total Veg cover:**______

**Overstory Conifer/Hardwood height:** _____/_____ **Tall Shrub/Low Shrub height:** _____/_____ **Herbaceous height:** _____

*Height classes:* 01=<1/2m 02=1/2-1m 03=1-2m 04=2-5m 05=5-10m 06=10-15m 07=15-20m 08=20-35m 09=35-50m 10=>50m

**Species (List up to 12 major species), Stratum, and Approximate % cover:** (Jepson Manual nomenclature please)

*Stratum categories*: T=tall, M=medium, L=low; *% cover intervals for reference*: <1%, 1-5%, >5-15%, >15-25%, >25-50%, >50-75%, >75%

| Strata | Species | % cover | | Strata | Species | % cover |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Major non-native species - With % cover:** _____________________________________________________________

**Unusual species:** _________________________________________________________________________________

**III. PROBLEMS WITH INTERPRETATION**

**Confidence in identification: (L, M, H)** ______ **Explain** ____________________________________________________

**Other identification problems (describe):** _____________________________________________________________

**Polygon is more than one type: (Yes, No)** ________ (Note: type with greatest coverage in polygon should be entered in above section)

**Other types:** ______________________________ ______________________________ ______________________________

**Has the vegetation changed since air photo taken? (Yes, No)** _____ **If Yes, how? What has changed** (write N/A if so)**?** _______

________________________________________________________________________________________________

CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ PROTOCOL
CNPS VEGETATION COMMITTEE
October 20, 2000 (Revised 4/2/04)

## Introduction

In *A Manual of California Vegetation* (Sawyer and Keeler-Wolf 1995), CNPS published a Vegetation Sampling Protocol that was developed as a simple quantitative sampling technique applicable to many vegetation types in California. Investigators use an ocular estimation technique called a relevé to classify and map large areas in a limited amount of time.

The relevé method of sampling vegetation was developed in Europe and was largely standardized by the Swiss ecologist Josias Braun-Blanquet. He helped classify much of Europe's vegetation, founded and directed a synecology center in France, and was editor of *Vegetatio* for many years. The relevé was, and is, a method used by many European ecologists, and others around the world. These ecologists refer to themselves as phytosociologists. The use of relevé in the United States has not been extensive with the exception of the US Forest Service.

The relevé is particularly useful when observers are trying to quickly classify the range of diversity of plant cover over large units of land. In general, it is faster than the point intercept technique. One would use this method when developing a classification that could be used to map of a large area of vegetation, for example. This method may also be more useful than the line intercept method when one is trying to validate the accuracy of mapping efforts.

The relevé is generally considered a "semiquantitative" method. It relies on ocular estimates of plant cover rather than on counts of the "hits" of a particular species along a transect line or on precise measurements of cover/biomass by planimetric or weighing techniques.

## Selecting a stand to sample:

A stand is the basic physical unit of vegetation in a landscape. It has no set size. Some vegetation stands are very small, such as alpine meadow or tundra types, and some may be several square kilometers in size, such as desert or forest types. A stand is defined by two main unifying characteristics:

1) It has <u>compositional</u> integrity. Throughout the site the combination of species is similar. The stand is differentiated from adjacent stands by a discernable boundary that may be abrupt or indistinct, and
2) It has <u>structural</u> integrity. It has a similar history or environmental setting that affords relatively similar horizontal and vertical spacing of plant species throughout.
   For example, a hillside forest originally dominated by the same species that burned on the upper part of the slopes, but not the lower, would be divided into two stands. Likewise, a sparse woodland occupying a slope with very shallow rocky soils would be considered a different stand from an adjacent slope with deeper, moister soil and a denser woodland or forest of the same species.

The structural and compositional features of a stand are often combined into a term called homogeneity. For an area of vegetated ground to meet the requirements of a stand it must be homogeneous.

Stands to be sampled may be selected by assessment prior to a site visit (e.g. delineated from aerial photos or satellite images), or may be selected on site (during reconnaissance to determine extent and boundaries, location of other similar stands, etc.). Depending on the project goals, you may want to select just one or a few representative stands for sampling (e.g., for developing a classification for a vegetation mapping project), or you may want to sample all of them (e.g., to define a rare vegetation type and/or compare site quality between the few remaining stands).

**Selecting a plot to sample within in a stand:**

Because most stands are large, it is difficult to summarize the species composition, cover, and structure of an entire stand. We are also usually trying to capture the most information with the least amount of effort. Thus, we are typically forced to select a representative portion to sample.

When sampling a vegetation stand, the main point to remember is to select a sample that, in as many ways possible, is representative of that stand. This means that you are not randomly selecting a plot; on the contrary, you are actively using your own best judgement to find a representative example of the stand.

Selecting a plot requires that you see enough of the stand you are sampling to feel comfortable in choosing a representative plot location. Take a brief walk through the stand and look for variations in species composition and in stand structure. In many cases in hilly or mountainous terrain look for a vantage point from which you can get a representative view of the whole stand. Variations in vegetation that are repeated throughout the stand should be included in your plot. Once you assess the variation within the stand, attempt to find an area that captures the stand's common species composition and structural condition to sample.

Plot Size

All releves of the same type of vegetation to be analyzed in a study need to be the same size. It wouldn't be fair, for example, to compare a 100 m2 plot with a 1000 m2 plot as the difference in number of species may be due to the size of the plot, not a difference in the stands.

A minimal area to sample is defined by species/area relationships; as the sampler identifies species present in an area of homogeneous vegetation, the number will increase quickly as more area is surveyed. Plot shape and size are somewhat dependent on the type of vegetation under study. Therefore general guidelines for plot sizes of tree-, shrub-, and herb-dominated upland, and fine-scale herbaceous communities have been established. Sufficient work has been done in temperate vegetation to be confident the following conventions will capture species richness:

Alpine meadow and montane wet meadow: 100 sq. m
Herbaceous communities: 100 sq. m plot or 400 sq. m plot (Consult with CNPS, and use one consistent size)
Grasslands and Shrublands: 400 sq. m plot
Forest and woodland communities: 1000 sq. m plot
Open desert vegetation: 1000 sq. m plot

Plot Shape

A relevé has no fixed shape, plot shape should reflect the character of the stand. If the stand is about the same size as a relevé, you need to sample the entire stand. If we are sampling a desert wash, streamside riparian, or other linear community our plot dimensions should not go beyond the community's natural ecological boundaries. Thus, a relatively long, narrow plot capturing the vegetation within the stand, but not outside it would be appropriate. Species present along the edges of the plot that are clearly part of the adjacent stand should be excluded.

If we are sampling broad homogeneous stands, we would most likely choose a shape such as a circle (which has the advantage of the edges being equidistant to the center point) or a square (which can be quickly laid out using perpendicular tapes). If we are trying to capture a minor bit of variety in the understory of a forest, for example a bracken fern patch within a ponderosa pine stand, we would want both bracken and non-bracken understory. Thus, a rectangular shape would be appropriate.

**GENERAL PLOT INFORMATION**

The following items appear on each data sheet and are to be collected for all plots. Where indicated, refer to attached code sheet.

Polygon or Relevé number: Assigned either in the field or in the office prior to sampling.

Date: Date of sampling.

County: County in which located.

USGS Quad: The name of the USGS map the relevé is located on; note series (15' or 7.5').

CNPS Chapter: CNPS chapter, or other organization or agency if source is other than CNPS chapter.

Landowner: Name of landowner or agency acronym if known. Otherwise, list as private.

Contact Person: Name, address, and phone number of individual responsible for data collection.

Observers: Names of individuals assisting. Circle name of recorder.

Plot shape: indicate the sample shape as: square, rectangle, circle, or the entire stand.

Plot size: length of rectangle edges, circle radius, or size of entire stand.

NOTE: See page 2 for standard plot sizes.

Study Plot Revisit: If the relevé plot is being revisited for repeated sampling, please circle "Yes".

Photo interpreter community code: If the sample is in area for which delineation and photo interpretation has already been done, the code which the photointerpreters applied to the polygon. If the sample site has not been photointerpreted, leave blank.

Other polygons of same type (yes or no, if applicable), if yes, mark on map: Other areas within view that appear to have similar vegetation composition. Again, this is most relevant to areas that have been delineated as polygons on aerial photographs as part of a vegetation-mapping project. If one is not working from aerial photographs, draw the areas as on a topographic map.

Is plot representative of whole polygon? (yes or no, if applicable), if no explain: Detail what other vegetation types occur in the polygon, and what the dominant vegetation type is if there is more than one type.

Global Positioning System Readings: Due to the recent availability of very accurate and relatively low cost GPS units, we highly recommend obtaining and using these as a standard piece of sampling equipment. Now that the military intentional imprecision (known as "selective availability") has been "turned off" (as of July 2000), it is typical for all commercial GPS units these units to be accurate to within 5 m of the actual location. Also note that the GPS units can be set to read in UTM or Latitude and Longitude coordinates and can be easily translated. Thus, the following fields for Latitude, Longitude, and legal description are now optional. In order for all positional data to be comparable within the CNPS vegetation dataset We request using UTM coordinates set for the NAD 83 projection (see your GPS users manual for instructions for setting coordinates and projections).

Caveat: Although GPS units are valuable tools, they may not function properly due to the occasionally poor alignment of satellites or due to the complexity of certain types of terrain, or vegetation. We thus also recommend that you carry topographic maps and are aware of how to note your position on them in the event of a non-responsive or inaccurate GPS.

UTMN and UTME: Northing and easting coordinates using the Universal Transverse Mercator (UTM) grid as delineated on the USGS topographic map, or using a Global Positioning System.

UTM zone: Universal Transverse Mercator zone. Zone 10S for California west of the $120^{th}$ longitude; zone 11S for California east of $120^{th}$ longitude.

Legal Description: Township/Range/Section/Quarter Section/Quarter-Quarter section/Meridian: Legal map location of the site; this is useful for determining ownership of the property. California Meridians are Humboldt, Mt. Diablo, or San Bernardino. (This is optional, see above discussion of GPS units)

Latitude and Longitude: Degrees north latitude and east longitude. This is optional (see above)

Elevation: Recorded in feet or meters. Please indicate units.

Slope: Degrees, read from clinometer or compass, or estimated; averaged over relevé

Aspect: Degrees from true north (adjust declination), read from a compass or estimated; averaged over relevé.

Macrotopography: Characterize the large-scale topographic position of the relevé. This is the general position of the sample along major topographic features of the area. *See attached code list.*

Microtopography: Characterize the local relief of the relevé. Choose the shape that mimics the lay of the ground along minor topographic features of the area actually within the sample. *See attached code list.*

**VEGETATION DESCRIPTION**

Dominant layer: Indicate whether the community is dominated by the Low layer (L), Mid-layer (M), or Tall (T) layer.

Preliminary Alliance name: Name of series, stand, or habitat according to CNPS classification (per Sawyer and Keeler-Wolf 1995); if the type is not defined by the CNPS classification, note this in the space.

Adjacent alliance: Adjacent vegetation series, stands or habitats according to CNPS classification; list in order of most extensive to least extensive.

Structure: Characterize the structure of each layer.

Continuous = greater than 2/3 (67%) cover; crowns touching
Intermittent = between 1/3 and 2/3 cover (33% to 66 %); interlocking or touching crowns interrupted by openings.
Open = less than 1/3 (33%) cover; crowns not touching or infrequently touching.

Phenology: Based on the vegetative condition of he principal species, characterize the phenology of each layer as early (E), peak (P), or late (L).

**WETLAND COMMUNITY TYPES**

Community type: Indicate if the sample is in a wetland or an upland; note that a site need not be officially delineated as a wetland to qualify as such in this context.

Dominant vegetation form: This is a four letter code which relates the vegetation of the plot to the higher levels of the NBS/NPS National Vegetation Classification System hierarchy. *See attached code list.*

Cowardin class: See “Artificial Keys to Cowardin Systems and Names” (attached). If the plot is located in a wetland, record the proper Cowardin system name. Systems are described in detail in Cowardin et al. 1979. Classification of wetlands and deepwater habitats of the United States. US Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

**Marine:** habitats exposed to the waves and currents of the open ocean (subtidal and intertidal habitats).

**Estuarine:** includes deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land (i.e. estuaries and lagoons).

**Riverine**: includes all wetlands and deepwater habitats contained within a channel, excluding any wetland dominated by trees, shrubs, persistent emergent plants, emergent mosses, or lichens. Channels that contain oceanic-derived salts greater than 0.5% are also excluded.

**Lacustrine**: Includes wetlands and deepwater habitats with all of the following characteristics: 1) situated in a topographic depression or a dammed river channel; 2) lacking trees or shrubs, persistent emergents, emergent mosses or lichens with greater than 30% aerial coverage; and total area exceeds 8 ha (20 acres). Similar areas less than 8 ha are included in the lacustrine system if an active wave-formed or bedrock shoreline feature makes up all or part of the low tide boundary, of if the water in the deepest part of the basin exceeds 2 m (6.6 feet) at low tide. Oceanic derived salinity is always less than 0.5%.

**Palustrine**: Includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity derived from oceanic salts is less than 0.5%. Also included are areas lacking vegetation, but with all of the following four characteristics: 1) areas less than 8 ha (20 acres); active wave-formed or bedrock shoreline features lacking; 3) water depth in the deepest part of the basin less than 2 m (6.6 feet) at low water; and 4) salinity due to ocean-derived salts less than 0.5%.

<u>Vertical distance from high water mark of active stream channel</u>: If the plot is in or near a wetland community, record to the nearest meter or foot the estimated vertical distance from the middle of the plot to the average water line of the channel, basin, or other body of water.

<u>Horizontal distance from high water mark of active stream channel</u>: If the plot is in or near a wetland community, record to the nearest meter or foot the estimated horizontal distance from the middle of the plot to the average water line of the channel, basin, or other body of water.

<u>Stream channel form</u>: If the plot is located in or near a community along a stream, river, or dry wash, record the channel form of the waterway. The channel form is considered S (single channeled) if it consists of predominately a single primary channel, M (meandering) if it is a meandering channel, and B (braided) if it consists of multiple channels interwoven or braided.

<u>Photographs</u>: Describe the number of color photographs taken at the relevé, and the camera's view direction from compass bearings. It is helpful to take a photograph of the relevé from the intersection of the tapes (if tapes were used to define the plot), and another from inside the relevé. Additional photos of the stand may also be helpful. If using a digital camera or scanning in the image into a computer, relevé numbers and compass directions can be recorded digitally. If using a 35mm camera, please note the roll number, frame number, compass direction, and the initials of the person whose camera is being used. (e.g. Roll 5, #1, to the NW, SS)

## STAND AND ENVIRONMENTAL INFORMATION

Vegetation trend: Based on the regenerating species and relationship to surrounding vegetation, characterize the stand as either increasing (expanding), stable, decreasing, fluctuating, or unknown.

Impacts: Enter codes for potential or existing impacts on the stability of the plant community. Characterize each as either 1. Light, 2. Moderate, of 3. Heavy. *See attached code list.*

Site location and plot description: A concise, but careful description that makes locating and/or revisiting the vegetation stand and plots possible; give landmarks and directions. Used in conjunction with the GPS position recorded earlier, this should enable precise re-location of the plot. Indicate where the GPS reading was taken within the plot. In general, the location of the GPS reading should be on the Southeastern corner of the plot, if the plot is square or rectangular, or in the center if the plot is circular. It is also helpful to briefly describe the topography, aspect, and vegetation structure of the site. If you can't take the GPS reading at the Southeast corner (an obstacle in the way) then note where the GPS point was taken. If you can't get a GPS reading, then spend extra time marking the plot location as precise as possible on a topo map.

Site history: Briefly describe the history of the stand, including type and year of disturbance (e.g. fire, landslides or avalanching, drought, flood, or pest outbreak). Also note the nature and extent of land use such as grazing, timber harvest, or mining.

Unknown plant specimens: List the numbers of any unknown plant specimens, noting any information such as family or genus (if known), important characters, and whether or not there is adequate material for identification. Do not take samples of plants of which there are only a few individuals or which you think may be rare. Document these plants with photographs.

Additional comments: Feel free to note any additional observations of the site, or deviations from the standard sampling protocol. If additional data were recorded, e.g. if tree diameters were measured, please indicate so here.

## COARSE FRAGMENTS AND SOIL INFORMATION

Coarse fragments, litter: Estimate the cover class of each size at or near the ground surface averaged over the plot. Always remember to estimate what you actually see on the surface as opposed to what you think is hiding under, organic litter, big rocks, etc. However, rocks, organic litter, or fine material visible under the canopy of shrubs or trees should be included in the cover estimate.

One way to consider this is to assume that all of the components of coarse fragments plus the basal cross-section of living plant stems and trunks (at ground level) will add up to 100%. Thus, estimate the cover value of each of the items in the box on the form for coarse fragments (including the basal area of plant stems) so that they will add up to 100%. Remember that the basal area of plant stems is usually minimal (e.g., if there were 10 trees, each 1 m in diameter at ground level on a 1000 square meter plot, they would cover less than 1% {0.79%} of the plot).

These data are asked for because certain categories of coarse fragments of rock and other materials have been shown to correlate with certain vegetation types and are thus likely influencing the type of vegetation that is growing in a given area. These estimates should be made quickly with the main point to keep in mind being a rough estimate of the relative proportions of different coarse fragments on the plot.

Fines: Fine mineral fragments including sand, silt, soil, “dirt” < 2 mm in diameter

Gravel: rounded and angular fragments 0.2-7.5 cm (0.08 -3 in.) diameter

Cobble: rounded and angular fragments >7.5-25 cm (3 -10 in.) in diameter

Stone: rounded and angular coarse fragments >25 cm-60 cm (10 -24 in.) in diameter

Boulder: rounded and angular coarse fragments >60 cm (>24 in.) in diameter

Bedrock: continuous, exposed, non-transported rock

Litter: extent of undecomposed litter on surface of plot (this includes all organic matter, e.g. fallen logs, branches, and twigs down to needles and leaves).

Soil texture: Record the texture of the upper soil horizon, below the organic layer if one is present. *See attached key and code list*.

Parent Material: Geological parent material of site. *See attached code list*.

## VEGETATION DATA

### Assessment of Layers

This first step is described in the CNPS point-intercept transect protocol. Estimates the maximum height for the low and mid layers and the minimum height for the tall layer are recorded. These estimates are made after a quick assessment of the vegetation and its structure. The estimates need not be overly precise and will vary among vegetation types. A caveat: if several relevés are being sampled within the same vegetation type, it is important to be consistent when assigning layers. Some types will have more than three layers (e.g. two tree layers of different maximum height); this should be indicated in the relevé description. However, data are recorded for only three layers (low, mid, and tall). The layer a species occupies will often be determined by growth form, but exceptions do occur. For example, with trees young seedlings may occupy the low layer, saplings the mid layer, and mature individuals the tall layer for some taxa, for example.

### Species List

The collection of vegetation data continues with making a comprehensive species list of all vascular plants within the relevé. This list is achieved by meandering through the plot to see all microhabitats. During list development, observers document each taxon present in each layer in which it occurs separately, recording it on a different line of the data form and noting which layer is represented. This is important for data entry because each layer of each represented taxon will be entered separately. Each individual plant is recorded in only one layer, the layer in which the tallest portion of the individual is found. One should reach a point at which new taxa are added to the list only very slowly, or sporadically. When one has reached that point, the list is probably done.

The following sections explain how to perform the actual relevé, the Estimation of Cover Values. The sections prefaced by bold-faced titles explain the technique, and the sections with regular font titles refer to the steps needed to complete the accompanying Field Form.

**Tree dbh** (optional)

The CNPS protocol does not require observers to record the diameter at breast height (dbh) of each tree species in the plot. However, the dbh is important in certain studies and may be recorded next to the each tree species name, in the column labeled "Final species determination or Tree dbh". You should measure the tree dbh of every tree trunk that has diameter > or = 10 cm at breast height in the plot, and each measurement should be in centimeters (cm) using a dbh tape measure. For trunks that may be fused below breast height and branched at breast height, each trunk at breast height gets a separate measurement.

Depending on the density of trees in each plot, you can record dbh of trees for every tree trunk in the plot, or you can sub-sample the trunks to estimate dbh for every tree species in relatively dense plots. If you opt to sub-sample, you should do it for each tree species in a representative "quarter" or quadrant of the plot, and then you will come up with an estimated dbh for the entire plot (once data is processed).

When sub-sampling, make sure to denote this as a sub-sample (can note in the Additional comments field) and record the sub-sample of dbh's for each tree species in the appropriate row on the Field Form. Once the data are post-processed and entered into a database, then you will need to record each sub-sampled dbh reading three additional times to come up with a full sample of dbh readings. For example, with a sub-sampled tree dbh of 15 cm, this value of 15 should be entered four times (not just once) when it is entered in the database.

**Estimating Cover:**

There are many ways to estimate cover. Many people who have been in the cover estimation "business" for a long time can do so quickly and confidently without any props and devices. However, to a novice, it may seem incomprehensible and foolhardy to stand in a meadow of 50 different species of plants and systematically be able to list by cover value each one without actually "measuring" them in some way.

Of course, our minds make thousands of estimates of various types every week. We trust that estimating plant cover can be done by anyone with an open mind and an "eye for nature." It's just another technique to learn.

It is very helpful to work initially with other people who know and are learning the technique. In such a group setting, typically a set of justifications for each person's estimate is made and a “meeting of the minds” is reached. This consensus approach and the concomitant calibration of each person’s internal scales is a very important part of the training for any cover estimate project.

An underlying point to remember is that estimates must provide some level of reliable values that are within acceptable bounds of accuracy. If we require an accuracy level that is beyond the realm of possibility, we will soon reject the method for one more quantitative and repeatable. As with any scientific measurement, the requirement for accuracy in the vegetation data is closely related to the accuracy of the information needed to provide a useful summary of it. Put into more immediate perspective - **to allow useful and repeatable analysis of vegetation data, one does not need to estimate down to the exact percent value the cover of a given plant species in a given stand**.

This point relates to two facts: there is inherent variability of species cover in any environment. For example, you would not expect to always have 23% *Pinus ponderosa*, 14% *Calocedrus decurrens*, and 11% *Pinus lambertiana* over an understory of 40% *Chamaebatia foliosa*, 3% *Clarkia unguiculata*, and 5% *Galium bolanderi* to define the Ponderosa pine-Incense cedar/mountain misery/bolander bedstraw plant community. Anyone who has looked at plant composition with a discerning eye can see that plants don’t space themselves in an environment by such precise rules. Thus, we can safely estimate the representation of species in a stand by relatively broad cover classes (such as <1%, 1-5 %, 5-25%, etc.) rather than precise percentages.

The data analysis we commonly use to classify vegetation into different associations and series (TWINSPAN and various cluster analysis programs, for example) is likewise forgiving. When analyzed by quantitative mutivariate statistics information on species cover responds to coarse differences in cover and presence and absence of species, but not to subtle percentage point differences. This has been proven time and again through quantitative analysis of vegetation classification. Many of the world’s plant ecologists estimate cover rather than measure it precisely. Some of the seminal works in vegetation ecology have been based on cover estimates taken by discerning eyes.

With this as a preamble, below we offer some suggestions on estimating cover that have proven helpful. These are simply “tricks” to facilitate estimation, some work better for different situations. You may come up with other methods of estimation that may seem more intuitive, and are equally reliable in certain settings. All values on the relevé protocol that require a cover class estimate, including coarse fragment and vegetation layer information, may rely on these techniques. Just make the appropriate substitutions (using the coarse fragment example substitute, bedrock, stone, cobbles, gravel, and litter for vegetation).

Method 1: The invisible point-intercept transect:

This method works well in relatively low, open vegetation types such as grasslands and scrubs where you can see over the major stand components. For those who have worked with the original CNPS line intercept methodology it’s like counting hits along an imaginary line at regular intervals of the 50 m tape. Here’s how it goes:

> Envision an imaginary transect line starting from your vantage point and running for 50 m (or however many meters you wish, as long as you are still ending up within the same

stand of vegetation you're sampling - never keep counting outside of your homogeneous stand). Now "walk" your eye along this tape for 50 m and visually "take a point" every 0.5 m. Don't worry about precision, just try to "walk" your eye along the line and stop every 0.5 m or at any other regular interval until you reach its end and mentally tally what species you hit. Once you come up with a number of hits for each major species in one imaginary transect, take another transect in another direction and estimate the number of hits on that one. Do this several times (usually 3-4 is enough if you are in a homogeneous stand), then average your results.

This can go quickly in simple environments and in environments where the major species are easily discernable (chaparral, bunch-grassland, coastal scrub, desert scrub). Your average number of hits need not be a total of 100 as in the original transect method, but could be 50 along a 25 m imaginary line (in which case you would multiply by two to get your estimated cover), or 25 along a 12.5 m line (multiply average by 4), etc.

Method 2: Subdivision of sample plot into quadrants:

Many plots, whether they are square, circular, or rectangular, may be "quartered" and have each quadrant's plant cover estimated separately. If the plot is a given even number of square meters (such as 100, 400, or 1000 $m^2$) then you know that a quarter of that amount is also an easily measurable number. If you can estimate the average size of the plants in each of the quarters (e.g, small pinyon pines may be 5 $m^2$ (2.2m x 2.2m), creosote bush may be $2m^2$ (or 1.41 m x 1.41 m), burrobush may be $0.5m^2$) then you simply count the number of plants in each size class and multiply by their estimated size for the cover in a given quadrant. Then you average the 4 quadrants together for your average cover value.

This method works well in vegetation with open-to-dense cover of low species such as grasses or low shrubs, in open woodlands, and desert scrubs.

Method 3; "Squash" all plants into a continuous cover in one corner of the plot :

Another way to estimate how much of the plot is covered by a particular species is to mentally group (or "march", or "squash") all members of that species into a corner of the plot and estimate the area they cover. Then calculate that area as a percentage of the total plot area. This technique works well in herb and shrub dominated plots but is not very useful in areas with trees.

Method 4: How to estimate tree cover:

Cover estimates of tall trees is one of the most difficult tasks for a beginning relevé sampler. However it is possible to do this with consistency and reliability using the following guidelines.

1. Have regular sized and shaped plots that you can easily subdivide.
2. Estimate average crown spread of each tree species separately by pacing the crown diameter of representative examples of trees of each species and then roughly calculating the crown area of each representative species.

3. Add together the estimated crown area of each individual of each species of tree on the plot for your total cover.

Method 5: T<u>he process of elimination technique:</u>

This method is generally good for estimating cover on sparsely vegetated areas where bare ground, rocks, or cobbles cover more area than vegetation. In such a situation it would be advisable to first estimate how much of the ground is not covered by plants and then subdivide the portion that is covered by plants into rough percentages proportional to the different plant species present. For example, in a desert scrub the total plot not covered by plants may be estimated at 80%. Of the 20% covered by plants, half is desert sunflower (10% cover), a quarter is California buckwheat (5% cover), an eighth brittlebush (2.5% cover), and the rest divided up between 10 species of herbs and small shrubs (all less than 1% cover).

Any of these techniques may be used in combination with one another for a system of checks and balances, or in stands that have characteristics lending themselves for a different technique for each layer of vegetation.

In a relevé, cover estimates, using the techniques described above, are made for each taxon as it is recorded on the species list. Estimates are made for each layer in which the taxon was recorded. For example, if individuals of coast live oak occur in the tall, the mid, and the low layer, an estimate is made for Tall CLO, for mid CLO, and for low CLO.

In a traditional relevé, cover is estimated in “cover classes,” not percentages, because of the variability of plant populations over time and from one point to another, even within a small stand. This protocol uses the following 6 cover classes:

Cover Class 1: the taxon in that layer covers < 1 % of the plot area
Cover Class 2: the taxon in that layer covers >1 % - 5 % of the plot area
Cover Class 3a: the taxon in that layer covers >5 - 15 % of the plot area
Cover Class 3b: the taxon in that layer covers >15 - 25 % of the plot area
Cover Class 4: the taxon in that layer covers >25 - 50 % of the plot area
Cover Class 5: the taxon in that layer covers >50 - 75 % of the plot area
Cover Class 6: the taxon in that layer covers > 75% of the plot area

**Percentages** (optional)

This CNPS protocol also encourages observers to estimate percentages if they feel confident in their estimation abilities. This optional step allows the data to be compared more easily to data collected using different methods, such as a line or point intercept. It also instills confidence in the cover estimate of borderline species that are close calls between two cover classes (e.g., a cover class 2 at 5% as opposed to a cover class 3 at 6%). It is particularly useful for calculating cover by the process of elimination techniques and for estimating total vegetation cover (see below) and coarse fragment cover.

## Total Vegetation Cover by Layer

In addition to cover of individual taxa described above, total cover is also estimated for each vegetation layer (e.g. tall, medium, low). This is done using the same cover classes as described above but combines all taxa of a given category. They can be calculated from the species percent cover estimates, but please make sure to disregard overlap of species within each layer. These estimates should be absolute aerial cover, or the “bird’s eye view” of the vegetation cover, in which each category cannot be over 100%.

## National Vegetation Classification height Classes for Vegetation Strata

The relevé method just described calls for estimates of plant cover for each taxon. It is strongly floristically oriented. Another way of considering the relationships between plants in vegetation is by evaluating structure, or physiognomy. The underlying thinking is that life forms within a stand of vegetation occur in response to similar ecological pressures (TNC 1998). Estimation of cover within predetermined height classes is one way to describe the structure of vegetation. Structure of a stand of vegetation also is used in modeling wildlife use of the vegetation (WHR).

For information gathered using this CNPS protocol to be comparable with the wealth of information being gathered by the National Park Service and the Biological Resources Division (BRD) of the USGS it is also necessary for CNPS to estimate vegetation cover according to pre-defined vegetation strata. The following height classes are defined by the USGS/NPS:

| | |
|---|---|
| High Tree | >30 m |
| Medium High Tree | 20-30 m |
| Medium Low Tree | 10-20 m |
| Low Tree | 5-10 m |
| High Shrub | 2-5 m |
| High Herb/ Medium Shrub | 1-2 m |
| Low Shrub | 0.5-1 m |
| Medium Herb | 25-50 cm |
| Low Herb | 0-25 cm |
| Moss/Lichen | |

Cover in these vegetation strata is estimated using the same cover classes as were used for cover of individual taxa. Again, estimation of percentages is optional. Please note that although these strata have names in the national classification, they don’t necessarily have to be populated by the type of species that are their namesake (e.g., tall herbaceous species may be diagnostic of the tall shrub category in the case of a giant reed stand). For this reason we have simply listed the strata by their height classes and have opted not to name them.

We have also requested that you list the diagnostic species for each layer. In this case the diagnostic species is the single species that seems to best characterize that layer it may be the only species found in a given layer, it may be as common as other species in that layer but is more restricted to that single layer, or it may be less common than other species in that layer, but so representative of that layer that it can't be ignored. The cover of the diagnostic species in that layer does not have to be re-estimated as it is estimated in the individual species tally already.

Caveats:

Please consult with the members of the vegetation committee for advice and feedback on proposed vegetation surveys prior on initiating projects.

<u>Notes on the Order and Division of Labor for Data Collection</u>: As with every procedure there are always more and less efficient ways to collect the information requested. Although we respect each field crews' option to choose in what order they collect the data, we suggest the following general rules:

- Work with teams of two for each plot collected.
- Both team members can determine the plot shape and size and lay out the tapes and mark the edges for the plot boundary (see below).
- The two person teams can also divide up tasks of data collection with one member collecting location, environmental (slope, aspect, geology, soil texture, etc.) and plot description information while the other begins the species list. Thus, two clipboards are useful and data sheets that are at first separated (not stapled).
- Following the making of the initial species list and collection of location and environmental data both team members convene to do the estimation of plant cover by species followed by the estimation of total vegetation cover and cover by layer.
- Following that process, the estimation of cover by the up to 10 height strata classes and the listing of the diagnostic species for each is done collaboratively.
- This is followed by the estimation of the coarse fragment information, again done collaboratively.

For egalitarian and familiarization purposes we suggest that the roles be switched regularly between the team members and that if multiple teams are being used in a larger project, that each team member switches frequently between teams, building all-important calibration, and camaraderie among the whole group.

<u>Suggestions for Laying out Plots</u>: If you are laying out a circular plot, work with two or more people. One person stands at the center of the plot and holds the tape case while the other walks the end of the tape out to the appointed distance (radium 5.6 for 100 $m^2$ circle, radius 11.3 m for a 400 $m^2$ circle, and radius 17.6 m for a 1000$m^2$ circle). The walker then fixes the tape end with a pin flag and walks back to the center where he/she instructs the center person to walk in the opposite direction of the already laid out tape radius, stretching the rest of the tape to an equal length (another 11.3 or 17.6 m) to the opposite edge of the plot, where he/she affixes it with another pin flag. This process is again repeated with another tape laid out perpendicular to the first so that an "+ " shape is created . The margins of the circle can be further delineated by

measuring to the center of the circle with an optical tape measure (rangefinder) and marking mid points between the four ends of the crossed tapes.

When laying out square or rectangular plots work with two or more people per team. If doing a rectangle, determine the long axis of the plot first and have one person be stationed at the zero m end of the tape while the other person walks the unrolling tape case out to the appropriate length. The stationary end person can guide the walker, keeping them moving in a straight line. Once that tape is laid out and the far end staked, the team lays out another tape perpendicular to the first, either at one end, using the same type of process. This establishes the width of the rectangle (or square). Using an optical rangefinder and pin-flags, or colored flagging the team can further mark additional points along the other parallel long axis and short axis of the plot (every 5 m for shorter plots or every 10 m for longer plots is suggested) so that the entire plot boundary can be easily visualized.

References:

Barbour M.G., J.H. Burk, and W.D. Pitts 1987. Terrestrial Plant Ecology, Second Edition. Benjamin/Cummings Publishing Co. Menlo Park, CA. 634 pages.

Sawyer and Keeler-Wolf. 1995. Manual of California Vegetation. California Native Plant Society, Sacramento, CA. 471 pages

The Nature Conservancy and Environmental Systems Research Institute. 1994. Final Draft, Standardized National Vegetation Classification System. Prepared for United States Department of the Interior, National Biological Survey, and National Park Service. Arlington, VA. Complete document available at the following website:
http||:biology.usgs.gov/npsveg/fieldmethods.html

Suggested Equipment:
Equipment List: Prices as of May 2000, toll free orders from Forestry Suppliers (1-800-647-5368) (item numbers in parentheses)

| | |
|---|---|
| Chaining pins, surveyor steel (#39167) | $21.50 |
| Fiberglass tapes 2 - 165’/50 m (#39972) | $42.90 |
| Logbook cover 8 ½ “ x 12” (#53200) | $23.95 |
| Perforated flagging (#57960) | $1.95 |
| UTM Coordinate Grid (#45019) | $16.95 |
| Rangefinder, 10-75m (#38973) | $51.60 |
| Silva Compass w/ clinometer (#37036) | $43.90 |
| Garmin GPS 12XL (#39095, #39111) | $244.90 |

**Simplified Key to Soil Texture** (Brewer and McCann, 1982)

Place about three teaspoons of soil in the palm of your hand. Take out any particles >2mm in size, and use the following key to figure out the soil texture (e.g. loamy sand). Then figure out the texture subclass by using the Code List attached (e.g. coarse loamy sand).

A1 Soil does not remain in a ball when squeezed........................................................ sand

A2 Soil remains in a ball when squeezed................................................................ B

B1 Add a small amount of water. Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger. Soil makes no ribbon..........................................................................................loamy sand

B2 Soil makes a ribbon; may be very short.................................................................C

C1 Ribbon extends less than 1 inch before breaking....................................................D

C2 Ribbon extends 1 inch or more before breaking.......................................................E

D1 Add excess water to small amount of soil; soil feels very gritty or at least slightly gritty ...............................................................................................loam or sandy loam

D2 Soil feels smooth.......................................................................................silt loam

E1 Soil makes a ribbon that breaks when 1–2 inches long; cracks if bent into a ring...........F

E2 Soil makes a ribbon 2+ inches long; does not crack when bent into a ring.....................G

F1 Add excess water to small amount of soil; soil feels very gritty or at least slightly gritty...............................................................................sandy clay loam or clay loam

F2 Soil feels smooth.........................................................................silty clay loam or silt

G1 Add excess water to a small amount of soil; soil feels gritty or at least slightly gritty........................................................................................sandy clay or clay

G2 Soil feels smooth......................................................................................silty clay

# CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ FIELD FORM CODE LIST (revised 7/8/02)

**MACRO TOPOGRAPHY**

00 Bench
01 Ridge top (interfluve)
02 Upper 1/3 of slope
03 Middle 1/3 of slope
04 Lower 1/3 of slope (lowslope)
05 Toeslope (alluvial fan/bajada)
06 Bottom/plain
07 Basin/wetland
08 Draw
09 Other
10 Terrace (former shoreline or floodplain)
11 Entire slope
12 Wash (channel bed)
13 Badland (complex of draws & interfluves)
14 Mesa/plateau
15 Dune/sandfield
16 Pediment
17 Backslope (cliff)

**MICRO TOPOGRAPHY**

01 Convex or rounded
02 Linear or even
03 Concave or depression
04 Undulating pattern
05 Hummock or Swale pattern
06 Mounded
07 Other

**SITE IMPACTS**

01 Development
02 ORV activity
03 Agriculture
04 Grazing
05 Competition from exotics
06 Logging
07 Insufficient population/stand size
08 Altered flood/tidal regime
09 Mining
10 Hybridization
11 Groundwater pumping
12 Dam/inundation
13 Other
14 Surface water diversion
15 Road/trail construction/maint.
16 Biocides
17 Pollution
18 Unknown
19 Vandalism/dumping/litter
20 Foot traffic/trampling
21 Improper burning regime
22 Over collecting/poaching
23 Erosion/runoff
24 Altered thermal regime
25 Landfill
26 Degrading water quality
27 Wood cutting
28 Military operations
29 Recreational use (non ORV)
30 Nest parasitism
31 Non-native predators
32 Rip-rap, bank protection
33 Channelization (human caused)
34 Feral pigs
35 Burros
36 Rills
37 Phytogenic mounding

**PARENT MATERIAL**

| | |
|---|---|
| ANDE | Andesite |
| ASHT | Ash (of any origin) |
| GRAN | Granitic (generic) |
| GREE | Greenstone |
| DIOR | Diorite |
| BASA | Basalt |
| OBSI | Obsidian |
| PUMI | Pumice |
| IGTU | Igneous (type unknown) |
| MONZ | Monzonite |
| PYFL | Pyroclastic flow |
| QUDI | Quartz diorite |
| RHYO | Rhyolite |
| VOLC | General volcanic extrusives |
| VOFL | Volcanic flow |
| VOMU | Volcanic mud |
| BLUE | Blue schist |
| CHER | Chert |
| DOLO | Dolomite |
| FRME | Franciscan melange |
| INTR | General igneous intrusives |
| GNBG | Gneiss/biotite gneiss |
| HORN | Hornfels |
| MARB | Marble |
| METU | Metamorphic (type unknown) |
| PHYL | Phyllite |
| SCHI | Schist |
| SESC | Semi-schist |
| SLAT | Slate |
| BREC | Breccia (non-volcanic) |
| CACO | Calcareous conglomerate |
| CASA | Calcareous sandstone |
| CASH | Calcareous shale |
| CASI | Calcareous siltstone |
| CONG | Conglomerate |
| FANG | Fanglomerate |
| GLTI | Glacial till, mixed origin, moraine |
| LALA | Large landslide (unconsolidated) |
| LIME | Limestone |
| SAND | Sandstone |
| SETU | Sedimentary (type unknown) |
| SHAL | Shale |
| SILT | Siltstone |
| DIAB | Diabase |
| GABB | Gabbro |
| PERI | Peridotite |
| SERP | Serpentine |
| ULTU | Ultramafic (type unknown) |
| CALU | Calcareous (origin unknown) |
| DUNE | Sand dunes |
| LOSS | Loess |
| MIIG | Mixed igneous |
| MIME | Mixed metamorphic |
| MIRT | Mix of two or more rock types |
| MISE | Mixed sedimentary |
| CLAL | Clayey alluvium |
| GRAL | Gravelly alluvium |
| MIAL | Mixed alluvium |
| SAAL | Sandy alluvium (most alluvial fans and washes) |
| SIAL | Silty alluvium |
| OTHE | Other than on list |

**SOIL TEXTURE**

| | |
|---|---|
| COSA | Coarse sand |
| MESN | Medium sand |
| FISN | Fine sand |
| COLS | Coarse, loamy sand |
| MELS | Medium to very fine, loamy sand |
| MCSL | Moderately coarse, sandy loam |
| MESA | Medium to very fine, sandy loam |
| MELO | Medium loam |
| MESL | Medium silt loam |
| MESI | Medium silt |
| MFCL | Moderately fine clay loam |
| MFSA | Moderately fine sandy clay loam |
| MFSL | Moderately fine silty clay loam |
| FISA | Fine sandy clay |
| FISC | Fine silty clay |
| FICL | Fine clay |
| SAND | Sand (class unknown) |
| LOAM | Loam (class unknown) |
| CLAY | Clay (class unknown) |
| UNKN | Unknown |
| PEAT | Peat |
| MUCK | Muck |

**DOMINANT VEGETATION GROUP**

| | |
|---|---|
| ***Trees:*** | |
| TBSE | Temperate broad-leaved seasonal evergreen forest |
| TNLE | Temperate or subpolar needle-leafed evergreen forest |
| CDF | Cold-deciduous forest |
| MNDF | Mixed needle-leafed evergreen-cold deciduous. forest |
| TBEW | Temperate broad-leaved evergreen woodland |
| TNEW | Temperate or subpolar needle-leaved evergreen woodland |
| EXEW | Extremely xeromorphic evergreen woodland |
| CDW | Cold-deciduous woodland |
| EXDW | Extremely xeromorphic deciduous woodland |
| MBED | Mixed broad-leaved evergreen-cold deciduous woodland |
| MNDW | Mixed needle-leafed evergreen-cold deciduous woodland |
| ***Shrubs:*** | |
| TBES | Temperate broad-leaved evergreen shrubland |
| NLES | Needle-leafed evergreen shrubland |
| MIES | Microphyllus evergreen shrubland |
| EXDS | Extremely xeromorphic deciduous shrubland |
| CDS | Cold-deciduous shrubland |
| MEDS | Mixed evergreen-deciduous shrubland |
| XMED | Extremely xeromorphic mixed evergreen-deciduous shrubland |
| ***Dwarf Shrubland:*** | |
| NMED | Needle-leafed or microphyllous evergreen dwarf shrubland |
| XEDS | Extremely xeromorphic evergreen dwarf shrubland |
| DDDS | Drought-deciduous dwarf shrubland |
| MEDD | Mixed evergreen cold-deciduous dwarf shrubland |
| ***Herbaceous:*** | |
| TSPG | Temperate or subpolar grassland |
| TGST | Temperate or subpolar grassland with sparse tree |
| TGSS | Temperate or subpolar grassland with sparse shrublayer |
| TGSD | Temperate or subpolar grassland with sparse dwarf shrub layer |
| TFV | Temperate or subpolar forb vegetation |
| THRV | Temperate or subpolar hydromorphic rooted vegetation |
| TAGF | Temperate or subpolar annual grassland or forb vegetation |
| ***Sparse Vegetation*:** | |
| SVSD | Sparsely vegetated sand dunes |
| SVCS | Sparsely vegetated consolidated substrates |

# CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ FIELD FORM

(Revised 4/2/04)

Page_______ of Relevé # ____________

***See code list for italicized fields***

| | **FOR OFFICE USE ONLY** |
|---|---|
| Polygon #____________ or Relevé # ____________ | Permanent Number: |
| Date ______/ ______/ _________ MM DD YYYY Airphoto # | Community Name: Community Number: Occurrence Number: |
| County | Source Code: |
| USGS Quad. 7.5' or 15' (Circle one) | Quad Code: Quad Name: Map Index Number: |
| CNPS Chapter | Update: Yes No (Circle one) |

Landowner

Contact Person

Address

| City | Zip | Phone number |
|---|---|---|

Observers

Relevé plot shape (square, rectangle, triangle, circle, entire stand) ___________________

NOTE: All forest and woodland plots should be 1000m$^2$. All shrub plots should be 400m$^2$. Herb plots should be 100 or 400m$^2$. Please consult with CNPS Vegetation Ecologist on herb plots.

Relevé plot size (length and width of rectangle, or circle-*diameter*) ________ ________ (m.)

Study Plot Revisit? Yes or No (Circle one)

Photo Interpreter Community Code for Polygon ____________________

Other polygons of same type? Yes or No Is plot representative of whole polygon? Yes or No (Circle one) If not, why not? ________________________________________

GPS File # _________ GPS name (or points in file) __________ Start Time _____:_____(am or pm) GPS Datum (from GPS setup) (e.g. WGS 84, NAD 27) ___________

File type: Point or Polygon (circle one) Releve: UTMN ____ ____ ____ ____ ____ ____ ____UTME ___ ___ ___ ___ ___ ___ Error ±_______ ft/m UTM Zone _________

Transect: Start UTME ___ ___ ___ ___ ___ ___UTMN ____ ____ ____ ____ ____ ____ ____End: UTME ___ ___ ___ ___ ___ ___ ___UTMN____ ____ ____ ____ ____ ____ ____

Elevation (ft.)_______________ Slope (°) ___________Aspect (°) ____________ Topography: *Macro* ________________________ *Micro* _______________________

## VEGETATION DESCRIPTION

Dominant Layer ___ 0-0.5 m, ___ 0.5-4 m, ___4 m Preliminary Alliance Name ________________________________________________________________________

Stand Size ____<1 acre, ____1-5 acres, ____ >5 acres *Dominant Vegetation Group* _________________________ *(use codes from code list)*

Structure: Ground _____________ Shrub _____________ Tree _____________ (1. Continuous 2. Intermittent 3. Open)

Phenology: Ground ___________Shrub ____________Tree __________ (Early, Peak, Late)

Wetland Community Type ________________________________________ (Wetland or Upland)

If Community Type = Wetland (see Artificial Keys to Cowardin Systems and Names)

Cowardin System _______________________ Subsystem ______________________Class ______________________

Distance to water (m): Vertical ________________________ Horizontal _________________________ Channel form (if riverine) _________________________ (Straight, Meandering, Braided)

| Adjacent Alliance Location (e.g., North, South, East, or West of stand) | Description (up to 4 species by layer) |
|---|---|
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**Photographs –** *Note position and direction of photo(s) relative to plot*

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## CALIFORNIA NATIVE PLANT SOCIETY RELEVÉ FIELD FORM

Page_______ of Relevé # ____________

### STAND AND ENVIRONMENTAL DESCRIPTION

Trend code ___________
1. Increasing 2. Stable 3. Decreasing
4. Fluctuating 5. Unknown

Site Impact codes __________ __________ __________ __________ __________ __________ __________ __________
(List codes in order, with most significant first)

Site Intensity __________ __________ __________ __________ __________ __________ __________ __________
1. Light 2. Moderate 3. Heavy (List beneath each impact code)

### Site Location and Plot Description

### Site History – *including observations of fire scars, insect/disease damage, grazing/browsing, human disturbance*

### Sensitive Species – *List species observed and GPS UTM's; Estimate size and extent of local populations*

### Unknown Specimens – *List code, identification notes (e.g. Genus, condition of specimen) of unknowns*

### Additional Comments – *Including animal observations, anthropological observations, abiotic features*

### Surface Coarse Fragments and Soils Information (see cover class intervals-**below** ⇓)

| Type: | Fines | Gravel | Cobble | Stone | Boulders | Bedrock | Litter | Water | Living stems | Other (Specify): |
|---|---|---|---|---|---|---|---|---|---|---|
| Descriptor: | Including sand, mud | 2mm-7.5 cm diameter | 7.5-25 cm diam | 25-60cm diam. | >60cm diam. | Including outcrops | Organic matter covering ground | Standing or running water | At ground surface | |
| Cover class (see below): | | | | | | | | | | |
| % Cover*: | | | | | | | | | | |

*note all surface fragments, non-vegetation, living stems, etc., should add up to 100%

***Soil Texture*** __________ ***Parent Material*** __________

**Cover Class Intervals: 1 (<1%), 2 (1-5%), 3a (>5-15%), 3b (>15-25%), 4 (>25-50%), 5 (>50-75%), 6 (>75%)**

| **Height Classes for Vegetation Strata & Cover Estimates** (see cover class intervals **- above ⇑**) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Layer name: | Cryptogam Layer | 0-25 cm | 25-50 cm | 0.5-1 m | 1-2 m | 2-5 m | 5-10 m | 10-20 m | 20-30 m | >30 m. |
| Main species: | | | | | | | | | | |
| Cover class: | | | | | | | | | | |

**CALIFORNIA PLANT COMMUNITIES RELEVÉ FIELD FORM (PART 2)**

SPECIES SHEET (Revised 5/17/01)

Page_______ of Relevé # ____________

**Cover Class Intervals: 1 (<1%), 2 (1-5%), 3a (>5-15%), 3b (>15-25%), 4 (>25-50%), 5 (>50-75%), 6 (>75%)**

*L=Low herbs and subshrubs (<0.5 m.), M=Medium height (0.5 m.-4.0 m.), T=Tall height (>4.0 m.)*

| L | M | T | Vascular plant name or moss/lichen cryptogamic crust cover | Final species determination or Tree dbh | Cover Class | % |
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Total Vegetation Cover (Class): ________ Total Tall________ Total Medium ________ Total Low ________ Total Non-Native ___________

percent cover of above: ________ ________ ________ _________ ___________

**CALIFORNIA PLANT COMMUNITIES RELEVÉ FIELD FORM (PART 2)**

SPECIES SHEET (Revised 5/17/01)

Page_______ of Relevé # ____________

**Cover Class Intervals: 1 (<1%), 2 (1-5%), 3a (>5-15%), 3b (>15-25%), 4 (>25-50%), 5 (>50-75%), 6 (>75%)**

*L=Low herbs and subshrubs (<0.5 m.), M=Medium height (0.5 m.-4.0 m.), T=Tall height (>4.0 m.)*

| L | M | T | Vascular plant name or moss/lichen cryptogamic crust cover | Final species determination or Tree dbh | Cover Class | % |
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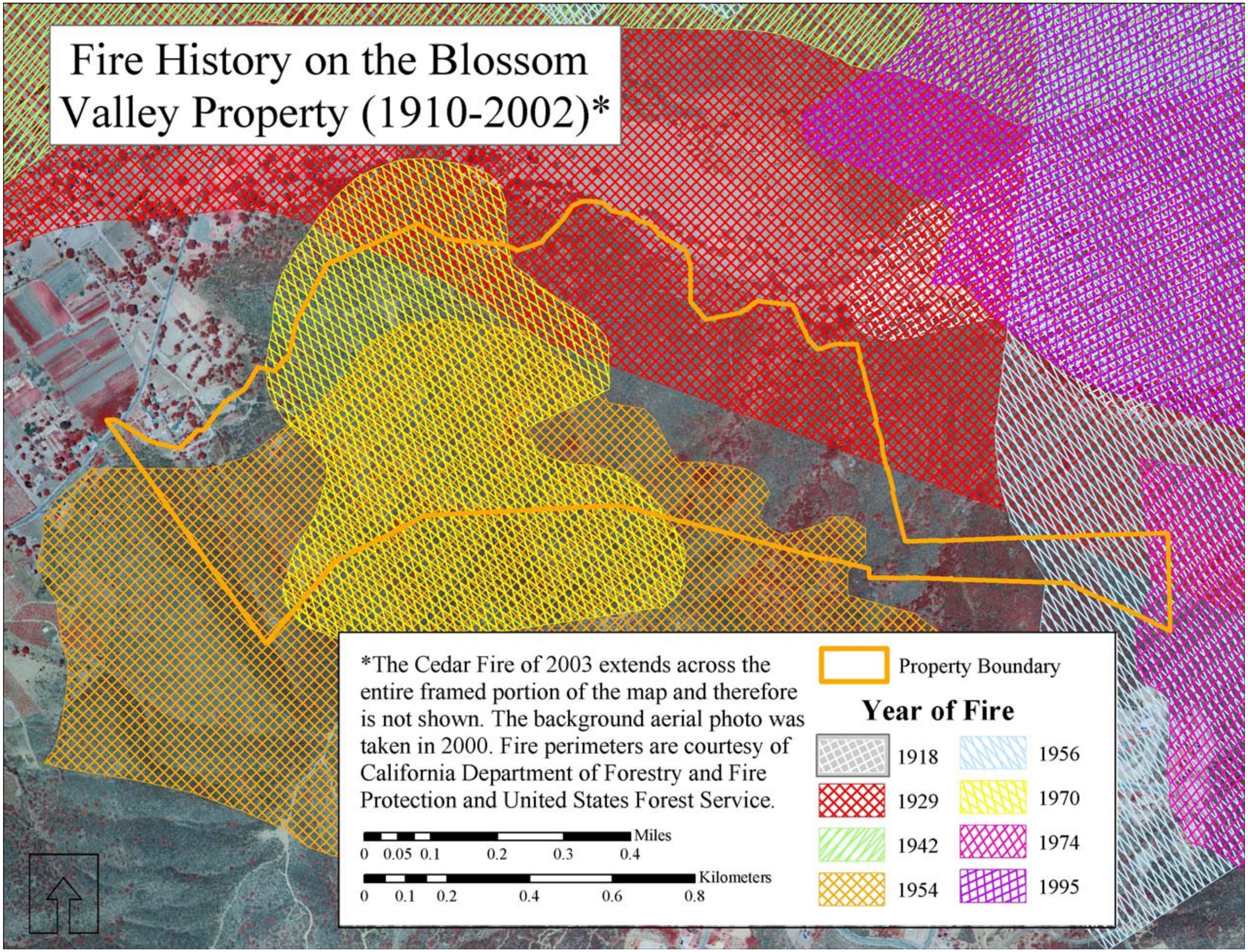
Total Vegetation Cover (Class): ________ Total Tall________ Total Medium ________ Total Low ________ Total Non-Native ___________

percent cover of above: ________ ________ ________ _________ ___________

# Appendix B: Fire History on Blossom Valley Property (1910 – 2002)



Fire History on the Blossom Valley Property (1910-2002)*
*The Cedar Fire of 2003 extends across the entire framed portion of the map and therefore is not shown. The background aerial photo was taken in 2000. Fire perimeters are courtesy of California Department of Forestry and Fire Protection and United States Forest Service.
Property Boundary
Year of Fire
1918
1929
1942
1954
1956
1970
1974
1995
Miles
0 0.05 0.1 0.2 0.3 0.4
Kilometers
0 0.1 0.2 0.4 0.6 0.8

# Appendix C: Protocol for 50:20 Rule

# APPENDIX 4: GUIDELINES TO APPLY THE "50/20 RULE" FOR PLANT SPECIES DOMINANCE

## Example of Determining Dominant Species Following the 50/20 Rule in the Federal Interagency Manual

| Species | | Wetland Indicator | % Cover |
|---|---|---|---|
| | | **Trees** | |
| *Acer rubrum* | | FAC | 70 |
| *Liquidambar styraciflua* | | FAC | 20 |
| *Quercus alba* | | FACU | 10 |
| *Fraxinus pennsylvanica* | | FACW | 30 |
| | | Total cover = | 130 |
| | (Dominance threshold) | 50% of Total cover = | 65 |
| | | 20% of Total cover = | 26 |
| | | **Shrubs** | |
| *Ilex opaca* | | FACU+ | 20 |
| *Vaccinium corymbosum* | | FACW– | 5 |
| *Acer rubrum* | | FAC | 10 |
| *Quercus alba* | | FACU– | 10 |
| | | Total cover = | 45 |
| | (Dominance threshold) | 50% of Total cover = | 22.5 |
| | | 20% of Total cover = | 9 |
| | | **Herbs** | |
| *Thelypteris noveboracensis* | | FAC | 5 |
| *Mitchella repens* | | FACU | 20 |
| *Maianthemum canadense* | | FAC– | 40 |
| | | Total cover = | 65 |
| | (Dominance threshold) | 50% of Total cover = | 32.5 |
| | | 20% of Total cover = | 13 |

Applying the 50/20 rule: Dominant species are determined by first seeing if any single species represents more than half of the total cover (= dominance threshold) for a stratum. So, for the tree stratum, *Acer rubrum* is a dominant (70% > 65%); then check to see if any other species represent 20% or more of the total cover for the tree stratum; then *Fraxinus pennsylvanica* also becomes a dominant. For the shrub stratum, there is no one species that represents more than half of the total shrub cover, so more than one species is needed to exceed the dominance threshold. Starting with top-ranked shrub *Ilex opaca*, then next ranked, *Acer rubrum* and *Quercus alba* have the same cover (tied), so both are taken to exceed the dominance threshold number. Three shrubs are dominant, *Ilex opaca*, *Acer rubrum*, and *Quercus alba*. The remaining shrub does not have more than 20% of the total shrub cover (9%). For herbs, *Maianthemum canadense* alone represents more than half of the herb cover; then check for species with more than 20% of the total herb cover (=13%); so *Mitchella repens* also is a dominant herb.

| | |
|---|---|
| Total number of dominants | = 7 |
| Number of dominants with FAC, FACW, or OBL status including FAC– | = 4 (57.1% of dominants) |
| Number of dominants with FAC, FACW, or OBL status (excluding FAC–) | = 3 (42.9% of dominants) |
| Is this community an indicator of hydrophytic? | Yes, following federal interagency manual, No, following Corps manual. |

Reproduced from Tiner (1999)

# Appendix D: Plant List with Life Form and Preliminary Grouping as to Fire Response

# Appendix D: Plant List with Life Form and Preliminary Grouping as to Fire Response

In order to identify at risk species, plants may be grouped as to their expected response to fire by life history traits. Response to variation in the fire regime varies with regeneration strategies.The groupings below were conceived to function as a resource for future fire management decision-making. Information for dominant shrubs was derived from the USFS Fire Effects Information System (USFS FEIS at http://www.fs.fed.us/database/feis/plants/). The breakdown of life histories used for shrubs and trees is based on Zedler (1977, 1995). Classification of herbaceous species is based on Zedler (1995), Keeley and Keeley (1984), and Keeley *et al*. (1985). Lichens are also considered.

***Obligate Shrub Seeders.*** Primary period of population expansion is post fire. Mature plants killed by fire, recruitment mostly from soil seed bank. Fire-dependent, shallower roots, higher tolerance of water stress, and greater post-fire seedling survivorship than obligate sprouters. Obligate seeders can be lost with a single premature burn. For non-sprouting species 7-15 years are needed for seedlings to mature enough to replenish the population, depending on weather and other factors. These shrubs have only limited dispersal ability and once lost from an area, recolonization from other established populations can be extremely slow (Zedler and Zammit 1989). Obligate seeders can disappear after a long fire-free period, but still remain in the soil seed bank. Absence at Blossom Valley may be an indicator of too-short interval or insufficiently hot fires in the fire history.

***Obligate Shrub/Tree Sprouters.*** Seeds killed by fire, regeneration by vegetative resprouting. Sprouts between fires but may need fire to create gaps for saplings to recruit to the canopy and for population expansion; more resilient to short return intervals for fires (Zedler et al. 1993, Fabritius and Davis 2000), but nevertheless may be severely impacted by sustained high-frequency fire regimes. Successful germination and recruitment of new individuals is correlated with the cooler, moister, low light conditions and increased litter depth associated with mature closed-canopy chaparral that develops over fire-free intervals of 40 years or more (Lloret and Zedler 1991, Keeley 1992a and b, DeSimone 1995). S. Keeley et al. (1981) investigated seedlings of obligate sprouters: Seedlings are established primarily in mature chaparral in gaps resulting from the death of senescing, shorter-lived species. Seedling establishment is often episodic and coincides with periods of above-normal rainfall. Although initial establishment may occur in burned or unburned stands during very wet years, continued survival is favored beneath mature stands on sites that are relatively mesic (north slopes) and which possess a well-developed litter layer. Long-term survival beneath mature chaparral is rare; seedlings are subjected to herbivory by small mammals. Seedlings are most common in very old stands (60 to 100+ years) where long fire free intervals allow for the build-up of seedling populations.

***Facultative Shrub/Tree Seeders/Sprouters (mixed seedling recruitment and vegetative resprouting).*** Mortality of the lignotuber (a woody swelling below or just above the ground, containing buds from which new shoots develop if the top of the plant is cut or burnt) can be very high if fire returns prematurely (Zedler et al. 1983, Haidinger and Keeley 1993). Since a premature fire also kills seedlings that germinated in response to the previous fire, facultative seeders show only limited ability to persist under repeated disturbance.

***Subshrubs (Coastal Sage Scrub).*** Intermediate- to long-lived dominant and canopy species which tolerate fire, but do not require it for establishment; they are sensitive to fire intensity because it affects sprouting ability (Zedler in Kalen et al. 1995). The ability of surviving shrubs to seed in the first year after fire appears to allow coastal sage scrub to persist under fire frequencies that eliminate chaparral (O'Leary 1995).

***Suffrutescents.*** Smaller, short-lived shrubs with slightly woody above ground stem that is killed by fire with no ability to resprout. Fire-stimulated seedling establishment. Obligate seeders following fire but will respond to other disturbances. Mostly absent in older communities or persist in gaps. No special dispersal mechanism. Germination is heat or charate stimulated, with a portion germinating without treatment (Keeley et al. 1985).

***Herbaceous Perennials.*** Underground storage structures such as a bulb, tuber, rhizome, or large tap root; these plants are normally dormant when a fire passes through, so are not directly affected, but benefit from nutrient flush, canopy opening, and other aspects of altered competitive status. Obligate resprouters.

***Herbaceous Perennials Dependent on Seed for Propagation.*** Generally germinate well without treatment, but high temperatures are lethal (Keeley et al. 1985)

***Stem Succulents and Cacti.*** Somewhat fire resistant due to succulence and low fuel loads associated with typically open habitats. No soil seed bank, so population recovery is slow if plants are killed by fire. Variability in different species ability to survive or resprout following fire. Most have some ability to resprout, but most also suffer some degree of mortality if fire is moderate or severe.

***Opportunistic Native Annuals (Zedler 1995).*** Usually found in canopy openings in shrublands. Fire can benefit by opening up canopy cover, but will seed with or without fire.

***Pyrophyte Annuals (Keeley and Keeley 1984).*** Considered fire followers because seeds stored in the soil seed bank are stimulated to germinate following fire by heat, smoke, or charate (ashy burned material). Fire eliminates canopy cover of competing species. No special dispersal mechanisms, largely disappear by third year after fire. Seed is long-lived.

***Lichens.*** Foliose lichens of rocks, bark, and shrubs are highly flammable because they desiccate when relative humidity drops (Brodo et al. 2001). At least some stands should be protected so they can get as old as possible, to act as refugia and sites of inocula to perpetuate lichens (Bowler and Riefner 2003).

| Scientific Name | Common Name | Native or Introduced | Life Form | Preliminary Fire Response Class |
|---|---|---|---|---|
| Rhus ovata S. Watson | sugar bush | N | shrub to small tree | Facultative Shrub/Tree Seeders/Sprouters (mixed seedling recruitment and vegetative resprouting) |
| Xylococcus bicolor Nutt. | mission manzanita | N | shrub, burled | Facultative Shrub/Tree Seeders/Sprouters (mixed seedling recruitment and vegetative resprouting) |
| Adenostoma fasciculatum Hook. & Arn. | chamise | N | shrub, burled | Facultative Shrub/Tree Seeders/Sprouters (mixed seedling recruitment and vegetative resprouting) |
| Malosma laurina (Nutt.) Abrams | laurel sumac | N | shrub, small tree | Facultative Shrub/Tree Seeders/Sprouters (mixed seedling recruitment and vegetative resprouting) |
| Malacothamnus fasciculatus (Torrey & A. Gray) E. Greene | chaparral mallow | N | subshrub, shrub | Facultative Shrub/Tree Seeders/Sprouters (mixed seedling recruitment and vegetative resprouting) |
| Heterotheca grandiflora Nutt. | telegraph weed | N | annual to short-lived perennial herb | Herbaceous Perennial |
| Adiantum jordani K.Mull. | California maiden-hair fern | N | perennial | Herbaceous Perennial |
| Chamaesyce polycarpa (Benth.) Millsp. | spurge | N | perennial | Herbaceous Perennial |
| Chamaesyce sp. | prostrate spurge | N | perennial | Herbaceous Perennial |
| Delphinium parryi A. Gray | blue larkspur | N | perennial | Herbaceous Perennial |
| Dudleya edulis (Nutt.) Moran | lady fingers | N | perennial | Herbaceous Perennial |
| Erigeron foliosus Nutt. | leafy fleabane | N | perennial | Herbaceous Perennial |
| Euphorbia polycarpa var. polycarpa; Chamaesyce polycarpa (Benth.) Millsp. | fairy mats | I | perennial | Herbaceous Perennial |
| Galium angustifolium Nutt. angustifolium | narrow-leaf bedstraw | N | perennial | Herbaceous Perennial |
| Galium nuttallii A. Gray | San Diego bedstraw | N | perennial | Herbaceous Perennial |
| Gnaphalium bicolor Bioletti | bicolored cudweed | N | perennial | Herbaceous Perennial |
| Grindelia robusta | gum plant | N | perennial | Herbaceous Perennial |
| Machaeranthera juncea | rush-like bristleweed | N | perennial | Herbaceous Perennial |
| Marrubium vulgare L. | horehound | I | perennial | Herbaceous Perennial |

| Scientific Name | Common Name | Native or Introduced | Life Form | Preliminary Fire Response Class |
|---|---|---|---|---|
| Scrophularia californica var. floribunda | coast figwort, bee plant | N | perennial | Herbaceous Perennial |
| Silene laciniata Cav. ssp. major C.L. Hitchc. & Maquire | Indian pink | N | perennial | Herbaceous Perennial |
| Vicia americana Willd. var. americana | American vetch | N | perennial | Herbaceous Perennial |
| Typha sp. | cattail | N | perennial from tough rhizomes | Herbaceous Perennial |
| Nassella sp. | needlegrass | N | perennial grass | Herbaceous Perennial |
| Stipa coronata | giant stipa | N | perennial grass | Herbaceous Perennial |
| Stipa lepida | foothill stipa | N | perennial grass | Herbaceous Perennial |
| Elymus sp. | wildrye | N | perennial grass, sometimes from rhizomes | Herbaceous Perennial |
| Calystegia macrostegia | chaparral morning-glory | N | perennial or subshrub | Herbaceous Perennial |
| Solanum douglasii Dunal | Douglas nightshade | N | perennial or subshrub | Herbaceous Perennial |
| Allium sp. | wild onion | I | perennial, bulb | Herbaceous Perennial |
| Bloomeria crocea (Torrey) Cov. | common goldenstar | N | perennial, corm | Herbaceous Perennial |
| Dichelostemma pulchellum; Dichelostemma capitatum (Benth.) A. W. Wood | wild hyacinth | N | perennial, corm | Herbaceous Perennial |
| Paeonia californica Torrey & A. Gray | California peony | N | perennial, sub-shrub | Herbaceous Perennial |
| Foeniculum vulgare Mill. | fennel | I | perennial, tap-root | Herbaceous Perennial |
| Marah macrocarpus E. Greene | wild cucumber | N | perennial, tuber | Herbaceous Perennial |
| Sisyrinchium bellum Wats. | blue-eyed grass | N | perennial | Herbaceous Perennial |
| Dicentra chrysantha | golden eardrops | N | perennial | Herbaceous Perennials Dependent on Seed for Propagation |
| Ceanothus tomentosus C. Parry ssp. olivaceus | Ramona ceanothus | N | shrub, small tree | Obligate Seeder |
| Rubus ursinus | California blackberry | N | perennial to shrub | Obligate Sprouter |
| Rhamnus crocea Nutt. | spiny redberry | N | shrub | Obligate Sprouter |
| Rhus integrifolia (Nutt.) Brewer & Watson | lemonadeberry | N | shrub | Obligate Sprouter |
| Sambucus mexicana C. Presl | blue elderberry | N | shrub | Obligate Sprouter |
| Toxicodendron diversilobum | western poison oak | N | shrub | Obligate Sprouter |
| Cercocarpus betuloides Torrey & A. Gray | mountain-mahogany | N | shrub, small tree | Obligate Sprouter |

| Scientific Name | Common Name | Native or Introduced | Life Form | Preliminary Fire Response Class |
|---|---|---|---|---|
| Heteromeles arbutifolia (Lindley) Roemer | toyon, Christmas berry | N | shrub, small tree | Obligate Sprouter |
| Tamarix sp. | tamarisk | N | shrub, tree | Obligate Sprouter |
| Eucalyptus sp. | gum tree | I | tree | Obligate Sprouter |
| Platanus racemosa Nutt. | western sycamore | N | tree | Obligate Sprouter |
| Populus fremontii | Fremont cottonwood | N | tree | Obligate Sprouter |
| Quercus berberidifolia | scrub oak | N | tree | Obligate Sprouter |
| Quercus dumosa Nutt. | Nuttall's scrub oak | N | tree | Obligate Sprouter |
| Salix gooddingii var. gooddingii | black willow | N | tree | Obligate Sprouter |
| Salix lasiolepis var. bracelinae | arroyo willow | N | tree | Obligate Sprouter |
| Salix sp. | willow | N | tree | Obligate Sprouter |
| Vitis girdiana | desert grape | N | woody vine | Obligate Sprouter |
| Quercus agrifolia var. agrifolia | coast live oak | N | tree | Obligate Sprouter |
| Amsinckia intermedia | yellow fiddleneck | N | annual | Opportunistic Annual |
| Anagallis arvensis L. | scarlet pimpernel, poor-man's weatherglass | I | annual | Opportunistic Annual |
| Brassica nigra (L.) Koch. | black mustard | I | annual | Opportunistic Annual |
| Bromus hordeaceus L. | smooth brome | I | annual | Opportunistic Annual |
| Camissonia californica (T.& G.) Raven | false-mustard | N | annual | Opportunistic Annual |
| Centaurea melitensis L. | tocolote, star-thistle | I | annual | Opportunistic Annual |
| Chenopodium album L. | lamb's quarters, pigweed | I | annual | Opportunistic Annual |
| Clarkia delicata | delicate clarkia | N | annual | Opportunistic Annual |
| Conyza canadensis (L.) Cronq. | horseweed | N | annual | Opportunistic Annual |
| Crassula erecta | stonecrop | I | annual | Opportunistic Annual |
| Cryptantha intermedia (A. Gray) E. Greene | nievita | N | annual | Opportunistic Annual |
| Eremocarpus setigerus (Hook.) Benth. | dove weed | N | annual | Opportunistic Annual |
| Eriastrum sp. | eriastrum | N | annual | Opportunistic Annual |
| Erodium cicutarium (L.) L. Her. | white-stemmed filaree | I | annual | Opportunistic Annual |
| Erodium sp. | filaree, storksbill | I | annual | Opportunistic Annual |
| Filago gallica L. | narrow-leaf herba impia | I | annual | Opportunistic Annual |
| Gastridium ventricosum (Gouan) Schinz & Thell. | nit grass | I | annual | Opportunistic Annual |
| Hemizonia fasciculata (DC.) Torrey & A. Gray | tarweed | N | annual | Opportunistic Annual |
| Hemizonia sp. (DC.) Torrey & A. Gray | tarplant | N | annual | Opportunistic Annual |

| Scientific Name | Common Name | Native or Introduced | Life Form | Preliminary Fire Response Class |
|---|---|---|---|---|
| Hypochaeris glabra L. | smooth cat's ear | I | annual | Opportunistic Annual |
| Lamarckia aurea (L.) Moench. | goldentop | I | annual | Opportunistic Annual |
| Layia platyglossa | tidy tips | N | annual | Opportunistic Annual |
| Lupinus hirsutissimus Benth. | stinging lupine | N | annual | Opportunistic Annual |
| Mimulus brevipes Benth. | hillside monkeyflower | N | annual | Opportunistic Annual |
| Navarretia hamata E. Greene | hooked navarretia | N | annual | Opportunistic Annual |
| Pectocarya linearis ssp. ferocula | slender pectocarya | N | annual | Opportunistic Annual |
| Plantago erecta Morris | dot-seed plantain | N | annual | Opportunistic Annual |
| Pterostegia drymarioides Fischer & C. Meyer | California thread-stem | N | annual | Opportunistic Annual |
| Salsola iberica Senne & Pau | Russian-thistle | I | annual | Opportunistic Annual |
| Salsola tragus L. | Russian thistle, tumbleweed | I | annual | Opportunistic Annual |
| Salvia columbariae | chia | N | annual | Opportunistic Annual |
| Sisymbrium irio L. | London rocket | I | annual | Opportunistic Annual |
| Sonchus oleraceus L. | common sow thistle | I | annual | Opportunistic Annual |
| Stephanomeria virgata (Benth.) ssp. virgata | slender stephanomeria | N | annual | Opportunistic Annual |
| Stylocline gnaphaloides Nutt. | everlasting nest straw | N | annual | Opportunistic Annual |
| Xanthium strumarium var. canadense | cocklebur | N | annual | Opportunistic Annual |
| Avena sp. | wild oat | I | annual grass | Opportunistic Annual |
| "Bromus rubens L.; Bromus madritensis L. ssp. rubens (L.) Husn. | "red brome | I | annual grass | Opportunistic Annual |
| Lepidium nitidum Torrey & A. Gray var. nitidum | shining peppergrass | N | annual grass | Opportunistic Annual |
| Poa annua L. | annual bluegrass | I | annual grass | Opportunistic Annual |
| Schismus barbatus (L.) Thell. | Mediterranean grass | I | annual grass | Opportunistic Annual |
| Carduus pycnocephalus L. | Italian thistle | I | annual or biennial | Opportunistic Annual |
| Agrostis sp. | awned bent grass | I | annual or perennial herb | Opportunistic Annual |
| Trifolium sp. | clover | N | annual or perennial herb | Opportunistic Annual |
| Viola pedunculata Torrey & A. Gray | Johnny-jump up | N | annual or perennial herb | Opportunistic Annual |
| Camissonia bistorta (Torrey & A. Gray) Raven | California sun cup | N | annual or short-lived perennial herb | Opportunistic Annual |
| Gnaphalium californicum DC. | green everlasting | N | annual, biennial | Opportunistic Annual |
| Lolium multiflorum Lam. | Italian ryegrass | I | annual, biennial | Opportunistic Annual |

| Scientific Name | Common Name | Native or Introduced | Life Form | Preliminary Fire Response Class |
|---|---|---|---|---|
| Picris echioides L. | bristly ox-tongue | I | annual, biennial | Opportunistic Annual |
| Chorizanthe fimbriata Nutt. | fringed spineflower | N | annual, perennial herb | Opportunistic Annual |
| Brassica geniculata; Hirschfeldia incana | short-podded perennial mustard | N | biennial, perennial herb | Opportunistic Annual |
| Cryptantha sp. | cryptantha | N | annual, biennial, perennial herb | Opportunistic Annual, but seems to benefit from fire |
| Eschscholzia californica Cham. | California poppy | N | annual (or perennial herb from heavy taproot) | Opportunistic Annual, Sprouter |
| Antirrhinum kelloggii E. Greene | wild snapdragon | N | annual | Pyrophyte Annual |
| Caulanthus heterophyllus (Nutt.) Payson var. heterophyllus | slender-pod jewel flower | N | annual | Pyrophyte Annual |
| Chaenactis artemisiifolia (A. Gray) A. Gray | white pincushion | N | annual | Pyrophyte Annual |
| Emmenanthe penduliflora Benth. | whispering bells | N | annual | Pyrophyte Annual |
| Lotus salsuginosus E. Greene var. salsuginosus | alkali lotus | N | annual | Pyrophyte Annual |
| Phacelia cicutaria E. Greene var. hispida (A. Gray) J. Howell | caterpillar phacelia | N | annual | Pyrophyte Annual |
| Phacelia parryi Torrey | Parry phacelia | N | annual | Pyrophyte Annual |
| Phacelia sp. | phacelia | N | annual | Pyrophyte Annual |
| Antirrhinum nuttallianum Benth. in DC. | snapdragon | N | annual, rarely biennial | Pyrophyte Annuals |
| Daucus pusillus Michx | rattlesnake weed | N | annual, biennial, taprooted | Sprouter |
| Stellaria media (L.) Villars | common chickweed | I | annual, slender taproot | Sprouter |
| Apiastrum angustifolium Nutt. in Torrey & A. Gray | wild celery | N | annual, taproot | Sprouter |
| Sanicula sp. | sanicle, snakeroot | N | biennial, perennial herb, rhizomed or tap- or tuberous-rooted | Sprouter |
| Sanicula arguta Coult. & Rose | little-jim sanicle | N | Biennial, perennial herb, taproot | Sprouter |
| Calochortus weedii Wood var. weedii | weed mariposa | N | bulb | Sprouter |
| Chlorogalum parviflorum Wats. | amole, soap plant | N | bulb | Sprouter |

| Scientific Name | Common Name | Native or Introduced | Life Form | Preliminary Fire Response Class |
|---|---|---|---|---|
| Helianthus gracilentus A. Gray | slender sunflower | N | perennial, tap-root | Sprouter |
| Dudleya pulverulenta (Nutt.) Britt. & Rose ssp. pulverulenta | chalk lettuce | N | perennial | Stem Succulents and Cacti |
| Yucca whipplei ssp. whipplei | Our Lord's Candle | N | subshrub or tree-like | Stem Succulents and Cacti |
| Corethrogyne filaginifolia var. virgata | sand-aster | N | perennial sub-shrub | Subshrub |
| Artemisia douglasiana | California mugwort | N | perennial, rhi-zomes | Subshrub |
| Lessingia filaginifolia (Hook. & Arn.) M.A. Lane var. filaginifo-lia | California-aster | N | perennial, sub-shrub | Subshrub |
| Mirabilis californica A. Gray | wishbone bush | N | perennial, sub-shrub | Subshrub |
| Eriogonum fasciculatum Benth. | California buckwheat | N | shrub | Subshrub (Coastal Sage Scrub) |
| Artemisia californica Less. | California sagebrush | N | shrub | Subshrub (Coastal Sage Scrub) |
| Hazardia squarrosa (Hook. & Arn.) E. Greene | sawtoothed goldenbush | N | shrub | Subshrub/Suffrutescent |
| Keckiella cordifolia (Benth.) Straw | climbing penstemon | N | subshrub, shrub | Subshrub/Suffrutescent |
| Mimulus puniceus | red bush monkeyflower | N | annual to shrub | Sub-shrub/Suffrutescent |
| Mimulus aurantiacus Curtis | bush monkeyflower | N | subshrub, shrub | Sub-shrub/Suffrutescent |
| Salvia apiana | white sage | N | perennial, sub-shrub | Subshrubs (Coastal Sage Scrub) |
| Helianthemum scoparium Nutt. | peak rush-rose | N | perennial, shrub | Suffrutescent |
| Eriophyllum confertiflorum (DC.) A. Gray var. confertiflo-rum | golden-yarrow | N | subshrub or shrub | Suffrutescent |
| Lotus scoparius (Nutt. in Tor-rey & A. Gray) Ottley var. sco-parius | California broom, deer-weed | N | perennial | Suffrutescents |
| Cuscuta californica Hook. & Arn. | dodder | N | annual, parasitic vine | |
| Chorizanthe procumbens Nutt. | prostrate spineflower | N | annual, peren-nial herb | |
| Gilia sp. | gilia | N | annual, peren-nial herb | |
| Harpagonella palmeri | Palmer's grapplinghook | N | annual, peren-nial herb | |
| Hordeum sp. | common barley | I | annual grass | |
| Lasthenia sp. | goldfields | N | annual herb | |

| Scientific Name | Common Name | Native or Introduced | Life Form | Preliminary Fire Response Class |
|---|---|---|---|---|
| Microseris sp. | microseris | N | annual, perennial herb | |
| Pellaea mucronata D. Eaton | bird's-foot fern | N | fern | |
| Pentagramma triangularis ssp. viscosa (D. Eaton) G. Yatskievych, M.D. Windham & E. Wollenweber | silverback fern | N | fern | |
| Pityrogramma triangularis var. viscosa | silverback fern | N | fern | |
| Selaginella bigelovii L. Underw. | Bigelow clubmoss | N | club moss | |
| Piptatherum miliaceum (L.) Cosson | smilo grass | I | perennial grass | |
| Carex sp. | sedge | N | perennial sedge | |
| Carex triquetra Boott. | triangular-fruit sedge | N | perennial, rhizomes | |
| Polypodium californicum Kaulf. | California polypody | N | perennial, rhizomes | |
| Baccharis glutinosa; Baccharis salicifolia | mule fat | N | shrub | |
| Baccharis sarothroides A. Gray | broom baccharis | N | shrub | |
| Brickellia californica (Torrey & A. Gray) A. Gray | California brickellbush | N | shrub | |
| Haplopappus squarrosus Hook. & Arn. ssp. grindelioides | saw-toothed goldenbush, hazardia | N | shrub | |
| Isomeris arborea Nutt. | bladderpod | N | shrub | |
| Lonicera subspicata Hook. & Arn. | southern honeysuckle | N | shrub | |
| Rhamnus ilicifolia | holly-leaf red berry | N | shrub | |
| Salvia clevelandii | cleveland sage | N | shrub | |
| Viguiera laciniata A. Gray | San Diego County viguiera | N | shrub | |
| Ricinus communis L. | castor bean | I | shrub, sometimes tree-like | |
| Haplopappus venetus | goldenbush | N | subshrub | |
| Porophyllum gracile | odora | N | subshrub | |
| Gutierrezia bracteata | matchweed | N | subshrub | |
| Nicotiana glauca Grah. | tree tobacco | I | tree, shrub | |
| Clematis pauciflora Nutt. | ropevine | N | woody vine | |

# Appendix E: Example Field Survey Forms

# TECHNICAL NOTES

## Modified Step-point System for Botanical Composition and Basal Cover Estimates

CLENTON E. OWENSBY

**Highlight:** *Instructions for use and assembly are presented for a modified step-point sampler. Modifications were made to eliminate bias and to increase ease of use.*

Basal-hit, single-point sampling in botanical census has been shown to be effective and efficient (Goodall, 1952). Evans and Love (1957), describing the step-point method of sampling, concluded that the method's accuracy and objectivity made it suitable for valid analysis of field research plots.

Step-point sampling uses a single pin lowered perpendicularly to the soil surface through a notch in the toe of the sampler's boot at a 30° angle to the ground. Basal or foliage hits may be recorded. Nonplant hits are recorded as misses and the species nearest to the point in a forward, 180° arc is recorded. Information is obtained for basal or foliage cover of individual species, their collective total, and for percentage composition. An estimated frequency may be obtained by grouping points.

Subconscious selection of plants that affects pin placement is a serious defect (Cain and Castro, 1959; Goodall, 1952), which random selection of a single pin from a point frame with several pins would alleviate (Goodall, 1952). Using a single pin instead of groups of pins reduces the number of points needed for comparable accuracy (Blackman, 1935; Goodall, 1952; Greig-Smith, 1957). Single pin measurements require one-third as many points as groups of pins do for comparable accuracy (Goodall, 1952), and time required is reduced to one-sixth or one-eighth that required for the point-frame method (Evans and Love, 1957).

The point-frame modification presented here seeks to eliminate subconscious bias in point placement and to make single-point sampling easier.

The author is research agronomist, Department of Agronomy, Kansas State University, Manhattan.

ment of Agronomy, Kansas Agr. Exp. Sta., Kansas State University, Manhattan.

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### Point-frame Design

The basic design of the point frame is shown in Figure 1. The sampling point (a) is offset from the initial ground contact (b) to alleviate subconscious placement by the sampler. The distance it is offset varies with the angle the point rod makes with the horizontal. The inset shows the

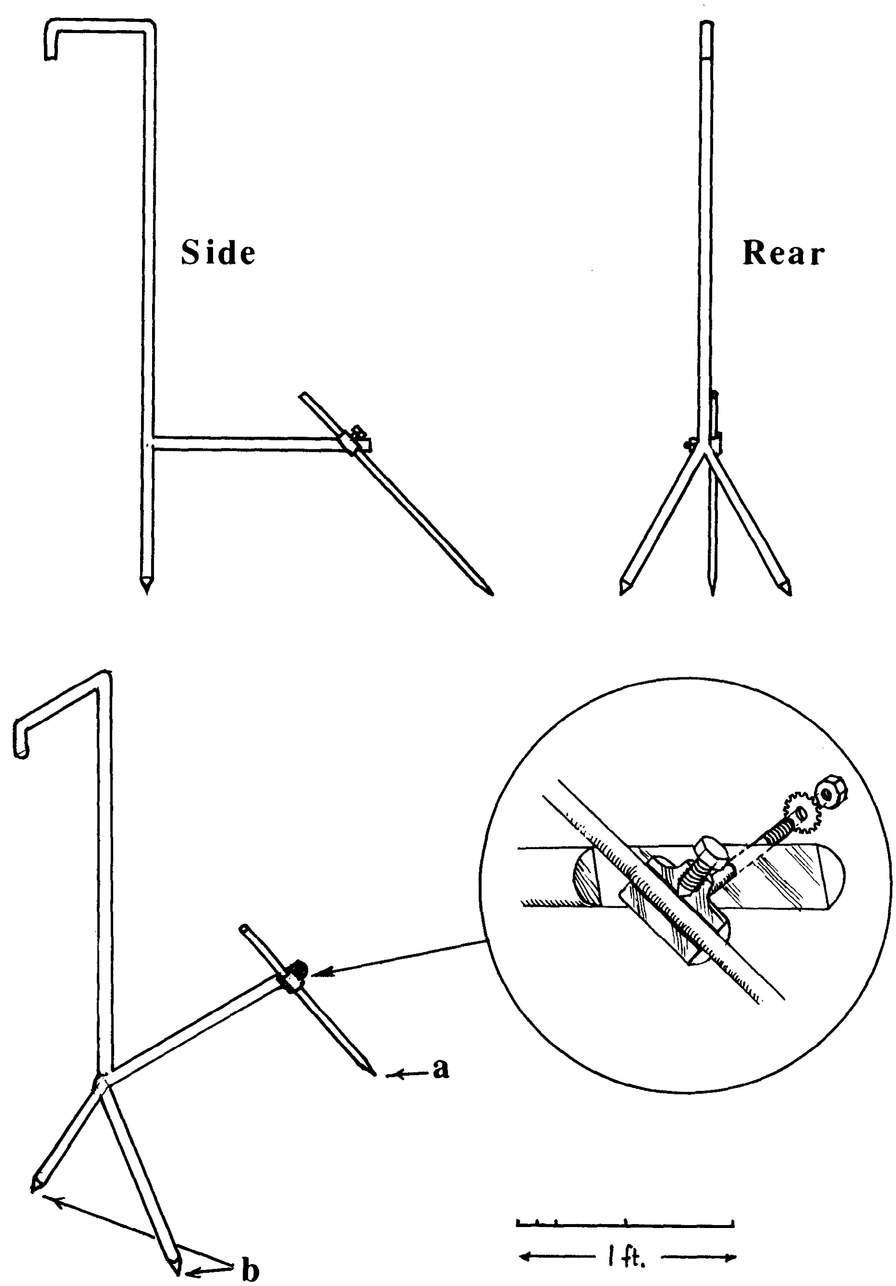


**Fig. 1.** *Diagram of the modified step-point sampler (a–sample point, b–initial contact points).*

pivot point mechanism, which adjusts horizontal angle and sample rod length. That enables the sampler to vary sample rod angle and length for sampling different vegetative types. Tinney et al. (1937) indicated better accuracy with an inclined point. Two legs sharpened at the tip (b) are used to eliminate side movement of the sample rod as it moves through the vegetation. Construction is of steel rod or tubular steel with the sample rod being hardened steel with a long-tapered, fine point.

## Procedure

The sampler follows a designated line through the plot area. One leg of the point frame is placed at the end of the sampler's boot each time his right (or left) foot hits the ground. The point frame is leaned back towards the sampler on initial ground contact and is leaned forward until point contact is made with a plant crown or bare soil. That enables the sampler to watch its progress much the same as with a point frame. Species recorded are those whose bases are contacted by the point. If no basal hit occurs, the species nearest the point forward (180° arc) is recorded. Basal hit or miss information is also recorded for basal cover estimates. Species and basal cover information are coded by number for ease in computer analysis.

Preliminary use of the device showed it to be easily used with two samplers and a recorder. The two samplers read from opposite feet with one moving while the other was reading the sample point. That permitted the samplers to read 3,000 to 4,000 points per 7-hour day, which covered about 60 acres in the experimental area. Monotony reduced the number taken. To remain alert and avoid inaccurate work, frequent rest breaks are recommended. An average of 2,500 to 3,000 points per day, we think, is realistic.

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# The Step-Point Method of Sampling—A Practical Tool in Range Research

RAYMOND A. EVANS AND R. MERTON LOVE

*Assistant Specialist and Professor of Agronomy and Agronomist, Department of Agronomy, University of California, Davis, California*

Step-point sampling provides a rapid, accurate, and objective method of determining the botanical composition and total cover of herbaceous vegetation. These determinations enable one to evaluate the forage stand on any specific area. The method has been used to inventory herbaceous cover relative to soil type, woody vegetation cover, aspect and slope, and other environmental factors by the Soil-Vegetation Survey in California. Values have been assessed by this method to seeding and fertilizer trials in irrigated pastures and improved dryland ranges. Changes in botanical composition of improved ranges resulting from grazing manipulation have also been recorded by use of this sampling method.

The step-point method of sampling is based on point quadrat sampling. Point quadrat sampling had its origin in a suggestion made to E. B. Levy by Dr. L. Cockayne in 1925 to the effect that a pin point would prove mathematically sound as the basis of a method for charting vegetation (Levy and Madden, 1933). Cockayne vaguely referred to point quadrat sampling in 1926. From 1927 to 1930 a number of papers by Levy, Smith, and Davies appeared recording results obtained by the use of this method. The first description of the method was that of Du Rietz in 1932; and in 1933 Levy and Madden published a full account of it (Goodall, 1952). The method used by Levy consisted of taking a number of locations at random and recording all vegetation that was hit as the point was projected from above into the sward. He used a frame of 10 pins spaced 2 inches apart (Levy and Madden, 1933). The use of inclined points in a frame was first developed by Tinney, *et al.* (1937). Eden and Bond (1948) first used a single point for analysis of herbaceous vegetation.

Crocker and Tiver (1948) used the point quadrat method for purposes of a grassland survey which they conducted in South Australia. Results of Goodall's study (1952) showed that when individual points are taken, about one-third the number are needed for the same level of precision as when points grouped in a frame are used. Biswell, *et al.* (1953) compared data of initial hits only wth those of all hits of each pin. Their results show that in terms of the more abundant species of the stand there was less than 3 percent difference in composition between methods. Distribution of sampling points used by various operators in point-frame sampling (ten pins in a frame) have been either at random, in transects, or grouped in individual plots or quadrats (Brown, 1954). Eden and Bond (1948) approximated an even spacing of single pins in their sampling. Brown (1954) stated that the general opinion of investigators using the point method of sampling is that it has every prospect of becoming the accepted one for large scale surveys as well as for exact field analyses.

## Procedure

In step-point sampling a single pin is used rather than pins grouped in a frame. An individual step-point is established by the sampler lowering the sampling pin to the ground, guided by a definite notch on the toe of his boot (Fig. 1). At each step-point the sampler places his boot at a 30° angle to the ground to avoid disturbing plants in the immediate vicinity,

FIGURE 1. The sampler is establishing a sampling point with the use of a pin and a notch on the toe of his boot—the step-point.

and lowers the pin perpendicularly to the sole of the boot until it either hits an herbaceous plant or the ground. The first herbaceous plant hit by the point or the side of the point of the pin is recorded. If no herbaceous plant is hit the pin is pushed into the ground and the plant nearest to it in a forward direction (180° arc) is recorded.

The position of the step-points are determined by specific designs. For investigation of the effects of a particular treatment, *e.g.*, grazing manipulation, fertilizer or seeding treatment, transects are run across the field or plot. The transects are equally spaced and the sampling points within transects are also equally spaced. Usually, 300 to 500 points are sufficient to encompass the variability found in a field or local area in which the vegetation is essentially of one type. Where variation of aspect, slope or woody vegetation is encountered in a specific field or sampling area, separate samples of smaller size (100 to 200 points) are usually taken. Information concerning variation resulting from the diverse sections of the field as well as mean values is obtained in this manner. In small sub-plots of fertilizer or seeding trials, the number of points per treatment varies from 100 to 300 depending upon the variation within the area to be sampled.

For purposes of the Soil-Vegetation Survey the sampling design covers an acre area and consists of 100 step-points. In the design there are 5 equally-spaced transects of 20 equally-spaced points (Fig. 2). The location of the design is determined by a randomly placed initial point. The specific area to be sampled is determined by criteria of soil, topography, and cover of vegetation. By this procedure the sampling results are correlated with a specific set of environmental factors. An experienced operator can sample an acre area using the step-point method in about one-half hour.

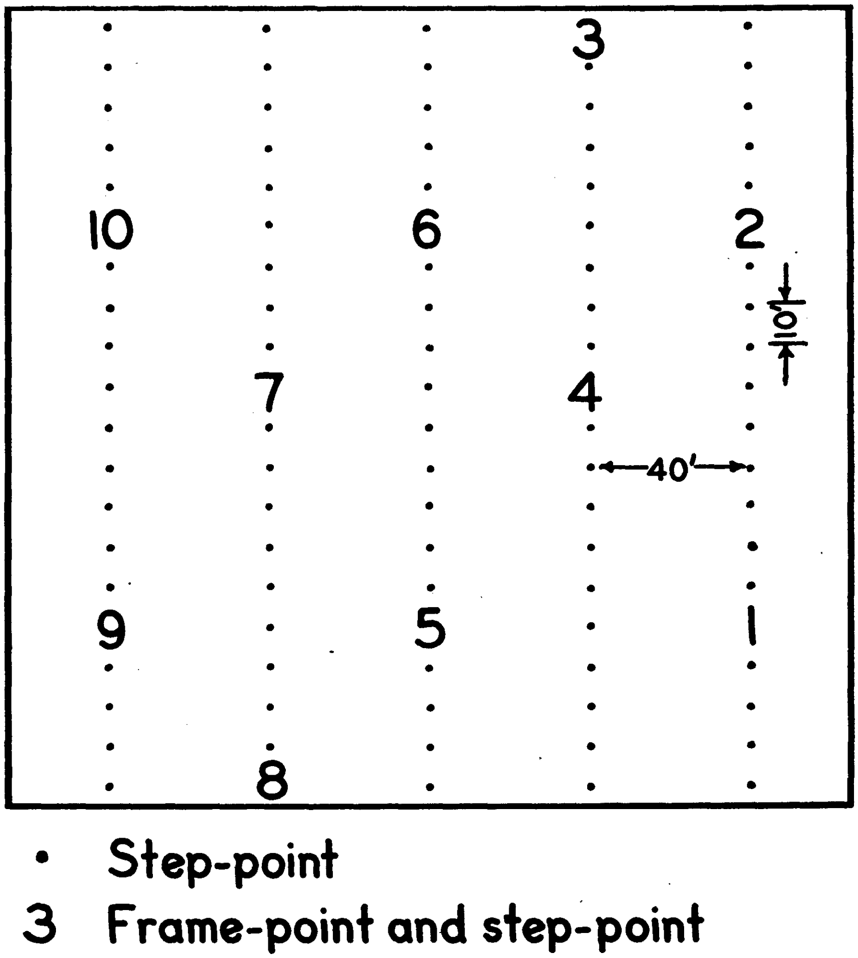


FIGURE 2. Sampling design for grassland survey plots.

Since readings of the sampling points are taken in terms of herbaceous plants and not of bare ground, an estimation method for determining total ground cover is incorporated in the technique. It is felt that to measure botanical composition and total cover by the point method alone would require a larger number of points for a valid sample. This is particularly true when sampling an area of low percentage cover of herbaceous vegetation. However, by combining the point method with an estimation method for determining total ground cover the number of sampling points can be reduced. Further, the intensity of sampling for botanical composition will remain constant regardless of the percentage cover. A sample of one hundred points will determine botanical composition with one hundred hits on herbaceous plants even when the areas sampled are of low percentage cover. Otherwise, for example, a sample of 1,000 points would be required to afford 100 hits on herbaceous vegetation in an area of 10 percent cover.

**Table 1. Classes of total herbaceous cover.**

| Cover class | percent |
|---|---|
| 0 | 0 — 5 |
| 1 | 6 — 15 |
| 2 | 16 — 25 |
| 3 | 26 — 35 |
| 4 | 36 — 45 |
| 5 | 46 — 55 |
| 6 | 56 — 65 |
| 7 | 66 — 75 |
| 8 | 76 — 85 |
| 9 | 86 — 95 |
| 10 | 96 —100 |

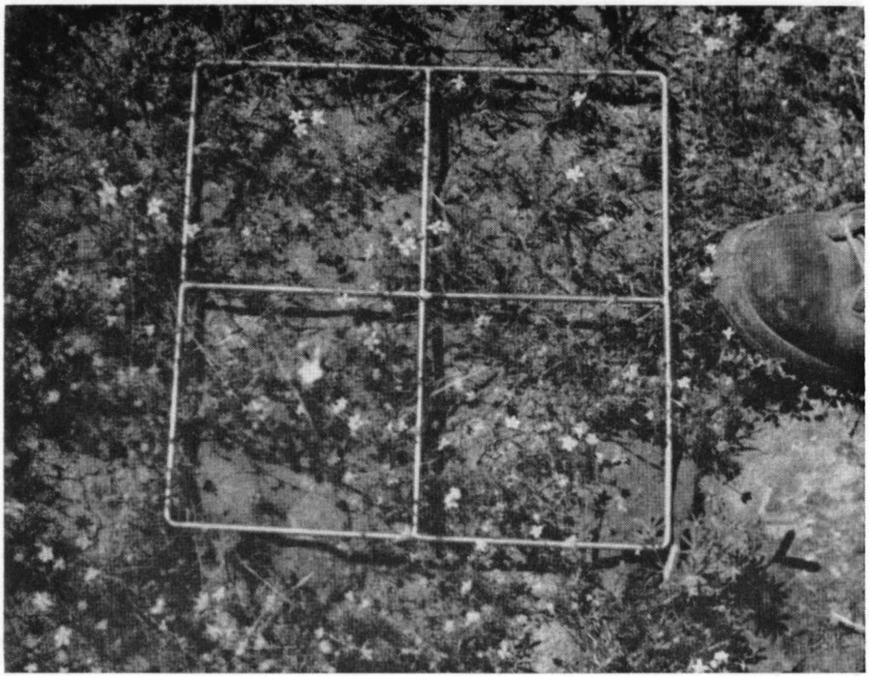

FIGURE 3. The frame is placed by aligning a cross bar with the notch on the toe of the boot. An estimate is made of the total cover of the herbaceous vegetation with the use of the square-foot frame—establishment of a frame point.

Estimates of total ground covered by herbaceous plants are made with the use of a square-foot frame subdivided into four 6-inch squares (Fig. 3). The estimates are made in terms of 10 percent classes (Table 1). Concepts of estimation are standardized among different operators if more than one is sampling and are checked with total cover values using the point-frame. The locations of the square-foot frame readings are incorporated within the sampling designs. Ten frame-points are used with 100 step-points for survey work (Fig. 2). Twenty frame readings are incorporated in the 300 step-point design. Sixteen to twenty frame readings are ordinarily used to sample one treatment in seeding or fertilizer plot work. Exact location of the square-foot frame is determined by aligning one of the subdivision crossbars of the frame with the notch on the toe of the sampler's boot (Fig. 3). This is done at specified step-points according to the sampling design.

For evaluation of a forage stand with respect to a range manipulation practice the sampling is done in terms of the pertinent species. If one is interested in recording data on one or a few key species, only these need be identified, and all others can be put into a general category. This saves much time in species identification, especially in seasons when inflorescences are not present. For the California grassland survey work herbaceous plants are grouped into six categories. They are: desirable and undesirable annual grasses; desirable and undesirable perennial grasses; and desirable and undesirable forbs. Individual species, or in some cases genera, are recorded within each of the categories of grasses and the more important forbs are recorded by species or genera.

## Results

Variability resulting from different operators sampling the same area was examined by field trials conducted at three different locations in annual grassland. In Table 2 are presented sampling data of nine different two-man teams sampling an acre area (Location 1). The two-man teams consisted of a sampler and a recorder. Ordinarily, for greatest expediency of time one man samples and records. Mean values and standard deviations for total cover percentages and species composition percentages are given in the table. The results show that the estimates of total ground cover were in close accord with a standard deviation of about 5 percent. The variability among species groups was of such magnitude that it did not change the relative positions of these groups except in cases where the mean values were similar. These data were collected by men who had no previous experience in this

**Table 2. Comparison of data of nine different two-man teams sampling the same area. (location 1).**

| Sampling team | Percent total cover % | Botanical Composition—Percent: *Bromus mollis* % | Other annual grasses % | Resident legumes % | *Erodium botrys* % | Other forbs % | Perennial grasses % |
|---|---|---|---|---|---|---|---|
| 1 | 43 | 42 | 9 | 18 | 15 | 15 | 1 |
| 2 | 31 | 58 | 8 | 13 | 12 | 9 | — |
| 3 | 41 | 37 | 9 | 24 | 16 | 12 | 2 |
| 4 | 33 | 52 | 4 | 19 | 9 | 15 | 1 |
| 5 | 43 | 45 | 14 | 19 | 11 | 10 | 1 |
| 6 | 34 | 41 | 14 | 15 | 8 | 21 | 1 |
| 7 | 31 | 61 | 8 | 13 | 10 | 7 | 1 |
| 8 | 43 | 47 | 4 | 17 | 14 | 18 | — |
| 9 | 39 | 39 | 6 | 21 | 13 | 19 | 2 |
| $\bar{x}$ | 37.5 | 46.9 | 8.4 | 17.7 | 12.0 | 14.0 | 1.0 |
| s | 5.3 | 8.4 | 3.7 | 3.7 | 2.7 | 4.7 | — |

**Table 3. Comparison of data of three different two-man teams sampling the same area (location 2).**

| | Botanical Composition—Percent | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling team | Percent total cover % | *Bromus mollis* % | *Festuca* spp. % | Other annual grasses % | Resident legumes % | *Erodium botrys* % | Other forbs % | Perennial grasses % |
| 1 | 67 | 24 | 58 | 15 | — | — | 3 | — |
| 2 | 57 | 22 | 57 | 10 | 2 | 2 | 5 | 2 |
| 3 | 59 | 17 | 63 | 12 | — | 1 | 5 | 2 |
| x̄ | 61.0 | 21.0 | 59.3 | 12.3 | 0.7 | 1.0 | 4.3 | 1.3 |
| s | 5.3 | 3.6 | 3.3 | 2.6 | — | — | 1.2 | — |

type of sampling. In fact, most of the men had not estimated herbaceous cover before that day.

In Table 3 a comparison is made of data of three two-man teams sampling an acre area (Location 2). The standard deviation of estimates of total ground cover was about 5 percent. The standard deviations of composition percentages among the major plant groups ranged from 2.6 to 3.6. Again, in this test the samplers had no previous experience. Table 4 compares the results of three different operators sampling an acre area of annual grassland (Location 3). The sampling was done early in the year so identification of species was impracticable. For this reason the data are grouped into general categories. Again, the standard deviation of the total ground cover estimates was about 5 percent. The magnitude of variation among plant group percentages ranged from 2.6 to 5.5. The relation among plant groups in all of these comparisons was not altered because of different operators sampling the same area of annual range.

In Table 5 a comparison is made between results of sampling an acre area of annual range with 500 points with pins grouped in sets of ten (point-frame method) and three step-point analyses using 100 individual points and 10 estimates of total cover. Both in measurements of total cover and botanical composition the step-point analyses compare favorably with the 500 point sample of the point frame. The only appreciable difference resulting from this comparison of methods is in percent of resident legumes in the stand. Results of the point frame sampling indicate about three percent resident legumes while step-point sampling indicates about seven percent. The magnitude of this difference is negligible compared with differences among forage classes. Only because of the low total percentage of this group in the stand is this discrepancy noteworthy. The average time required to sample the area using the step-point method was 30 minutes. Between three and four hours were required to run the point-frame analysis.

When a more precise determination of botanical composition of the minor elements of the stand is desired, a large number of points is recommended. For instance, in Table 5, a larger number of points would be required to differentiate with precision between three and seven percent composition of resident legumes. However, the relation between resident legumes and other plant groups is established at the lowest sampling level (100 step-points and 10 frame-points).

Most of the authors' experience with step-point sampling has been on annual ranges. Some sampling has been done in the perennial ranges on the north coast of California. In tall, heavy vegetation the method has limitations. It is difficult not to disturb the vegetation to be sampled in these cases and also to determine exactly what plant has been hit by the pin. In chaparral or other areas of dense woody vegetation a sampling design consisting of straight transects is not feasible. In these instances the sampling points are

**Table 4. Comparison of data of three different operators sampling the same area (location 3).**

| | Botanical Composition—Percent | | | | |
|---|---|---|---|---|---|
| Sampler | Percent total cover % | Annual grasses % | Forbs % | *Erodium* spp. % | Resident legumes % |
| 1 | 57 | 65 | 28 | — | 7 |
| 2 | 59 | 55 | 26 | 2 | 17 |
| 3 | 50 | 59 | 31 | 2 | 8 |
| x̄ | 55.3 | 59.7 | 28.3 | 1.3 | 10.7 |
| s | 4.7 | 5.0 | 2.6 | — | 5.5 |

**Table 5. Comparison between the point-frame and step-point methods of sampling.**

| | Botanical Composition—Percent | | | | |
|---|---|---|---|---|---|
| Sampling method | Percent total cover | Annual grasses | *Erodium* spp. | Resident legumes | Other forbs |
| Point frame | % | % | % | % | % |
| (500 points) | 54.1 | 63.6 | 0.7 | 2.9 | 32.8 |
| Step-point | | | | | |
| (Means values and standard deviations of three samples of 100 points and 10 density estimates) | | | | | |
| x̄ | 57.7 | 62.0 | 1.3 | 6.7 | 30.0 |
| s | 0.6 | 3.0 | — | 1.6 | 2.0 |

usually placed at random among the woody plants.

## Summary

The step-point method of sampling consists of procedures for determining total ground cover and percentage cover of the herbaceous species in the stand. Involved in the procedure is the point method using individual points and an estimate method utilizing a square-foot frame. Predetermined sampling designs are used in the sampling procedures.

In comparisons among data of different operators sampling the same acre area standard deviations of total ground cover and botanical composition measurements are of low magnitude. Also data of total ground cover and botanical composition from the step-point method were comparable to that of the point-frame method. The time required to sample an area with the step-point method was about one-sixth to one-eighth as much as required by the point-frame method.

From comparisons presented in this paper and from three years of field experience with the method, it is felt that the degree of accuracy and objectivity are suitable for valid analyses of field plots and are comparable to other methods. Of prime importance is the short time in which areas can be sampled using this method. The latter point in many cases is the factor which will mean success or failure of range experimentation, particularly in respect to long-term continuity of the collection of data.

## Acknowledgements

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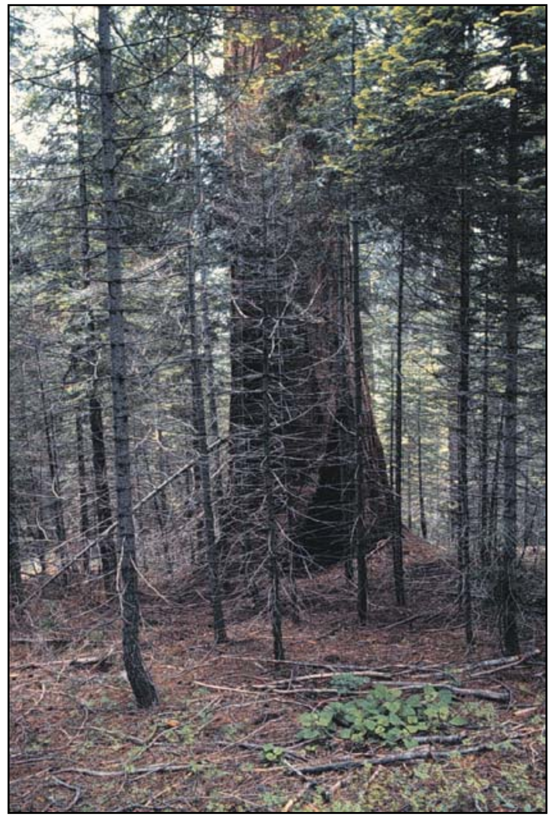
# Vegetation – Sapling/Pole-size Trees



This document describes methods for monitoring changes in density and basal area of sapling/pole-size trees in forest or woodland areas. The sampling unit is a permanently marked plot of adjustable size and shape where individual trees are mapped and tagged. Attributes observed include tree species, diameter, and height class. These methods were developed for the National Park Service's (NPS) fire monitoring program but may be adapted for other monitoring purposes. For background information on the fire monitoring program, including the purpose and overview of the program, related policy, and personnel responsibilities, refer to Chapter 1, pages 1-5 of the NPS Fire Monitoring Handbook (FMH, http://www.nps.gov/fire/fmh/FEMHandbook.pdf). An overview of management objectives and the process for developing corresponding monitoring program objectives is reviewed in Chapter 3, pages 19-32 of the FMH.

Sampling design, including defining the population of interest, pilot sampling, calculating minimum sample size, and addressing potential design problems, is described in FMH Chapter 4, pages 33-54. Methods for generating and selecting plot locations and installing plots are found in FMH Chapter 5, pages 59-79. The schedule for monitoring prior to and following fire treatment is located in FMH Chapter 5, pages 55-58, although the schedule may be revised for other purposes. For a list of field equipment needs recommended for implementing this protocol, see FMH Appendix E, pages 221-224. Information about monitoring program file maintenance and data storage is found in FMH Chapter 5, pages 112-113. To review data quality procedures, see FMH Chapter 5, pages 114-117.

The field methods for the protocol described below are taken from FMH Chapter 5, pages 100-101 (http://www.nps.gov/fire/fmh/FEMHandbook.pdf). Specific forms developed for field data collection follow the protocol description.

# Monitoring Pole-size Trees

Pole-size trees are defined in this monitoring system as standing living and dead trees with a diameter at breast height (DBH) $\geq$2.5 cm and $\leq$15 cm. You may modify this definition for your purposes; see page 44 for details.

## Pole-size Tree Accuracy Standards

Accuracy standards for each variable discussed in this section are listed at the end of this section (Table 23, page 101).

### MEASURE DENSITY AND DBH OF POLE-SIZE TREES

#### RS Procedures

Count and measure DBH for all pole-size trees within the sampling area chosen during the monitoring design process (see page 45). Check your protocols (FMH-4) before proceeding.

Tagging pole-size trees is optional. If you choose to tag pole-size trees, for each plot be sure to use numbers different from those used for overstory trees, e.g., 1-100 for poles and 500-600 for overstory. The procedure is as for overstory trees: drive an aluminum nail into **each** tree at BH so that the tag hangs down and away from the tree and several centimeters of nail remain exposed, leaving ample space for tree growth. Second, measure DBH (in centimeters) to the nearest mm, just above the nail. When the tree is too small to tag at BH, or the tagging nail could split the trunk, place the tag at the base of the tree.

On the Pole-size tree data sheet (FMH-9) record the quarter in which the tree occurs (Qtr), tag or map number, the species (Spp), the diameter (DBH) of each tree, and whether it is alive (Live).

For non-sprouting tree species forked below BH, individually tag and measure each pole-size bole. For sprouting tree species, tag and measure only the largest bole (in diameter) of the cluster. Remember that if the largest bole has a DBH of >15 cm, the tree is an overstory tree. Tally seedling-size sprouts as resprout class seedlings until they grow into the pole tree size class. **Note:** If the main bole of a sprouting species has died, but the tree is sprouting from the base, consider the main bole dead.

If the bole of a fallen tree is below BH, and the individual is resprouting, treat the sprouting branches as individuals and place them in the appropriate size class (seedling, pole, or overstory). Include clarifying comments on the data sheet, especially for resprouting trees.

For trees with swellings or voids at BH, refer to page 92 in the overstory tree section.

If you do not individually tag trees, you can assign a map number for each tree, or simply count them by species (and height class, if desired). Finally, map each tree using a map (or tag) number on the appropriate tree map (FMH-11, -12, -13, or -14).

### OPTIONAL MONITORING PROCEDURES

#### Measuring Diameter at Root Crown for Woodland Species

Measurement of a tree's diameter at root crown (DRC) is an alternative to DBH measurement for tree species that are typically highly forked. This method is presented in the Overstory Tree section (page 97).

#### Measure Pole-size Tree Height

If you choose to measure this optional dataset, measure and record pole-size tree height (Hgt) on the Pole-size tree data sheet (FMH-9) for each tree encountered. Use height class codes five through 13 (Table 22, also available for reference on FMH-9).

**Table 22. Height class codes for pole-size trees.**
A tree must be breast height (1.37 cm) or taller to be classified as pole-size.

| Code | Height (cm) | Code | Height (cm) | Code | Height (cm) | Code | Height (cm) |
|---|---|---|---|---|---|---|---|
| 1<br>2<br>3<br>4 | Æ Not Applicable for Pole-size Trees | 5<br>6<br>7<br>8 | 100.1–200<br>200.1–300<br>300.1–400<br>400.1–500 | 9<br>10<br>11<br>12 | 500.1–600<br>600.1–700<br>700.1–800<br>800.1–900 | 13 | 900.1+ |

**Note:** Measure height from ground level to the highest point of growth on the tree. The highest point on a bent tree would be down the trunk of the tree instead of at the growing apex.

**Table 23. Accuracy standards for pole-size tree (RS) variables.**

| Pole Tree | |
|---|---|
| DBH/DRC | ± 0.5 cm |
| Pole Height | Within Class |
| Number of Individuals | ± 5% |

Park/Unit 4-Character Alpha Code: ___________

**FMH-9** **POLE-SIZE TREE DATA SHEET** Page __ of __

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ______________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___

Record: quarter (if other than Q1), tag # (Optional), species by code (Spp), DBH in centimeters, live/dead, and height by code (Hgt, Optional).

| Qtr | Tag or Map# | Spp | DBH (cm) | Live | Hgt Code | Qtr | Tag or Map# | Spp | DBH (cm) | Live | Hgt Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Y N | | | | | | Y N | |
| | | | | Y N | | | | | | Y N | |
| | | | | Y N | | | | | | Y N | |
| | | | | Y N | | | | | | Y N | |
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Height Class Codes (height in centimeters):

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1** | ↑ Not Applicable for Pole-size Trees ↓ | **5** | 100.1–200 | **9** | 500.1–600 | **13** | 900.1+ |
| **2** | | **6** | 200.1–300 | **10** | 600.1–700 | | |
| **3** | | **7** | 300.1–400 | **11** | 700.1–800 | | |
| **4** | | **8** | 400.1–500 | **12** | 800.1–900 | | |

**Note:** Measure height from ground level to the highest point of growth on the tree. The highest point on a bent tree would be down the trunk of the tree instead of at the growing apex.

Date Entered: ____/____/____

| Qtr | Tag or Map# | Spp | DBH (cm) | Live | Hgt Code | Qtr | Tag or Map# | Spp | DBH (cm) | Live | Hgt Code |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Y N | | | | | | Y N | |
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| | | | | Y N | | | | | | Y N | |
| | | | | Y N | | | | | | Y N | |

Park/Unit 4-Character Alpha Code: ___________

**FMH-4** **MONITORING TYPE DESCRIPTION SHEET**

Monitoring Type Code: _________________________ Date Described: __/__/__

Monitoring Type Name: _________________________

FGDC Association(s): ____________________________________________

Preparer(s) (FEMO/RMS/FMO): ____________________________________

Burn Prescription (including other treatments: ________________________

Management Objective(s): ______________________________________

Monitoring Objective(s): _______________________________________

Objective Variable(s): _________________________________________

Physical Description: __________________________________________

Biological Description: ________________________________________

Rejection Criteria: ____________________________________________

Notes: _______________________________________________________

Date Entered: ____/____/____

# PLOT PROTOCOLS

| GENERAL PROTOCOLS | | (Circle One) | | | (Circle One) | |
|---|---|---|---|---|---|---|
| Preburn | Control Treatment Plots (Opt) | Y | N | Herb Height (Opt) | Y | N |
| | Herbaceous Density (Opt) | Y | N | Abbreviated Tags (Opt) | Y | N |
| | OP/Origin Buried (Opt) | Y | N | Herb. Fuel Load (Opt) | Y | N |
| | Voucher Specimens (Opt) | Y | N | Brush Fuel Load (Opt) | Y | N |
| | Count Dead Branches of Living Plants as Dead (Opt) | | | | Y | N |
| | Width Sample Area Species Not Intercepted But Seen in Vicinity of Herbaceous Transect(s): | | | | | |
| | Length/Width Sample Area for Shrubs: | | | Stakes Installed: | | |
| | Herbaceous Frame Dimensions: | | | | | |
| | Herbaceous Density Data Collected At: | | | | | |
| Burn | Duff Moisture (Opt) | Y | N | Flame Depth (Opt) | Y | N |
| Postburn | 100 Pt. Burn Severity (Opt) | Y | N | Herb. Fuel Load (Opt) | Y | N |
| | Herbaceous/Shrub Data (Opt): FMH- 15/16/17/18 | | | | | |

| FOREST PLOT PROTOCOLS | | (Circle One) | | | (Circle One) | |
|---|---|---|---|---|---|---|
| Overstory (>15 cm) | Live Tree Damage (Opt) | Y | N | Live Crown Position (Opt) | Y | N |
| | Dead Tree Damage (Opt) | Y | N | Dead Crown Position (Opt) | Y | N |
| | Record DBH Year-1 (Opt) | Y | N | | | |
| | Length/Width of Sample Area: | | | Quarters Sampled: Subset ⬩ Q1 ⬩ Q2 ⬩ Q3 ⬩ Q4 | | |
| Pole-size (≥2.5≤15) | Height (Opt) | Y | N | Poles Tagged (Opt) | Y | N |
| | Record DBH Year-1 (Opt) | Y | N | Dead Pole Height (Opt) | Y | N |
| | Length/Width of Sample Area: | | | Quarters Sampled: Subset ⬩ Q1 ⬩ Q2 ⬩ Q3 ⬩ Q4 | | |
| Seedling (<2.5 cm) | Height (Opt) | Y | N | Seedlings Mapped (Opt) | Y | N |
| | Dead Seedlings (Opt) | Y | N | Dead Seedling Height (Opt) | Y | N |
| | Length/Width of Sample Area: | | | Quarters Sampled: Subset ⬩ Q1 ⬩ Q2 ⬩ Q3 ⬩ Q4 | | |
| Fuel Load | Sampling Plane Lengths:___ 1 hr ⬩ ___ 10 hr ⬩ ___ 100 hr ⬩ ___ 1,000 hr-s ⬩ ___ 1,000 hr-r | | | | | |
| Herbaceous | Cover Data Collected at: Q4–Q1 ⬩ Q3–Q2 ⬩ 0P–50P ⬩ Q4–30 m | | | | | |
| Postburn | Char Height (Opt) | Y | N | Poles in Assessment (Opt) | Y | N |
| | Collect Severity Along: Fuel Transects ⬩ Herbaceous Transects | | | | | |

(Opt) = Optional

**FMH-5** **PLOT LOCATION DATA SHEET**

Plot ID: ____________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ____________________________________ Recorder(s): ____________________

Topo Quad: ______________________ Transect Azimuth: ____ Declination: _______

| | | | |
|---|---|---|---|
| UTM ZONE: _____ | Lat: __________ | Section: ________ | Slope (%) along Transect Azimuth: _______ |
| UTMN: _________ | Long: __________ | Township: _______ | Slope (%) of Hillside: __________ |
| UTME: _________ | | Range: _________ | Aspect: ________ Elevation: ____________ |

Location Information Determined by (Circle One): Map & Compass / GPS

If determined by GPS: Datum used: ____________________________ (Circle One) PDOP/EHE: ______

Fire History of the Plot (including the date of the last known fire):___________________________________

_______________________________________________________________________________

1. Road and trail used to travel to the plot:______________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

2. True compass bearing at point where road/trail is left to hike to plot: _____°
3. Describe the route to the plot; include or attach a hand-drawn map illustrating these directions, including the plot layout, plot reference stake and other significant features. In addition, attach a topo, orthophoto, and/or trail map.

4. Describe reference feature: _____________________________________________________
5. True compass bearing from plot reference feature to plot reference stake: _________°
6. Distance from reference feature to reference stake: __________m
7. Problems, comments, notes:______________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

Date Entered: ____/____/____

**FMH-5A**

## HISTORY OF SITE VISITS

Plot ID: ____________ B / C (Circle One) Burn Unit: ____________________

| Date | Burn Status | Purpose | Comments |
|---|---|---|---|
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Date Entered: ____/____/____

Park/Unit 4-Character Alpha Code: ___________

**FMH-6** **SPECIES CODE LIST** Page ___ of ___

Use this form to record unknowns and official species codes. **Tip:** Place an asterisk next to each species you voucher.

| Species Code | Life Form | Genus/Species (spell out full name) | Native (Circle One) | Annual/ Biennial/ Perennial |
|---|---|---|---|---|
| | | | Y N | |
| | | | Y N | |
| | | | Y N | |
| | | | Y N | |
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**Life Forms Codes:**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **A** | Fern or Fern Ally | **G** | Grass | **R** | Grass-like | **T** | Tree | ***** | Substrate |
| **F** | Forb | **N** | Non-vascular | **S** | Shrub | **U** | Subshrub | **V** | Vine |

Date Entered: ___/___/___

## VOUCHER SPECIMEN DATA COLLECTION FORMS

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

---

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

---

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

---

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

Park/Unit 4-Character Alpha Code: ___________

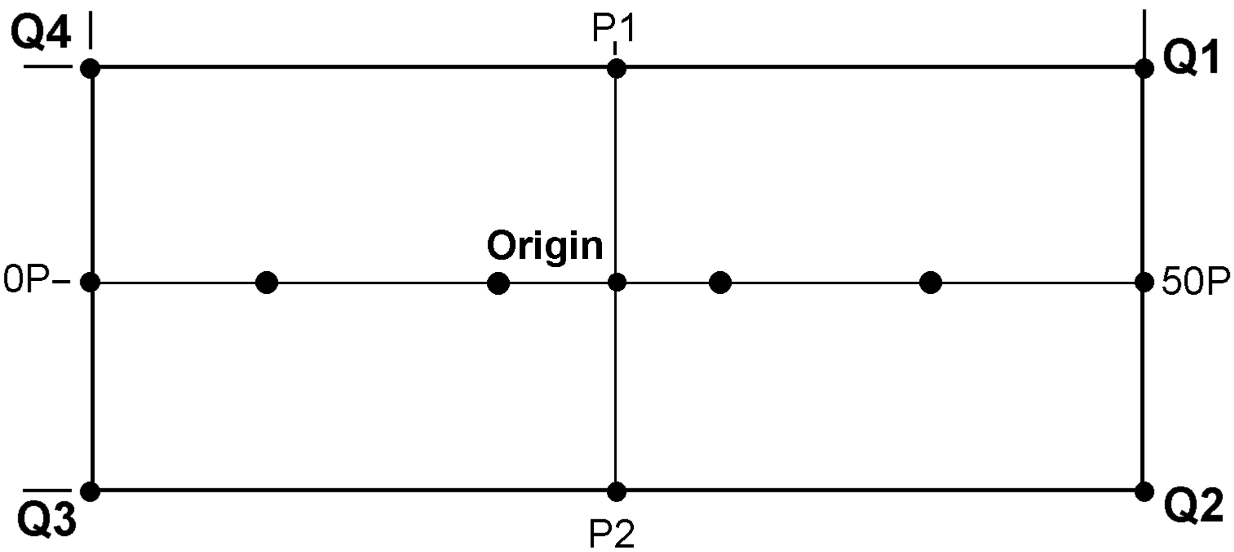
**FMH-7** **FOREST PLOT DATA SHEET**

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ______________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___




**Sampling Areas:**

Overstory: _____$m^2$ in Q ____ Pole: _____$m^2$ in Q _____ Seedling: _____$m^2$ in Q ____

Shrub: _____$m^2$ along Q4–Q1 ⬩ Q3–Q2 ⬩ 0P–50P ⬩ Q4–30 m

Shade in the sampling areas for each tree class and for the shrub sampling area(s) on the plot layout above.

**Photo Subject Order**

| | |
|---|---|
| 1. 0P ➔ Origin | 6. Q2 ➔ Q3 |
| 2. Q4 ➔ Q1 | 7. P2 ➔ Origin |
| 3. P1 ➔ Origin | 8. Q3 ➔ Q2 |
| 4. Q1 ➔ Q4 | 9. Origin ➔ REF |
| 5. 50P ➔ Origin | 10. REF ➔ Origin |

Record photo documentation data for each visit on FMH-23, Photographic record sheet

**Fuel Load Transects**

| | Azimuth | Slope |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |

Draw in fuel load transect lines on the plot layout above.

Date Entered: ____/____/____

Park/Unit 4-Character Alpha Code: ___________

**FMH-11** **FULL PLOT TREE MAP**

Plot ID: ______________________________ B/C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ____________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20 Other: ___-yr____; ____-mo___

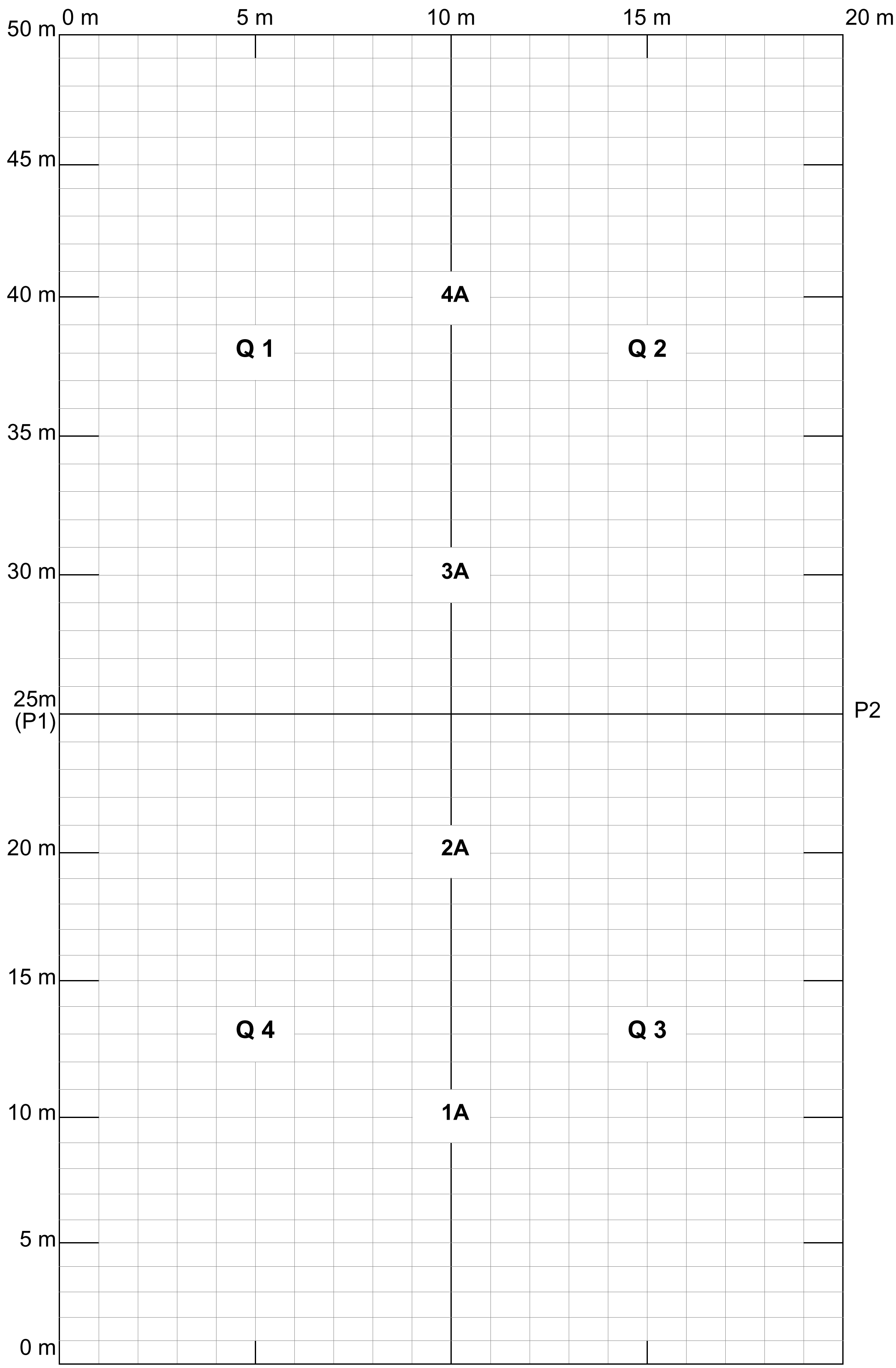
**Tree Class**

**(Circle One)**

**Overstory**

**Pole**

**Seedling**



Park/Unit 4-Character Alpha Code: ___________

**FMH-12** **QUARTER PLOT TREE MAP**

Plot ID: ______________________________ B/C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ____________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20 Other: ___-yr___; ____-mo___

**Tree Class**

**(Circle One)**

**Overstory**

**Pole**

**Seedling**

0 m 5 m 10 m

____m

____m ____m

____m ____m

____m ____m

____m ____m

25m 25m

Park/Unit 4-Character Alpha Code: ___________

**FMH-13** **ALTERNATE TREE MAP**

Plot ID: ______________________________ B/C (Circle One) Date: ____/____/_____

Burn Unit: ________________________________ Recorders: _____________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20 Other: ___-yr___; ____-mo___

**Tree Class**

**(Circle One)**

**Overstory**

**Pole**

**Seedling**

| ____m | ___m | ___m | ___m |
|---|---|---|---|
| ___m | | | |
| ___m | | | |
| ___m | | | |
| ___m | | | |
| ___m | | | |

Park/Unit 4-Character Alpha Code: ___________

**FMH-14**

# 50 $m^2$ TREE MAP

Plot ID: ______________________________ B/C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ______________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20 Other: ___-yr____; ____-mo___

**Tree Class**

**(Circle One)**

**Overstory**

**Pole**

**Seedling**

(P1) 25 m 27.5 m 30 m

0 m

2.5 m

5 m

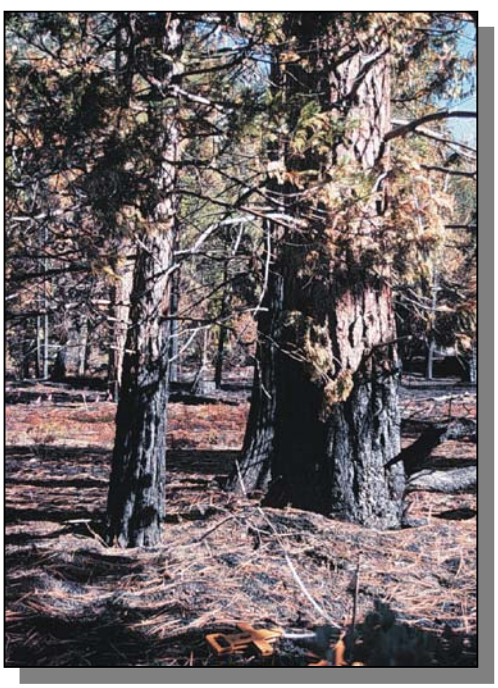
7.5 m

10 m

(Origin) 30 m (3A)

# Vegetation – Immediate Postburn Effects

This document describes methods for measuring burn severity on organic substrate and vegetation (above ground plant parts) following fire in grassland, brush or shrubland, woodland, and forest areas. Protocols also include measuring fire effects on individual trees including bark char height, crown scorch height, and crown scorch percent. This protocol was developed for the National Park Service's (NPS) fire monitoring program but may be adapted for other monitoring purposes. For background information on the fire monitoring program, including the purpose and overview of the program, related policy, and personnel responsibilities, refer to Chapter 1, pages 1-5 of the NPS Fire Monitoring Handbook (FMH, http://www.nps.gov/fire/fmh/FEMHandbook.pdf). An overview of management objectives and the process for developing corresponding monitoring program objectives is reviewed in Chapter 3, pages 19-32 of the FMH.



Sampling design, including defining the population of interest, pilot sampling, calculating minimum sample size, and addressing potential design problems, is described in FMH Chapter 4, pages 33-54. Methods for generating and selecting plot locations and installing plots are found in FMH Chapter 5, pages 59-79. The schedule for monitoring prior to and following fire treatment is located in FMH Chapter 5, pages 55-58, although the schedule may be revised for other purposes. For a list of field equipment needs recommended for implementing this protocol, see FMH Appendix E, pages 221-224. Information about monitoring program file maintenance and data storage is found in FMH Chapter 5, pages 112-113. To review data quality procedures, see FMH Chapter 5, pages 114-117.

The field methods for the protocol described below are taken from FMH Chapter 5, pages 108-111 (http://www.nps.gov/fire/fmh/FEMHandbook.pdf). Specific forms developed for field data collection follow the protocol description.

# Monitoring Immediate Postburn Vegetation & Fuel Characteristics

## GRASSLAND AND BRUSH PLOTS

After the burned plot has cooled sufficiently (generally within two to three weeks), remeasure the RS variables (see Tables 5 and 6 on page 57). Record postburn conditions that characterize the amount of heat received in the type on the Brush and grassland plot burn severity data sheet (FMH-22). On each form, circle the postburn status code as "01 Post" (within two months of the burn, see tip box below). The first number represents the number of treatment iterations, e.g., 02 Post would indicate that the plot had been burned (or otherwise treated) twice.

## FOREST PLOTS

After the burned plot has cooled sufficiently (generally within two to three weeks), remeasure the RS variables (see Table 7 on page 57) using the preburn monitoring techniques. Record postburn conditions that characterize the amount of heat received in the type on the Forest plot burn severity data sheet (FMH-21). Remeasure the overstory and record data on the Tree postburn assessment data sheet, FMH-20 (optional for pole-size trees). Do not remeasure the diameter of overstory trees for at least one year postburn, but at every visit record whether each tree is alive or dead. On each form, circle the postburn status code as "01 Post" (within two months of the burn). The first number represents the number of treatment iterations, i.e., 02 Post would indicate that the plot had been burned (or otherwise treated) twice.

### Timing Burn Severity Data Collection

You can lose burn severity data by waiting too long to collect it, and having rain or snow mar the data collection. Collect burn severity data as soon as possible after the plot cools, which can be much less time than the recommended two weeks, especially in grasslands.

### Immediate Postburn Vegetation & Fuel Characteristics Accuracy Standards

Accuracy standards for each variable discussed in this section are listed at the end of this section (Table 29, page 111).

## MONITOR POSTBURN CONDITIONS

**Burn Severity—All Plot Types**

Visual assessments of burn severity allow managers to broadly predict fire effects upon the monitoring type, from changes in the organic substrate to plant survival (Ryan and Noste 1985). Burn severity is rated and coded separately for organic substrate and vegetation, distinguished by an S or V, respectively. Rate burn severity according to the coding matrix (Table 28, page 110; adapted from Conrad and Poulton 1966; Ryan and Noste 1985; Bradley and others 1992).

**Example:**

In a plant association dominated by shrubs you observe the following conditions at one of the 4 $dm^2$ burn severity data collection points: the leaf litter has been consumed, leaving a coarse, light colored ash; the duff is deeply charred, but the underlying mineral soil is not visibly altered; foliage and smaller twigs are completely consumed, while shrub branches are mostly intact (40% of the shrub canopy is consumed). Burn severity would be coded as S2 (substrate impacts) and V3 (vegetation impacts) on the Brush and grassland plot burn severity data sheet (FMH-22), or the Forest plot burn severity data sheet (FMH-21).

---

Where there was no organic substrate present preburn, enter a 0 to indicate that the severity rating is not applicable. Do the same if there was no vegetation present preburn. You can often determine whether there was vegetation or substrate at a point by examining the preburn data sheets.

***Grassland and brush plots***

Record burn severity measurements every 5 m, starting at 1 m and ending at the 30P (1 m, 5 m, 10 m, etc.). Record data from a minimum of seven areas per plot. You can choose to rate burn severity at every point sampled (100 data points, optional) along the transect. The additional effort may be minimal since vegetation data may be collected at each of these points anyway. Space has been provided on FMH-22 for this optional data.

### Grassland & Brush Plot Burn Severity

In past versions of this handbook, the protocol for collecting burn severity ratings was to collect data every 5 m, starting at the 0P and ending at the 30P. To avoid the influence of the plot rebar, it is now recommended that the first reading be made at 1 m, with all other measurements being the same.

At each sample point, evaluate burn severity to the organic substrate and to the above-ground plant parts in a 4 $dm^2$ area (2 dm × 2 dm) and record the value on FMH-22. Use the burn severity coding matrix for the appropriate plant association (Table 28, page 110) to determine the severity ratings.

***Forest plots***

Burn severity ratings are determined at the same points on the forest dead and downed fuel inventory transect lines where duff depth is measured: 1, 5, 10, 15, 20, 25, 30, 35, 40, and 45 ft. Alternatively, if the Q4–30 m (the first 30 m of the Q4–Q1 transect) line is used, you can use the same methods used in grassland and brush plots. See the warning box below for another alternative.

Using the dead and downed fuel inventory transect lines you will have 40 points rated per plot. At each sample point, evaluate burn severity to the organic substrate and to above-ground plants in a 4 $dm^2$ area (2 dm × 2 dm). Use the burn severity code matrix (Table 28, page 110) for the appropriate plant association, and record the value on FMH-21.

### Forest Plot Burn Severity

You may now use the herbaceous transects (e.g., Q4–Q1, Q3–Q2) instead of the fuel transects to monitor burn severity in forest plots. The intervals (except for Q4–30 m) are at the 1, 5, 10, 15, 20, 25, 30, 35, 40, and 45 m marks. Only collect this data for the portions of the plot where you have vegetation transects.

**Table 28. Burn severity coding matrix.**

| | Forests | | Shrublands | | Grasslands | |
|---|---|---|---|---|---|---|
| | **Substrate (S)** | **Vegetation (V)** | **Substrate (S)** | **Vegetation (V)** | **Substrate (S)** | **Vegetation (V)** |
| **Unburned (5)** | not burned | not burned | not burned | not burned | not burned | not burned |
| **Scorched (4)** | litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged | foliage scorched and attached to supporting twigs | litter partially blackened; duff nearly unchanged; wood/ leaf structures unchanged | foliage scorched and attached to supporting twigs | litter partially blackened; duff nearly unchanged; leaf structures unchanged | foliage scorched |
| **Lightly Burned (3)** | litter charred to partially consumed; upper duff layer may be charred but the duff layer is not altered over the entire depth; surface appears black; woody debris is partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned | foliage and smaller twigs partially to completely consumed; branches mostly intact | litter charred to partially consumed, some leaf structure undamaged; surface is predominately black; some gray ash may be present immediately postburn; charring may extend slightly into soil surface where litter is sparse, otherwise soil is not altered | foliage and smaller twigs partially to completely consumed; branches mostly intact; less than 60% of the shrub canopy is commonly consumed | litter charred to partially consumed, but some plant parts are still discernible; charring may extend slightly into soil surface, but soil is not visibly altered; surface appears black (this soon becomes inconspicuous); burns may be spotty to uniform depending on the grass continuity | grasses with approximately two inches of stubble; foliage and smaller twigs of associated species partially to completely consumed; some plant parts may still be standing; bases of plants are not deeply burned and are still recognizable |
| **Moderately Burned (2)** | litter mostly to entirely consumed, leaving coarse, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common | foliage, twigs, and small stems consumed; some branches still present | leaf litter consumed, leaving coarse, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common | foliage, twigs, and small stems consumed; some branches (>.6–1 cm in diameter) (0.25–0.50 in) still present; 40–80% of the shrub canopy is commonly consumed. | leaf litter consumed, leaving coarse, light gray or white colored ash immediately after the burn; ash soon disappears leaving bare mineral soil; charring may extend slightly into soil surface | unburned grass stubble usually less than two inches tall, and mostly confined to an outer ring; for other species, foliage completely consumed, plant bases are burned to ground level and obscured in ash immediately after burning; burns tend to be uniform |
| **Heavily Burned (1)** | litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed. This code generally applies to less than 10% of natural or slash burned areas | all plant parts consumed, leaving some or no major stems or trunks; any left are deeply charred | leaf litter completely consumed, leaving a fluffy fine white ash; all organic material is consumed in mineral soil to a depth of 1–2.5 cm (0.5–1 in), this is underlain by a zone of black organic material; colloidal structure of the surface mineral soil may be altered | all plant parts consumed leaving only stubs greater than 1 cm (0.5 in) in diameter | leaf litter completely consumed, leaving a fluffy fine white ash, this soon disappears leaving bare mineral soil; charring extends to a depth of 1 cm (0.5 in) into the soil; this severity class is usually limited to situations where heavy fuel load on mesic sites has burned under dry conditions and low wind | no unburned grasses above the root crown; for other species, all plant parts consumed leaving some or no major stems or trunks, any left are deeply charred; this severity class is uncommon due to the short burnout time of grasses |
| **Not Applicable (0)** | inorganic preburn | none present preburn | inorganic preburn | none present preburn | inorganic preburn | none present preburn |

### Scorch Height

Record the tree tag number (Tag), whether the tree is alive (L), dead (D), resprouting (R), consumed/down (C), broken below BH (B) or cut stump (S) (Live Code), maximum scorch height (ScHgt), and the scorched proportion of the crown (ScPer). See Glossary for definitions. Trees that have fallen should be noted, though they will be recorded during the year-1 remeasurement. You may also record char height (Char), an optional variable, on FMH-20.

Estimate the maximum scorch height on each overstory tree two weeks to two months after the fire has burned across the monitoring plot. **Note:** If another time frame (e.g., 3 months or year-1 postburn) exposes scorch patterns more definitively, measure scorch height again at that time and enter the data with the other Post data. Record this information in the Notes section of the FMH-4.

Maximum scorch height is measured from ground level to the highest point in the crown where foliar death is evident (see Figure 35). Some trees will show no signs of scorch, but the surrounding fuels and vegetation will have obviously burned. In this case, you can estimate scorch height by examining adjacent vegetation. It may be useful to produce a graph of scorch heights to show the variation around the average. Managers may want to correlate scorch height with the preburn locations of large dead and down fuels; these correlations usually require photographs or maps of fuel pockets.

### Percent Crown Scorched

For each overstory tree, estimate the percent of the entire crown that is scorched. Average percent crown scorched may be calculated, but percent crown scorched is a better indicator of individual tree mortality.

## OPTIONAL MONITORING PROCEDURES

### Char Height

You can often measure char height simultaneously with scorch height. To obtain an average maximum char height, measure the height of the maximum point of char for each overstory tree (see Figure 35). For these data calculate the mean of maximum char heights. It may be useful to note on the data sheet the extent of the cambial damage to the tree and to describe the char on the ground surrounding each tree in the Notes section of FMH-20.


**Figure 35. Scorch and char height.**

## Scorch and Char for Pole-size Trees (Optional)

You may collect scorch height, percent crown scorch, and char height for pole-size trees if these data are important to resource and/or fire management staff.

**Table 29. Accuracy standards for during burn and immediate postburn (RS) variables.**

| Fire Behavior and Severity | | |
|---|---|---|
| Flame Length or Depth/ROS | <10 ft | ± 1 ft |
| | >10 ft | ± 5 ft |
| Burn Severity | | ± 1 Class |
| Scorch/Char Height | <10 m | ± 1 m |
| | >10 m | ± 5 m |
| Percent Crown Scorch | | ± 10% |

Park/Unit 4-Character Alpha Code: ___________

**FMH-20** **TREE POSTBURN ASSESSMENT DATA SHEET** Page ___ of ___

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ______________________________ Recorders: ______________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-Post, 02-Post) ______ Post

For each tagged tree record: Tag #, tree status (Live Code) (see below), **maximum** scorch height (ScHgt), percent crown scorched (ScPer), and char height (Char) (Optional).

**Overstory** w **Pole** (Circle One)

| Tag | Live Code | ScHgt (m) | ScPer | Char (m) | Tag | Live Code | ScHgt (m) | ScPer | Char (m) |
|---|---|---|---|---|---|---|---|---|---|
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Live Codes:

| L | Live | D | Dead | R | Resprouting | C | Consumed/Down | B | Broken below DBH | S | Cut Stump |
|---|---|---|---|---|---|---|---|---|---|---|---|

Notes: :

Date Entered: ____/____/____

**Overstory w Pole** (Circle One)

| Tag | Live Code | ScHgt (m) | ScPer | Char (m) | Tag | Live Code | ScHgt (m) | ScPer | Char (m) |
|---|---|---|---|---|---|---|---|---|---|
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**FMH-21** **FOREST PLOT BURN SEVERITY DATA SHEET** Page __ of __

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ______________________________ Recorders: ______________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-Post, 02-Post) ______ Post

When collecting burn severity on fuel transects, rate each fuel load transect at the duff measurement points using the Coding Matrix below. When collecting burn severity on herbaceous transects, rate each herbaceous transect (Q4–Q1—transect 1, Q3–Q2—transect 2, 0P–50P—transect 3) at the meter measurement points on the tape listed in the tables below (1, 5, 10, etc.) using the same matrix. Collect data only along the transects where you collected preburn data. Note: If you read only herbaceous transect Q4–30 m, use FMH-22.

Each observation is from a 4 $dm^2$ area.

| Transect 1 | 1 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|
| Vegetation | | | | | | | | | | |
| Substrate | | | | | | | | | | |

| Transect 2 | 1 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|
| Vegetation | | | | | | | | | | |
| Substrate | | | | | | | | | | |

| Transect 3 | 1 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|
| Vegetation | | | | | | | | | | |
| Substrate | | | | | | | | | | |

| Transect 4 | 1 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|
| Vegetation | | | | | | | | | | |
| Substrate | | | | | | | | | | |

**Coding Matrix:**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **5** | Unburned | **4** | Scorched | **3** | Lightly Burned | **2** | Moderately Burned | **1** | Heavily Burned | **0** | Not Applicable |

Note: See reverse for detailed definitions.

Date Entered: ____/____/____

| | Unburned (5) | Scorched (4) | Lightly Burned (3) | Moderately Burned (2) | Heavily Burned (1) | Not Applicable (0) |
|---|---|---|---|---|---|---|
| **Substrate (S)** | not burned | litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged | litter charred to partially consumed; upper duff layer may be charred but the duff layer is not altered over the entire depth; surface appears black; woody debris is partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned | litter mostly to entirely consumed, leaving coarse, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common | litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed. This code generally applies to less than 10% of natural or slash burned areas | inorganic preburn |
| **Vegetation (V)** | not burned | foliage scorched and attached to supporting twigs | foliage and smaller twigs partially to completely consumed; branches mostly intact | foliage, twigs, and small stems consumed; some branches still present | all plant parts consumed, leaving some or no major stems/trunks; any left are deeply charred | none present preburn |

Park/Unit 4-Character Alpha Code: ___________

**FMH-22** **BRUSH AND GRASSLAND PLOT BURN SEVERITY DATA SHEET** Page __ of __

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: __________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-Post, 02-Post) ______ Post

Burn severity ratings are made every 5 m using the Coding Matrix below. Each observation is from a 4 $dm^2$ area (top form). Optionally, you can use the lower form, which will allow you to rate severity at all 100 points. Note: If your herbaceous transect(s) are longer than 30 m, use FMH-21.

(Circle One) Q4–30 m w 0P–30P

| | 1 m | 5 m | 10 m | 15 m | 20 m | 25 m | 30 m |
|---|---|---|---|---|---|---|---|
| **Vegetation** | | | | | | | |
| **Substrate** | | | | | | | |

**OR**

Substrate and Vegetation Burn Severity at Every Point (Optional)

| | | | | |
|---|---|---|---|---|
| 0.3 S____ V____ | 6.3 S____ V____ | 12.3 S____ V____ | 18.3 S____ V____ | 24.3 S____ V____ |
| 0.6 S____ V____ | 6.6 S____ V____ | 12.6 S____ V____ | 18.6 S____ V____ | 24.6 S____ V____ |
| 0.9 S____ V____ | 6.9 S____ V____ | 12.9 S____ V____ | 18.9 S____ V____ | 24.9 S____ V____ |
| 1.2 S____ V____ | 7.2 S____ V____ | 13.2 S____ V____ | 19.2 S____ V____ | 25.2 S____ V____ |
| 1.5 S____ V____ | 7.5 S____ V____ | 13.5 S____ V____ | 19.5 S____ V____ | 25.5 S____ V____ |
| 1.8 S____ V____ | 7.8 S____ V____ | 13.8 S____ V____ | 19.8 S____ V____ | 25.8 S____ V____ |
| 2.1 S____ V____ | 8.1 S____ V____ | 14.1 S____ V____ | 20.1 S____ V____ | 26.1 S____ V____ |
| 2.4 S____ V____ | 8.4 S____ V____ | 14.4 S____ V____ | 20.4 S____ V____ | 26.4 S____ V____ |
| 2.7 S____ V____ | 8.7 S____ V____ | 14.7 S____ V____ | 20.7 S____ V____ | 26.7 S____ V____ |
| 3.0 S____ V____ | 9.0 S____ V____ | 15.0 S____ V____ | 21.0 S____ V____ | 27.0 S____ V____ |
| 3.3 S____ V____ | 9.3 S____ V____ | 15.3 S____ V____ | 21.3 S____ V____ | 27.3 S____ V____ |
| 3.6 S____ V____ | 9.6 S____ V____ | 15.6 S____ V____ | 21.6 S____ V____ | 27.6 S____ V____ |
| 3.9 S____ V____ | 9.9 S____ V____ | 15.9 S____ V____ | 21.9 S____ V____ | 28.9 S____ V____ |
| 4.2 S____ V____ | 10.2 S____ V____ | 16.2 S____ V____ | 22.2 S____ V____ | 28.2 S____ V____ |
| 4.5 S____ V____ | 10.5 S____ V____ | 16.5 S____ V____ | 22.5 S____ V____ | 28.5 S____ V____ |
| 4.8 S____ V____ | 10.8 S____ V____ | 16.8 S____ V____ | 22.8 S____ V____ | 29.8 S____ V____ |
| 5.1 S____ V____ | 11.1 S____ V____ | 17.1 S____ V____ | 23.1 S____ V____ | 29.1 S____ V____ |
| 5.4 S____ V____ | 11.4 S____ V____ | 17.4 S____ V____ | 23.4 S____ V____ | 29.4 S____ V____ |
| 5.7 S____ V____ | 11.7 S____ V____ | 17.7 S____ V____ | 23.7 S____ V____ | 29.7 S____ V____ |
| 6.0 S____ V____ | 12.0 S____ V____ | 18.0 S____ V____ | 24.0 S____ V____ | 30.0 S____ V____ |

**Coding Matrix:**

| | | | | | |
|---|---|---|---|---|---|
| **5** Unburned | **4** Scorched | **3** Lightly Burned | **2** Moderately Burned | **1** Heavily Burned | **0** Not Applicable |

**Note:** See reverse for detailed definitions.

Date Entered: ____/____/____

| | Shrublands | | Grasslands | |
|---|---|---|---|---|
| | Substrate (S) | Vegetation (V) | Substrate (S) | Vegetation (V) |
| Unburned (5) | not burned | not burned | not burned | not burned |
| Scorched (4) | litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged | foliage scorched and attached to supporting twigs | litter partially blackened; duff nearly unchanged; leaf structures unchanged | foliage scorched |
| Lightly Burned (3) | litter charred to partially consumed, some leaf structure undamaged; surface is predominately black; some gray ash may be present immediately postburn; charring may extend slightly into soil surface where litter is sparse, otherwise soil is not altered | foliage and smaller twigs partially to completely consumed; branches mostly intact; less than 60% of the shrub canopy is commonly consumed | litter charred to partially consumed, but some plant parts are still discernible; charring may extend slightly into soil surface, but soil is not visibly altered; surface appears black (this soon becomes inconspicuous); burns may be spotty to uniform depending on the grass continuity | grasses with approximately two inches of stubble; foliage and smaller twigs of associated species partially to completely consumed; some plant parts may still be standing; bases of plants are not deeply burned and are still recognizable |
| Moderately Burned (2) | leaf litter consumed, leaving coarse, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common | foliage, twigs, and small stems consumed; some branches (>.6–1 cm in diameter) (0.25–0.50 in) still present; 40–80% of the shrub canopy is commonly consumed | leaf litter consumed, leaving coarse, light gray or white colored ash immediately after the burn; ash soon disappears leaving bare mineral soil; charring may extend slightly into soil surface | unburned grass stubble usually less than 2 in tall, and mostly confined to an outer ring; for other species, foliage completely consumed, plant bases are burned to ground level and obscured in ash immediately after burning; burns tend to be uniform |
| Heavily Burned (1) | leaf litter completely consumed, leaving a fluffy fine white ash; all organic material is consumed in mineral soil to a depth of 1–2.5 cm (0.5–1 in), this is underlain by a zone of black organic material; colloidal structure of the surface mineral soil may be altered | all plant parts consumed leaving only stubs greater than 1 cm (0.5 in) in diameter | leaf litter completely consumed, leaving a fluffy fine white ash, this soon disappears leaving bare mineral soil; charring extends to a depth of 1 cm (0.5 in) into the soil; this severity class is usually limited to situations where heavy fuel load on mesic sites has burned under dry conditions and low wind | no unburned grasses above the root crown; for other species, all plant parts consumed, leaving some or no major stems or trunks, any left are deeply charred; this severity class is uncommon due to the short burnout time of grasses |
| Not Applicable (0) | inorganic preburn | none present preburn | inorganic preburn | none present preburn |

# Vegetation – Seedling Trees

This document describes methods for monitoring changes in density of seedling trees in forest or woodland areas. The sampling unit is a permanently marked plot of adjustable size and shape where individual seedling trees are tallied by species and height class. These methods were developed for the National Park Service's (NPS) fire monitoring program but may be adapted for other monitoring purposes. For background information on the fire monitoring program, including the purpose and overview of the program, related policy, and personnel responsibilities, refer to Chapter 1, pages 1-5 of the NPS Fire Monitoring Handbook (FMH, http://www.nps.gov/fire/fmh/FEMHandbook.pdf). An overview of management objectives and the process for developing corresponding monitoring program objectives is reviewed in Chapter 3, pages 19-32 of the FMH.

Sampling design, including defining the population of interest, pilot sampling, calculating minimum sample size, and addressing potential design problems, is described in FMH Chapter 4, pages 33-54. Methods for generating and selecting plot locations and installing plots are found in FMH Chapter 5, pages 59-79. The schedule for monitoring prior to and following fire treatment is located in FMH Chapter 5, pages 55-58, although the schedule may be revised for other purposes. For a list of field equipment needs recommended for implementing this protocol, see FMH Appendix E, pages 221-224. Information about monitoring program file maintenance and data storage is found in FMH Chapter 5, pages 112-113. To review data quality procedures, see FMH Chapter 5, pages 114-117.

The field methods for the protocol described below are taken from FMH Chapter 5, page 102 (http://www.nps.gov/fire/fmh/FEMHandbook.pdf). Specific forms developed for field data collection follow the protocol description.

# Monitoring Seedling Trees

Seedling trees are defined in this monitoring system as living trees with a diameter at breast height (DBH) <2.5 cm (**recording information on dead seedlings is optional**). Trees that are less than the height required for DBH are treated as seedlings, regardless of age and diameter. By definition, a tree cannot be pole-size **and** less than the height necessary for DBH. You may modify this definition for your purposes; see page 44 for details. **Note:** Accuracy standards for each seedling tree variable are listed in Table 24.

**Table 24. Accuracy standards for seedling tree (RS) variables.**

| Seedling Tree | | |
|---|---|---|
| DBH | <2.5 cm | No Errors |
| Seedling Height | | Within Class |
| # of Individuals | | ± 5% |

## COUNT SEEDLING TREES TO OBTAIN SPECIES DENSITY

Count the number of seedling trees by species within the sampling area chosen during the monitoring design process (see page 45). Check your protocols (FMH-4) before proceeding.

### RS Procedures

Record the heading information on the Seedling tree data sheet (FMH-10 in Appendix A). For all seedling trees, record the number of individuals (Num) by species (Spp) on the FMH-10. An optional sketch map of the seedling tree aggregates may be made on any tree map (FMH-11, -12, -13, or -14). In areas with few seedlings in the understory or where tracking individual seedlings through time is important, an optional mapping procedure is to give individual seedlings sequential map numbers (Map#), so that data can be correlated between the Seedling tree data sheet (FMH-10) and the appropriate tree map (FMH-11, -12, -13, or -14). On the data sheet, indicate whether each group of tallied trees is alive or dead (Live) or a resprout (Rsprt).

### Seedling Resprout Class

Seedlings can now be classed as **resprouts**. See page 255 in the Glossary for a definition.

***Anticipated dramatic increases in postburn seedling density***

The seed banks of some tree species may germinate profusely following a burn. Rather than count thousands of seedlings, it may be more efficient to subsample the plot during temporary high density periods. To subsample, grid the sample area listed on your FMH-4 and randomly select an appropriate subsample (i.e., 10%, 20%) of the area. Then proceed to count the individuals in the subsample area and extrapolate to the full sample area listed on your FMH-4. Again, this should only be done in consultation with resource and fire managers.

## OPTIONAL MONITORING PROCEDURES

### Measure Seedling Tree Height

Record the number of seedling trees (Num) by species (Spp) in each height class (Hgt) on the Seedling tree data sheet (FMH-10) for each tree encountered. Use the following height class codes (Table 25, also available for reference on FMH-10):

**Table 25. Height class codes for seedling trees.**

| Code | Height (cm) | Code | Height (cm) | Code | Height (cm) | Code | Height (cm) |
|---|---|---|---|---|---|---|---|
| 1 | 0–15 | 5 | 100.1–200 | 9 | 500.1–600 | 13 | 900.1+ |
| 2 | 15.1–30 | 6 | 200.1–300 | 10 | 600.1–700 | | |
| 3 | 30.1–60 | 7 | 300.1–400 | 11 | 700.1–800 | | |
| 4 | 60.1–100 | 8 | 400.1–500 | 12 | 800.1–900 | | |

**Note:** Measure height from ground level to the highest point of growth on the tree. The highest point on a bent tree would be down the trunk of the tree instead of at the growing apex.

Park/Unit 4-Character Alpha Code: ___________

**FMH-10** **SEEDLING TREE DATA SHEET** Page __ of __

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ______________________________ Recorders: ______________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___

Record: map number (Map#, Optional), species code (Spp), live/dead, height by class (Hgt Code, Optional), resprout (Rsprt), and # by species and height class (Num/Tally).

Area Sampled: ____________________in Quarter(s): _________________

| Map# | Spp | Live | Hgt Code | Rsprt | Num/Tally | Map# | Spp | Live | Hgt Code | Rsprt | Num/Tally |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |
| | | Y N | | Y N | | | | Y N | | Y N | |

Height Class Codes (height in centimeters)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1** | 0–15 | **5** | 100.1–200 | **9** | 500.1–600 | **13** | 900.1+ |
| **2** | 15.1–30 | **6** | 200.1–300 | **10** | 600.1–700 | | |
| **3** | 30.1–60 | **7** | 300.1–400 | **11** | 700.1–800 | | |
| **4** | 60.1–100 | **8** | 400.1–500 | **12** | 800.1–900 | | |

**Note:** Measure height from ground level to the highest point of growth on the tree. The highest point on a bent tree would be down the trunk of the tree instead of at the growing apex.

Date Entered: ____/____/____

Park/Unit 4-Character Alpha Code: ___________

**FMH-10A** **ALTERNATE SEEDLING TREE DATA SHEET** Page __ of __

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ___________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___

Record: map number (Map#, Optional), species code (Spp), live/dead, height by class (Hgt, Optional), resprout (Rsprt), and # by species and height class (Num/Tally).

Area Sampled: ____________________in Quarter(s): _________________

| Map# | Spp | Live | Hgt Code | Rsprt | Num | Tally |
|---|---|---|---|---|---|---|
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |
| | | Y N | | Y N | | |

Height Class Codes (height in centimeters)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1** | 0–15 | **5** | 100.1–200 | **9** | 500.1–600 | **13** | 900.1+ |
| **2** | 15.1–30 | **6** | 200.1–300 | **10** | 600.1–700 | | |
| **3** | 30.1–60 | **7** | 300.1–400 | **11** | 700.1–800 | | |
| **4** | 60.1–100 | **8** | 400.1–500 | **12** | 800.1–900 | | |

**Note:** Measure height from ground level to the highest point of growth on the tree. The highest point on a bent tree would be down the trunk of the tree instead of at the growing apex.

 Date Entered: ____/____/____

Park/Unit 4-Character Alpha Code: ___________

**FMH-4** **MONITORING TYPE DESCRIPTION SHEET**

Monitoring Type Code: ________________________ Date Described: __/__/__

Monitoring Type Name: ________________________

FGDC Association(s): ________________________

Preparer(s) (FEMO/RMS/FMO): ________________________

Burn Prescription (including other treatments: ________________________

Management Objective(s): ________________________

Monitoring Objective(s): ________________________

Objective Variable(s): ________________________

Physical Description: ________________________

Biological Description: ________________________

Rejection Criteria: ________________________

Notes: ________________________

Date Entered: ____/____/____

# PLOT PROTOCOLS

| GENERAL PROTOCOLS | | (Circle One) | | | (Circle One) | |
|---|---|---|---|---|---|---|
| Preburn | Control Treatment Plots (Opt) | Y | N | Herb Height (Opt) | Y | N |
| | Herbaceous Density (Opt) | Y | N | Abbreviated Tags (Opt) | Y | N |
| | OP/Origin Buried (Opt) | Y | N | Herb. Fuel Load (Opt) | Y | N |
| | Voucher Specimens (Opt) | Y | N | Brush Fuel Load (Opt) | Y | N |
| | Count Dead Branches of Living Plants as Dead (Opt) | | | | Y | N |
| | Width Sample Area Species Not Intercepted But Seen in Vicinity of Herbaceous Transect(s): | | | | | |
| | Length/Width Sample Area for Shrubs: | | | Stakes Installed: | | |
| | Herbaceous Frame Dimensions: | | | | | |
| | Herbaceous Density Data Collected At: | | | | | |
| Burn | Duff Moisture (Opt) | Y | N | Flame Depth (Opt) | Y | N |
| Postburn | 100 Pt. Burn Severity (Opt) | Y | N | Herb. Fuel Load (Opt) | Y | N |
| | Herbaceous/Shrub Data (Opt): FMH- 15/16/17/18 | | | | | |

| FOREST PLOT PROTOCOLS | | (Circle One) | | | (Circle One) | |
|---|---|---|---|---|---|---|
| Overstory (>15 cm) | Live Tree Damage (Opt) | Y | N | Live Crown Position (Opt) | Y | N |
| | Dead Tree Damage (Opt) | Y | N | Dead Crown Position (Opt) | Y | N |
| | Record DBH Year-1 (Opt) | Y | N | | | |
| | Length/Width of Sample Area: | | | Quarters Sampled: Subset ⬩ Q1 ⬩ Q2 ⬩ Q3 ⬩ Q4 | | |
| Pole-size (≥2.5≤15) | Height (Opt) | Y | N | Poles Tagged (Opt) | Y | N |
| | Record DBH Year-1 (Opt) | Y | N | Dead Pole Height (Opt) | Y | N |
| | Length/Width of Sample Area: | | | Quarters Sampled: Subset ⬩ Q1 ⬩ Q2 ⬩ Q3 ⬩ Q4 | | |
| Seedling (<2.5 cm) | Height (Opt) | Y | N | Seedlings Mapped (Opt) | Y | N |
| | Dead Seedlings (Opt) | Y | N | Dead Seedling Height (Opt) | Y | N |
| | Length/Width of Sample Area: | | | Quarters Sampled: Subset ⬩ Q1 ⬩ Q2 ⬩ Q3 ⬩ Q4 | | |
| Fuel Load | Sampling Plane Lengths:___ 1 hr ⬩ ___ 10 hr ⬩ ___ 100 hr ⬩ ___ 1,000 hr-s ⬩ ___ 1,000 hr-r | | | | | |
| Herbaceous | Cover Data Collected at: Q4–Q1 ⬩ Q3–Q2 ⬩ 0P–50P ⬩ Q4–30 m | | | | | |
| Postburn | Char Height (Opt) | Y | N | Poles in Assessment (Opt) | Y | N |
| | Collect Severity Along: Fuel Transects ⬩ Herbaceous Transects | | | | | |

(Opt) = Optional

Park/Unit 4-Character Alpha Code: ___________

**FMH-5** **PLOT LOCATION DATA SHEET**

Plot ID: ____________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ____________________________________ Recorder(s): ____________________________

Topo Quad: ______________________ Transect Azimuth: ____ Declination: _______

| | | | |
|---|---|---|---|
| UTM ZONE: _____ | Lat: __________ | Section: ________ | Slope (%) along Transect Azimuth: _______ |
| UTMN: _________ | Long: _________ | Township: _______ | Slope (%) of Hillside: ___________ |
| UTME: _________ | | Range: _________ | Aspect: _________ Elevation: ____________ |

Location Information Determined by (Circle One): Map & Compass / GPS

If determined by GPS: Datum used: ____________________________ (Circle One) PDOP/EHE: ______

Fire History of the Plot (including the date of the last known fire):___________________________________

_____________________________________________________________________________

1. Road and trail used to travel to the plot:________________________________________________

_____________________________________________________________________________

_____________________________________________________________________________

2. True compass bearing at point where road/trail is left to hike to plot: _____°

3. Describe the route to the plot; include or attach a hand-drawn map illustrating these directions, including the plot layout, plot reference stake and other significant features. In addition, attach a topo, orthophoto, and/or trail map.

4. Describe reference feature: _____________________________________________________________

5. True compass bearing from plot reference feature to plot reference stake: _________°

6. Distance from reference feature to reference stake: __________m

7. Problems, comments, notes:______________________________________________________________

_____________________________________________________________________________

_____________________________________________________________________________

Date Entered: ____/____/____

**FMH-5A** **HISTORY OF SITE VISITS**

Plot ID: ____________ B / C (Circle One) Burn Unit: ____________________

| Date | Burn Status | Purpose | Comments |
|---|---|---|---|
| | | | |
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Date Entered: ___/___/___

**FMH-6** **SPECIES CODE LIST** Page ___ of ____

Use this form to record unknowns and official species codes. **Tip:** Place an asterisk next to each species you voucher.

| Species Code | Life Form | Genus/Species (spell out full name) | Native (Circle One) | Annual/ Biennial/ Perennial |
|---|---|---|---|---|
| | | | Y N | |
| | | | Y N | |
| | | | Y N | |
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| | | | Y N | |
| | | | Y N | |

**Life Forms Codes:**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **A** | Fern or Fern Ally | **G** | Grass | **R** | Grass-like | **T** | Tree | ***** | Substrate |
| **F** | Forb | **N** | Non-vascular | **S** | Shrub | **U** | Subshrub | **V** | Vine |

Date Entered: ___/___/___

## VOUCHER SPECIMEN DATA COLLECTION FORMS

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

---

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

---

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

---

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

Park/Unit 4-Character Alpha Code: ___________

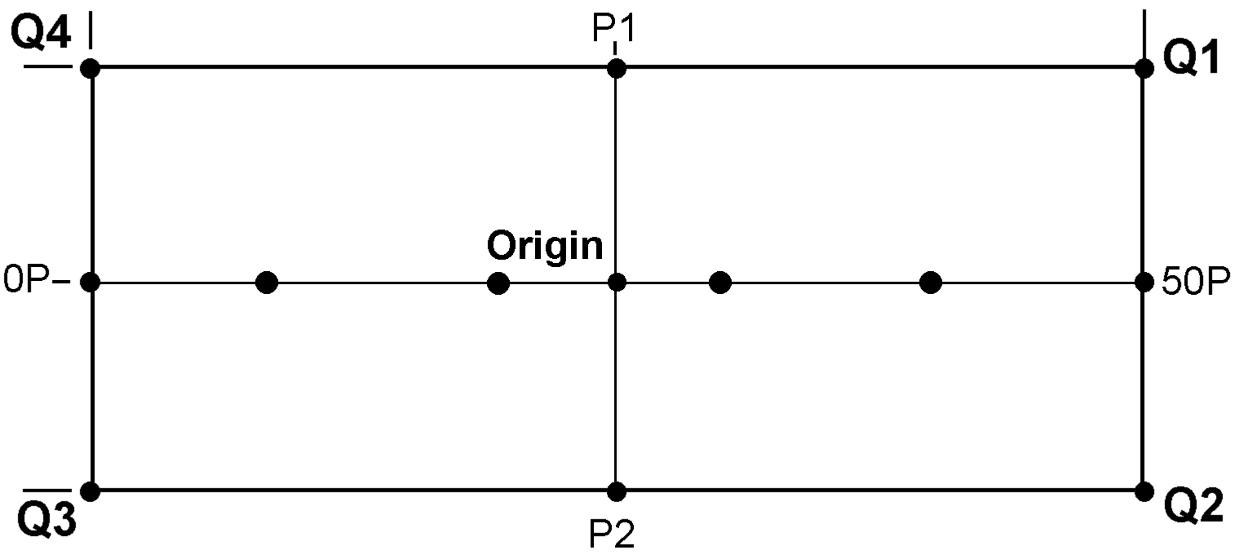
**FMH-7** **FOREST PLOT DATA SHEET**

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ______________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___




**Sampling Areas:**

Overstory: _____m$^2$ in Q ____ Pole: _____m$^2$ in Q _____ Seedling: _____m$^2$ in Q ____

Shrub: _____m$^2$ along Q4–Q1 ⬩ Q3–Q2 ⬩ 0P–50P ⬩ Q4–30 m

Shade in the sampling areas for each tree class and for the shrub sampling area(s) on the plot layout above.

**Photo Subject Order**

| | |
|---|---|
| 1. 0P ➔ Origin | 6. Q2 ➔ Q3 |
| 2. Q4 ➔ Q1 | 7. P2 ➔ Origin |
| 3. P1 ➔ Origin | 8. Q3 ➔ Q2 |
| 4. Q1 ➔ Q4 | 9. Origin ➔ REF |
| 5. 50P ➔ Origin | 10. REF ➔ Origin |

Record photo documentation data for each visit on FMH-23, Photographic record sheet

**Fuel Load Transects**

| | Azimuth | Slope |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |

Draw in fuel load transect lines on the plot layout above.

Park/Unit 4-Character Alpha Code: ___________

**FMH-11** **FULL PLOT TREE MAP**

Plot ID: ______________________________ B/C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ____________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20 Other: ___-yr___; ____-mo___

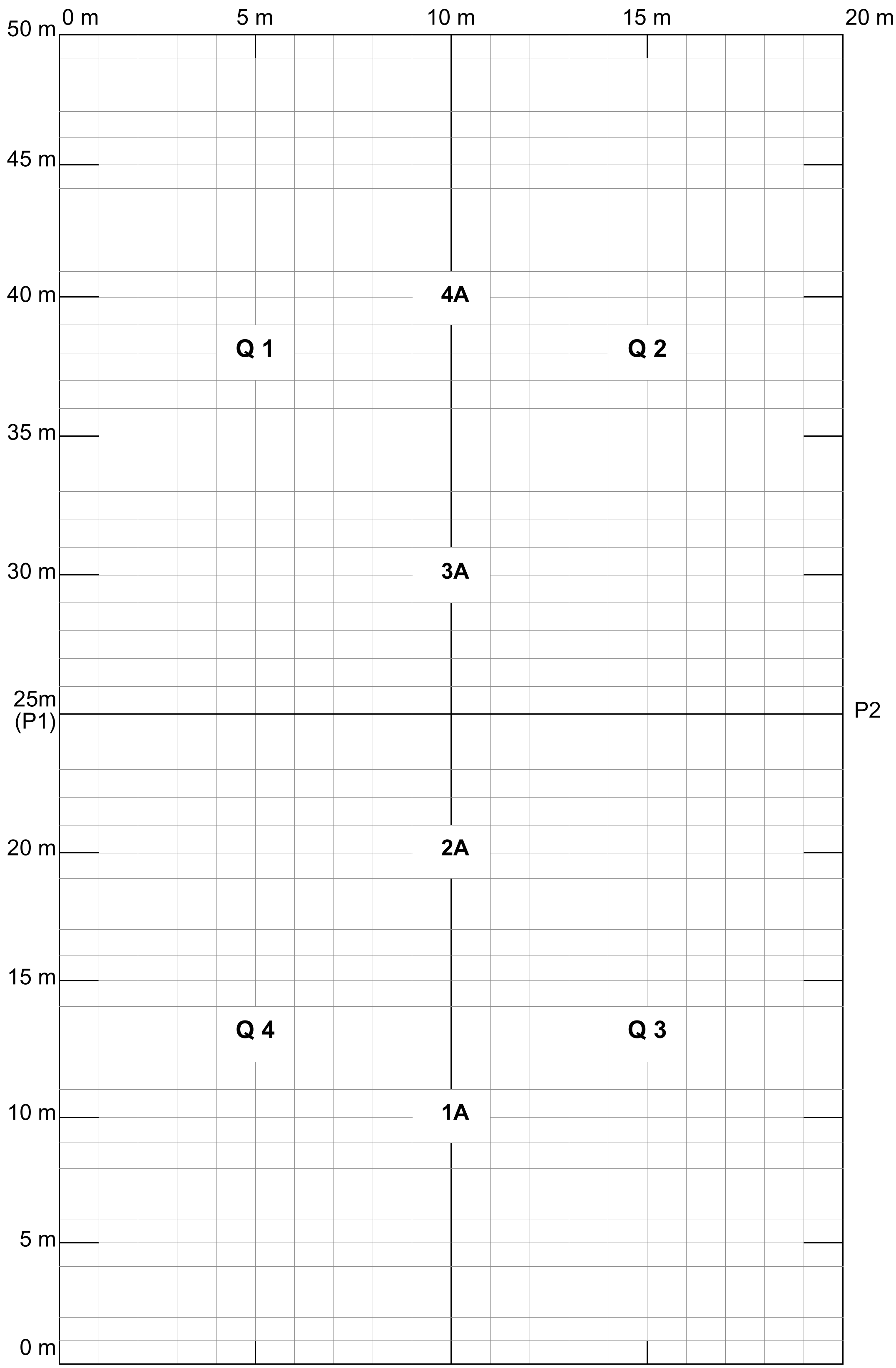
**Tree Class**

**(Circle One)**

**Overstory**

**Pole**

**Seedling**



Park/Unit 4-Character Alpha Code: ___________

**FMH-12** **QUARTER PLOT TREE MAP**

Plot ID: ______________________________ B/C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ____________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20 Other: ___-yr___; ____-mo___

**Tree Class**

**(Circle One)**

**Overstory**

**Pole**

**Seedling**

0 m 5 m 10 m

____m

____m ____m

____m ____m

____m ____m

____m ____m

25m 25m

Park/Unit 4-Character Alpha Code: ___________

**FMH-13** **ALTERNATE TREE MAP**

Plot ID: ______________________________ B/C (Circle One) Date: ____/____/_____

Burn Unit: ________________________________ Recorders: _____________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20 Other: ___-yr___; ____-mo___

**Tree Class**

**(Circle One)**

**Overstory**

**Pole**

**Seedling**

| | ___m | ___m | ___m |
|---|---|---|---|
| ____m | | | |
| ___m | | | |
| ___m | | | |
| ___m | | | |
| ___m | | | |
| ___m | | | |

Park/Unit 4-Character Alpha Code: ___________

**FMH-14**

## 50 $m^2$ TREE MAP

Plot ID: ______________________________ B/C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ____________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20 Other: ___-yr___; ____-mo___

**Tree Class**

**(Circle One)**

**Overstory**

**Pole**

**Seedling**

(P1) 25 m 27.5 m 30 m

0 m

2.5 m

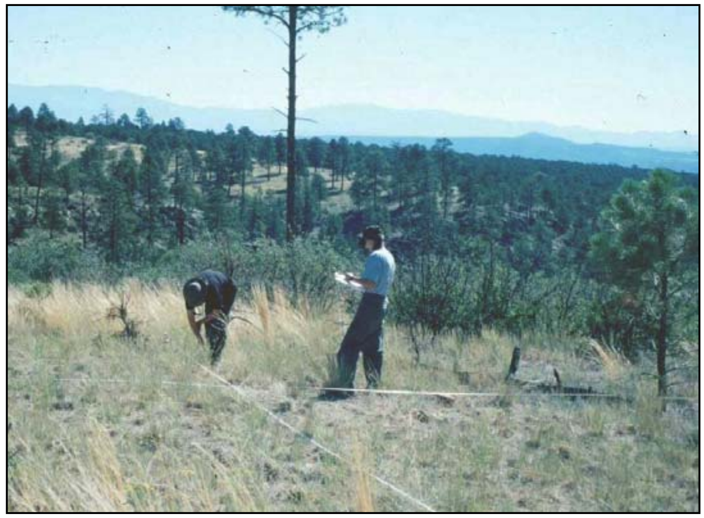
5 m

7.5 m

10 m

(Origin) 30 m (3A)

# Vegetation – Shrub and Herbaceous Layer



This document describes methods for monitoring changes in shrub and herbaceous layer density and cover in grassland, brush or shrubland, woodland, and forest areas. Observations for shrub and herbaceous cover occur along permanently marked point intercept transects of adjustable length and number. Species intercepted and height of tallest vegetation are recorded. Observations for shrub density occur in permanently marked belt transects of adjustable width, length, and number, where individuals or stems are tallied by species and age class (seedling/immature, mature, resprout). Herbaceous vegetation density observations occur in quadrats of adjustable size and shape along permanently marked transects where individuals are tallied by species. The methods were developed for the National Park Service's (NPS) fire monitoring program but may be adapted for other monitoring purposes. For background information on the fire monitoring program, including the purpose and overview of the program, related policy, and personnel responsibilities, refer to Chapter 1, pages 1-5 of the NPS Fire Monitoring Handbook (FMH, http://www.nps.gov/fire/fmh/FEMHandbook.pdf). An overview of management objectives and the process for developing corresponding monitoring program objectives is reviewed in Chapter 3, pages 19-32 of the FMH.

Sampling design, including defining the population of interest, pilot sampling, calculating minimum sample size, and addressing potential design problems, is described in FMH Chapter 4, pages 33-54. Methods for generating and selecting plot locations and installing plots are found in FMH Chapter 5, pages 59-79. The schedule for monitoring prior to and following fire treatment is located in FMH Chapter 5, pages 55-58, although the schedule may be revised for other purposes. For a list of field equipment needs recommended for implementing this protocol, see FMH Appendix E, pages 221-224. Information about monitoring program file maintenance and data storage is found in FMH Chapter 5, pages 112-113. To review data quality procedures, see FMH Chapter 5, pages 114-117.

The field methods for the protocol described below are taken from FMH Chapter 5, pages 80-90 (http://www.nps.gov/fire/fmh/FEMHandbook.pdf). Specific forms developed for field data collection follow the protocol description.

## ALL PLOT TYPES

This section describes specific methods for data collection. Each variable may be sampled in various levels of intensity depending on the monitoring type characteristics. These protocols are predetermined for each monitoring type; sample each variable the same way for every plot within a monitoring type (see page 43). Before you begin data collection, refer to the Monitoring type description sheet (FMH-4) and review the exact protocols to be followed for each specific monitoring type. For quick reference, use the Forest plot data sheet (FMH-7) to record and shade in the sampling areas for overstory, pole-size and seedling trees; see previous page.

### Accuracy Standards

Accuracy standards for each variable are listed at the end of each subsection of this chapter.

### Form Headings

Fill out the form heading completely. Record the monitoring plot ID code, whether it is a burn plot (B) or a control plot (C), the date the data were collected, the burn unit name or number, the names of the data collector and recorder (in that order), and the burn status (with the first two digits referring to the treatment number, and the last four letters and numbers referring to the visit relative to the last treatment). For example, 01 yr02 refers to a year-2 data collection visit the next sampling season after the first burn or other treatment (thinning, etc.), 03 Post refers to the immediate post-burn data collection following the third burn or other treatment. Preburn data are always coded 00 PRE, but if preburn data are updated before the first burn, the code for the original preburn data in the database will change to 00 PR01. If preburn data are collected a third time before the plot burns, the second preburn data will be re-coded 00 PR02 and so on. The code 00 PRE is always used for the newest set of preburn data.

### Streamlining the Form Filling Process

Fill out form headings (minus the date and recorders) and other transferable information (fuel transect azimuths, tree tag numbers, etc.) before you go into the field. Forms can be assembled for each plot during slow periods in the office, during bad weather, or when there is a little extra time.

### Before You Visit a Previously Established Plot

Use the Plot maintenance log (FMH-25) to document any items that you notice during a plot visit that need to be attended to during the next plot visit. Once you establish a plot, maintain the plot log and update it after each visit. By reviewing this log before visiting the plot, you can gather the necessary items to "fix" the problem noted previously. This form provides a reliable method of communication with monitors of the future. Examples of plot maintenance needs: replacement of a tag that was missing on the last visit, a missing rebar, or verification of a species identification.

## HERBACEOUS AND SHRUB LAYERS

### RS Procedures

Use form FMH-16 for 30 m transects or FMH-15 for 50 m transects (both are found in Appendix A). Use a point intercept method to record the number of transect hits and to obtain relative and percent cover by species over time. On forest and brush plots, also measure shrub density within a brush belt for the same distance, along the same transect. The collection of voucher specimens is strongly recommended; this is discussed on page 87.

### Be Kind to the Fragile Herbage, Fine Fuels and Soils Beneath Your Feet

In order to minimize the effect of trampling on the data, stay outside the plot as much as possible, and sample forest types in the following sequence:

- Lay out tapes
- Photograph plot
- Collect herbaceous and shrub data, and fuels data (decide which layer is the most fragile, and collect those data first)
- Collect seedling tree data
- Collect overstory and pole-size tree data

Avoid heavy boots in favor of light shoes; set down sampling equipment, backpacks etc., to the side or below the plot, not in or above it; and minimize the number of people working in the plot. Additionally, use extreme caution on steep slopes.

### Herbaceous and Shrub Layer Accuracy Standards

Accuracy standards for each variable discussed in this section are listed at the end of this section (Table 16, page 90).

***Locate the 0 point on the point intercept transect***

The data collection starting point is at the 0P (origin stake) on grassland and brush plots, and the Q4 (and possibly Q3 and 0P) on forest plots. The length and number of transects is determined during the monitoring design process (Chapter 4). Check your protocols on the Monitoring type description sheet (FMH-4) before proceeding.

***Collect number of transect hits—grassland, brush and forest types***

Start 30 cm from the 0P or Q4. Drop a ¼ in diameter pole (a rigid plumb bob), graduated in decimeters, gently so that the sampling rod is plumb to the ground (on slopes this will not be perpendicular to the ground), every 30 cm along the transect line. Where the transect length is 30 m, there will be 100 points from 30 to 3,000 cm. On forest plots where the transect is read along the full 50 m, there will be 166 points from 30 to 5,000 cm. In either case, the first intercept hit is at 30 cm, not at 0.

At each "point intercept" (Pnt), gently drop the pole to the ground, and record each species (Spp) that touches the pole on the appropriate data sheet (FMH-16 for grassland and brush plots, FMH-15 for most forest plots, and FMH-16 for forest monitoring types that use only the Q4–30 m line). Count each species only once at each point intercept even if the pole touches it more than once. Record the species from tallest to the shortest. If the pole fails to intercept any vegetation, record the substrate (bare soil, rock, forest litter, etc. (see Table 15, page 86)). **Note:** You can occasionally find vegetation under a substrate type; in this case you would ignore the substrate and record the vegetation. If the rod encounters multiple types of substrate, record only that which the pole hits first.

Do not count foliage or branches intercepted for trees over 2 m tall, but count all other vegetation, including shrubs, no matter its height. (This is because trees are better sampled using other procedures, and the target variables using the point intercept transect are shrubs and herbs.) If the sampling rod intersects the bole of a tree that is over 2 m tall, record "2BOLE," or "2SDED" if the tree is dead. **Note:** Record species not intercepted but seen in the vicinity (in a belt on either side of the brush and herbaceous layer transect) on the bottom of the data sheet (FMH-15 or -16). The width of this belt is specified on your Monitoring type description sheet (FMH-4).

**Note:** If you have selected to use the point intercept method to calculate basal cover (see page 46), record only the bottom hit for each point, regardless of whether it is substrate or vegetation.

### Sampling Rods

A useful sampling rod can be made in any of several ways. Choose one that best suits your needs (see Table 12, page 82). One-dm markings can be made with an engraver, then filled in with a permanent marker; road paint and road sign adhesives can also be useful. Note that surface marking with most pens or paints wears off quickly, and many adhesives get gooey in the heat.

**Table 12. Types of sampling rods.**

| Pole Type | Pros | Cons |
|---|---|---|
| **Fiberglass Rod:** This is the preferred choice. | Moderately available (your maintenance shop may already have some, or you can buy a bicycle whip (remove the flag)), moderate in price, lightweight, easy to carry, can be screwed together to adjust size and all pieces need not be carried if not needed, very durable. | None to note. |
| **Tent Pole:** Fiberglass with shock cord. This is the second choice. | Readily available (sporting good store), moderately priced, lightweight, foldable, durable. | Possibly hard to find 0.25" diameter, shock cord can break. |
| **Steel Rod:** | Readily available (hardware stores), moderately priced, extremely durable. | Bend, heavy, difficult to carry in the field. |
| **Wooden Dowel:** | Readily available (hardware stores), cheap, lightweight. | Fragile, inconvenient to carry. |

### Tall Vegetation Sampling Problems

If your protocols (FMH-4) require you to record height and the vegetation is **unexpectedly** taller than the sampling rod, try dropping the rod at the sampling point, then placing your hand at the 1 or 1.5 m point on the rod and sliding the rod up (without looking up), elevating it by 1 or 1.5 m and recording where it touches the vegetation above you. If the vegetation is consistently taller, find a taller sampling rod.

### Dead Herbaceous and Shrub Species Sampling Problems

You may encounter dead standing vegetation along your transects. Always record dead **annual** vegetation in the same way you record live individuals. Record dead **biennial** and **perennial** vegetation (except dead branches of living plants) by placing a "D" at the end of the species code. This permits dead vegetation to be treated separately from live vegetation. Dead perennials may not be included in species abundance indices, but their presence may provide information for estimating fire behavior and determining mortality. In general (see the warning box below for exceptions) count **dead branches of living plants** as a live intercept. In the case of shrub and herbaceous species, this also applies if the main plant is dead but sprouting, and the dead part is encountered.

### Counting Dead Branches of Living Plants as Dead (Optional)

In some cases, such as where animal habitat or aerial fuels are a concern, you may want to know the cover of dead branches, regardless of whether they are attached to living bases. If your monitoring type requires it, you may count dead branches of living plants as dead. However consistency is essential—if transects were not initially read this way for a monitoring type, a change "midstream" will cause an apparent dip in the cover of live shrubs that is not necessarily true.

### Sprouting Dead Trees

**Trees under 2 m tall:** If the bole (>2 m tall) is dead but sprouting at the base, consider any live sprout (<2 m tall) you encounter as live.
**Trees over 2 m tall**: If you encounter a live basal sprout over 2 m tall, the sprout should be considered a tree (2BOLE) in its own right.

## Optional Monitoring Procedures

### *Shrub and herbaceous layer height*

At every sampling point, measure the height of the tallest living or dead individual of each species (to the nearest decimeter, in meters) at the highest place on the sampling rod touched by vegetation. Record this height (Hgt) on FMH-15 or -16. A ¼ in wide sampling rod graduated in decimeters should make this measurement relatively easy. Do not record data for aerial substrate such as the leaves or stems attached to a dead and downed tree.

### Record Species Codes

Species codes are assigned in a systematic way following Natural Resource Conservation Service methodology, as used in the USDA PLANTS Database (USDA NRCS 2001). For existing programs, see the warning box below. This naming convention uses a 4–7 character alpha code beginning with the first two letters of the genus name and the first two letters of the species name. The following 0–3 characters are assigned as needed to avoid confusion of plants with duplicate codes. If there is no subspecies or variety, the next character(s) may not be needed or will simply be a one or two digit number representing the alphabetical ranking of that plant on the national list.

| Examples: | |
|---|---|
| **DACA** | Dalea californica |
| **DACA3** | Danthonia californica |
| **DACA13** | Dasistoma calycosa |

If the plant is a subspecies or variety, then the character in the fifth position will be the first letter of that infraspecific name, and if there are duplicates, a number will follow.

| Examples: | |
|---|---|
| **ACRUT** | *Acer rubrum* var. *trilobum* |
| **ACRUT3** | *Acer rubrum* var. *tridens* |
| **DACAP** | *Dalea carthagenensis* var. *portoricana* |
| **DACAP3** | *Danthonia californica* var. *palousensis* |

### Assigning Species Codes

If you have an existing monitoring program it is not necessary to look up every species in your Species code list (FMH-6). The FMH.EXE software will convert your species codes for you.

If you are starting a new program, simply enter the genus, species, and infraspecific name (if appropriate) into the FMH.EXE software, and the software will look up the species code for you.

When you add a new species to the database, you must note certain other information as well. This includes the species code, its lifeform (see the warning box below) the full name, whether the species is native or non-native, and whether it is annual, biennial, or perennial. This information is recorded on the Species code list (FMH-6).

### Life Form

Life form categories and their codes are as follows; see Glossary for full definitions.

| | |
|---|---|
| A - Fern or fern ally | S - Shrub |
| F - Forb | T - Tree |
| G - Grass | U - Subshrub |
| N - Non-vascular | V - Vine |
| R - Grass-like | * - Substrate |
| Blank - Unknown, non-plant | |

**Note:** If blank is selected, you may also leave the following codes blank—whether the species is native or non-native, and whether it is annual, biennial, or perennial.

The FMH-6 serves as a running list of species codes. Keep only one list for the entire monitoring program in a given park, to avoid assigning incorrect codes. You should carry this sheet whenever you are collecting data, and you should refer to it every time you assign a species code. If you are unsure of the official code for a new plant (see page 83 for coding guidelines), assign a temporary code, then correct it on your data sheets and species list once you look up the official code. Once you enter the initial data into the FMH software (Sydoriak 2001), you may print out the Species code list from the database. Using this form will keep the same code from being used for two different species, and will greatly facilitate data processing.

***Dealing with unknown plants***

Use an identification guide to make every attempt to identify every plant to the species (and subspecies or variety) level. If you cannot identify a plant because you need to have specific parts (e.g., flowers, fruits, etc.) not available during your sampling time (see page 199 for guidance on identifying dead and dormant plants), or you need to use a dissecting scope, take steps to allow future identification. Collect the plant (**from off the plot**), label it, describe it in detail, and then press it (see page 193 for guidelines on voucher collections). Assign an unknown code that is unique from all other unknown codes in the park and note a detailed description of the plant.

**ALWAYS** collect (or draw) and describe unknowns in the field, so that future field technicians will record the same unknown with the same code.

Management of unknown species can easily get out of hand, especially if there is a turnover of monitors from year to year, the flora is particularly diverse and complex, monitors are overworked or monitors lack the requisite plant identification skills. The remedies for these conditions are obvious: try to retain monitors from year to year, stress good documentation and quality, hire monitors who are trained in plant identification, and be realistic about their workload. But even under the best of circumstances, you will encounter the occasional unknown species.

Here are some tips that may help you keep your unknowns straight and get them identified.

- Keep meticulous notes including a detailed, botanical description of all the plant parts, location and micro-habitat, as well as any guesses as to genus or species.

**Example:**

Plants are herbaceous, 15–25 cm tall (but have been browsed) with several stems originating from the base. Leaves are 2–3 cm long, 0.5–1 cm wide, alternate, oblanceolate with finely dentate margins, glabrous above and tomentose below. Leaf tips are acuminate. No fruits or flowers are present. Plant is occasional in light openings in the ponderosa pine understory.

- Collect the plants (off the plot) and sketch if necessary.
- Make vouchers for the herbarium, but be sure to also make a set of field reference vouchers for unknowns.
- Refer to the vouchers or field reference often throughout the season to see if last year's unknown is this year's well-known friend.
- Keep a list of unknowns with notes as to why they were not able to be identified. Review the list in the early season and make a special trip to try to get the plants that were encountered after they had flowered and fruited.
- Scout around in similar areas for other individuals that may be more easily identifiable.
- Ask an expert, in park or out. Botanically-minded folk from a nearby university or the local native plant club are usually more than happy to help. Also consider taking digital photos and distributing them over the Internet to groups who have botanical expertise.

Assign each unknown plant a unique code; make every effort to match up duplicates of the same unknown. The PLANTS database has a series of default codes for unknowns (Table 13), and genera (see database (USDA NRCS 2001)). If you have more than one unknown (whether vascular or non-vascular) that matches the code of the category or where you can only key it to genus, then add a number to the codes as shown below. **Note:** Some genera have numbers at the end of their codes; always check the PLANTS database to be sure that the code you intend to use is not used by another genus or species. In the example below, the code for *Dryopteris* is DRYOP, however the code DRYOP2 is used for *Dryopetalon*, so monitors had to use numbers starting with 3 to avoid conflicts.

| Examples: | |
|---|---|
| **2GLP1** | for unknown perennial grass number 1 (a densely tufted grass, with basal and cauline flat spreading leaves, hairy ligules) |
| **2GLP2** | for unknown perennial grass number 2 (a loose rhizomatous grass, with rolled basal and cauline leaves, no ligules) |
| **DRYOP3** | for unknown *Dryopteris* number 1 (petioles less than one quarter the length of the leaf, blade elliptic, 2-pinnate, marginal teeth curved, growing on limestone) |
| **DRYOP4** | for unknown *Dryopteris* number 2 (petioles one-third the length of the leaf, scales with a dark brown stripe; blade deltate-ovate, 3-pinnate, pinnule margins serrate) |

**Table 13. Species codes for unknown vascular plants.**

| | |
|---|---|
| **2FA** | Forb, annual |
| **2FB** | Forb, biennial |
| **2FD** | Forb, dicot |
| **2FDA** | Forb, dicot, annual |
| **2FDB** | Forb, dicot, biennial |
| **2FDP** | Forb, dicot, perennial |
| **2FERN** | Fern or Fern Ally |
| **2FM** | Forb, monocot |
| **2FMA** | Forb, monocot, annual |
| **2FMB** | Forb, monocot, biennial |
| **2FMP** | Forb, monocot, perennial |
| **2FORB** | Forb (herbaceous, not grass nor grasslike) |
| **2FP** | Forb, perennial |
| **2FS** | Forb, succulent |
| **2FSA** | Forb, succulent, annual |
| **2FSB** | Forb, succulent, biennial |
| **2FSP** | Forb, succulent, perennial |
| **2GA** | Grass, annual |
| **2GB** | Grass, biennial |
| **2GL** | Grasslike (not a true grass) |
| **2GLA** | Grasslike, annual |

**Table 13. Species codes for unknown vascular plants. (Ctd.)**

| | |
|---|---|
| **2GLB** | Grasslike, biennial |
| **2GLP** | Grasslike, perennial |
| **2GP** | Grass, perennial |
| **2GRAM** | Graminoid (grass or grasslike) |
| **2GW** | Grass, woody (bamboo, etc.) |
| **2PLANT** | Plant |
| **2SB** | Shrub, broadleaf |
| **2SD** | Shrub, deciduous |
| **2SDB** | Shrub, deciduous, broadleaf |
| **2SDBD** | Shrub, deciduous, broadleaf, dicot |
| **2SDBM** | Shrub, deciduous, broadleaf, monocot |
| **2SDN** | Shrub, deciduous, needleleaf |
| **2SE** | Shrub, evergreen |
| **2SEB** | Shrub, evergreen, broadleaf |
| **2SEBD** | Shrub, evergreen, broadleaf, dicot |
| **2SEBM** | Shrub, evergreen, broadleaf, monocot |
| **2SEN** | Shrub, evergreen, needleleaf |
| **2SHRUB** | Shrub (>.5m) |
| **2SN** | Shrub, needleleaf (coniferous) |
| **2SSB** | Subshrub, broadleaf |
| **2SSD** | Subshrub, deciduous |
| **2SSDB** | Subshrub, deciduous, broadleaf |
| **2SSDBD** | Subshrub, deciduous, broadleaf, dicot |
| **2SSDBM** | Subshrub, deciduous, broadleaf, monocot |
| **2SSDN** | Subshrub, deciduous, needleleaf |
| **2SSE** | Subshrub, evergreen |
| **2SSEB** | Subshrub, evergreen, broadleaf |
| **2SSEBD** | Subshrub, evergreen, broadleaf, dicot |
| **2SSEBM** | Subshrub, evergreen, broadleaf, monocot |
| **2SSEN** | Subshrub, evergreen, needleleaf |
| **2SSN** | Subshrub, needleleaf (coniferous) |
| **2SUBS** | Subshrub (<.5m) |
| **2TB** | Tree, broadleaf |
| **2TD** | Tree, deciduous |
| **2TDB** | Tree, deciduous, broadleaf |
| **2TDBD** | Tree, deciduous, broadleaf, dicot |
| **2TDBM** | Tree, deciduous, broadleaf, monocot |

Table 13. Species codes for unknown vascular plants. (Ctd.)

| | |
|---|---|
| 2TDN | Tree, deciduous, needleleaf |
| 2TE | Tree, evergreen |
| 2TEB | Tree, evergreen, broadleaf |
| 2TEBD | Tree, evergreen, broadleaf, dicot |
| 2TEBM | Tree, evergreen, broadleaf, monocot |
| 2TEN | Tree, evergreen, needleleaf |
| 2TN | Tree, needleleaf (coniferous) |
| 2TREE | Tree |
| 2VH | Vine, herbaceous |
| 2VHA | Vine, herbaceous, annual |
| 2VHD | Vine, herbaceous, dicot |
| 2VHDA | Vine, herbaceous, dicot, annual |
| 2VHDP | Vine, herbaceous, dicot, perennial |
| 2VHM | Vine, herbaceous, monocot |
| 2VHMA | Vine, herbaceous, monocot, annual |
| 2VHMP | Vine, herbaceous, monocot, perennial |
| 2VHP | Vine, herbaceous, perennial |
| 2VHS | Vine, herbaceous, succulent |
| 2VHSA | Vine, herbaceous, succulent, annual |
| 2VHSP | Vine, herbaceous, succulent, perennial |
| 2VW | Vine, woody |
| 2VWD | Vine, woody, deciduous |
| 2VWDD | Vine, woody, deciduous, dicot |
| 2VWDM | Vine, woody, deciduous, monocot |
| 2VWE | Vine, woody, evergreen |
| 2VWED | Vine, woody, evergreen, dicot |
| 2VWEM | Vine, woody, evergreen, monocot |

Make frequent checks of new unknowns against existing unknowns throughout the field season to avoid assigning the same code to two different species, or two different codes to the same species. Become familiar with your unknowns so that you can be on the lookout for the plant in a stage that is more easily identifiable. If the unknown is identified at a later date, the code (ex.: 2VWE1, etc.) must be corrected globally throughout your data sheets and in the FMH database. The FMH software will automatically change a species code in all databases when you change it on the FMH-6 data form.

### *Non-vascular plants*

For the plants that you may have difficulty identifying, e.g., non-vascular plants like bryophytes, fungi, and algae, you can use broad codes as shown below.

Table 14. Species codes for non-vascular plants.

| | |
|---|---|
| 2AB | Alga, Brown |
| 2AG | Alga, Green |
| 2ALGA | Alga |
| 2AR | Alga, Red |
| 2BRY | Bryophyte (moss, liverwort, hornwort) |
| 2CYAN | Cyanobacteria, cryptobiotic/cryptogamic/microbiotic/microphytic soil or crust |
| 2FF | Fungus, fleshy (mushroom) |
| 2FJ | Fungus, Jelly |
| 2FR | Fungus, Rust |
| 2FSMUT | Fungus, Smut |
| 2FUNGI | Fungus |
| 2HORN | Hornwort |
| 2LC | Lichen, crustose |
| 2LF | Lichen, foliose |
| 2LICHN | Lichen |
| 2LU | Lichen, fruticose |
| 2LW | Liverwort |
| 2MOSS | Moss |
| 2PERI | Periphyton |
| 2SLIME | Slime Mold |

### *Dead or inorganic material*

Dead or inorganic material should be coded in the following way (Table 15):

Table 15. Codes for dead or inorganic material.

| | |
|---|---|
| 2BARE | Bare ground, gravel, soil, ash; soil particles <1 in diameter. |
| 2DF | Forest duff. Duff is the fermentation and humus layer. It usually lies below the litter and above mineral soil. |
| 2LTR | Vegetation litter. Forest litter includes freshly fallen dead plant parts other than wood, including cones, bracts, seeds, bark, needles, and detached leaves that are less than 50% buried in the duff layer. |
| 2LTRH | Litter, herbaceous |
| 2LTRL | Litter, lichen |

Table 15. Codes for dead or inorganic material. (Ctd.)

| | |
|---|---|
| 2LTRWL | Litter, woody, >2.5 cm |
| 2LTRWS | Litter, woody, <2.5 cm |
| 2RB | Rock, bedrock or mineral particles >1 in diameter. |
| 2RF | Rock, fragments <1 in diameter. |
| 2SC | Native, exotic, and feral animal scat. |
| 2SDED | Standing dead tree. |
| 2ST | Tree stump, no litter at intercept point. |
| 2W | Water; permanent body of water or running water present six months of the year or more. |

### Make Voucher Collection

General protocols for collecting voucher specimens are included here; a detailed discussion on collecting, processing, labeling and preserving plant specimens is located in Appendix C. Collect vouchers when there is any doubt as to the identification of a plant species recorded in the data set, unless the species is threatened or endangered, or the plant cannot be found outside of the plot.

Identify specimens within two days. Prompt identification is essential for data accuracy, and saves time and money. For the initial phase of this monitoring program, collection of voucher specimens of all plants present is strongly recommended.

Collection of vouchers using the following guidelines (which are the same for all plot types) should enable consistent and correct identifications:

- Collect the voucher specimen off or outside of the monitoring plot. Collect enough of the plant to enable identification. Do not collect plants that are—or are suspected to be—rare, threatened, or endangered; sketch these plants and take pictures as vouchers.
- Press the plant materials immediately, but retain some unpressed flowers for easier identification.
- Record collection information on a form (see page 195) that you press with the voucher specimen.
- Keep all specimens in proper herbarium storage. See Appendix C for more information on proper herbarium storage.
- A field notebook of pressed specimens (including unknowns) is a very useful way to verify species identifications in the field.

## Documenting Rare Plants

**Do not collect a plant that is or may be rare, threatened, or endangered!** Sketch or photograph these plants and substitute pictures for vouchers. In all cases your collection should follow the one in twenty rule: remove no more than one plant per twenty plants; remove no plants if there are less than twenty.

## Voucher Label

The handbook now contains a voucher collection data sheet. You will find this data sheet on the back of the Species code list (FMH-6).

## BRUSH AND FOREST PLOTS

### Collect and Record Shrub Density Data

Record shrub density along a brush belt adjacent to the point intercept transect. The width of this belt is specified on your Monitoring type description sheet (FMH-4). Count each individual having >50% of its rooted base within the belt transect. For brush plots, the belt will be on the uphill side of the transect. When it is not clear which side of the transect is the uphill side, use the right side of the transect when viewed from 0P looking down the transect towards 30P. For forest plots, the belt will be inside the plot (Figure 22).

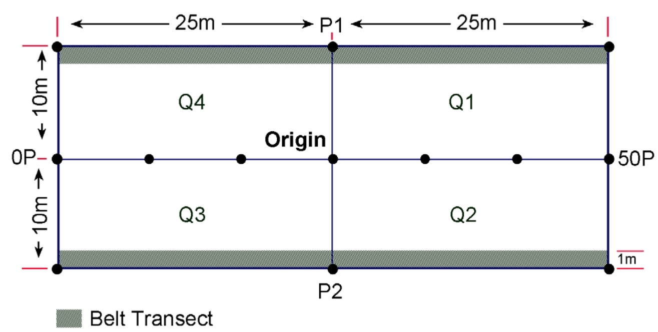



**Figure 22. Belt transect for forest plots (see Figure 18, page 66, for stake codes).**

Use the Shrub density data sheet (FMH-17) to record the data. You may divide the belt transect into 5 m intervals to facilitate counts. Number each 5 m interval from 1 to 6 (30 m), or 1 to 10 (50 m); interval 1 is from 0 to 5 m and so on. Record the interval (Int). Record data by species (Spp), age class (Age), whether it is living (Live), and number of individuals (Num) of that species. Tally any change in species, age, or live-dead as a separate entry on the data sheet, e.g., ARTR1, M, L, would be tallied separately from ARTR1, M, D. Under age class, identify each plant as either a immature-seedling (I), a resprout (R), or as a mature-adult (M) (see Glossary for definitions).

### Subshrubs in Shrub Density

Generally, shrub density data should not include data on subshrubs (see Glossary), unless there are specific objectives tied to density of those species. If you have objectives tied to subshrubs, use the herbaceous density sampling methods discussed below.

### Troubleshooting Shrub Data Collection

***Dead burls***
After dead burls have been counted at least once since dying, you can omit them from density sampling, but it may be useful to note them on the form in case they sprout again in another year.

***Clonal or rhizomatous species***
Shrub individuals may be very difficult to define in some species, and monitors may get very different numbers depending on their perception of what an individual is. Relative or percent cover may be a more accurate way to describe these species. However, it may be appropriate to count something other than the individual in this case, e.g., a surrogate plant part such as culm groups, inflorescences, or stems.

**Examples:**

*Arctostaphylos* spp. stems are often easy to trace to a basal burl. This usually defines the individual. The "burl unit" may be an appropriate delineator of individuals, even when two or more individuals have grown together.

*Vaccinium* spp. are often rhizomatous, making it difficult to distinguish an "individual." The recommended response for dealing with rhizomatous or clonal species is to ignore these species when you collect shrub density data. **Note:** If these species are ecologically significant (e.g., for wildlife habitat), count stem density instead of individual density. The "stem unit," in this case, becomes the basis for quantifying density.

The usefulness of these surrogates depends on the biological significance of changes within these surrogates. Consult with resource and fire managers before you use a surrogate, or omit a species from shrub density sampling. Note any species for which you plan to use surrogates, or omit from monitoring, in the "Notes" section of the FMH-4.

***Resprouts***
Once a disturbance has caused a plant to die back and resprout, the plant should be considered a resprout for the first year, and then an immature until it is once again reproductive (mature).

***Anticipated dramatic increases in postburn shrub density***
It may be advantageous to establish a protocol to count seedlings in density plots only after their second or third year of survivorship. However, you should at least estimate seedling presence in all cases, with estimates such as 10/$m^2$ or 50/$m^2$.

You may wish to subsample the density plot during temporary high density periods. To subsample, grid the plot and randomly select an appropriate subsample (i.e., 10%, 20%) of the area. Then proceed to count the individuals in the subsample area and extrapolate to the sample area listed on your FMH-4. Again, this should be done only in consultation with resource and fire managers.

## Optional Monitoring Procedures

### *Herbaceous layer species density*

**Grassland and brush plots—**To measure the density of forbs and/or grasses, place a frame (the size and shape of which is determined during pilot sampling; see page 47) on the uphill side of the shrub and herbaceous layer transect every 10 m (unless you are using a belt transect because the vegetation is sparse). When it is not clear which side of the transect is the uphill side, use the right side of the transect when viewed from 0P looking down the transect towards 30P. It is important to record on the Herbaceous density data sheet (FMH-18) which side of the transect you sampled so future monitors will repeat your actions. The highest corner of the first frame would be at the 10 m mark, therefore, sampling frame 1 would fall between 6 and 10 m on the tape if you use a 0.25 × 4 m (1 $m^2$) frame; the next sampling areas would be between 16 and 20 m (frame 2), and 26 and 30 m (frame 3) (see Figure 23). The total area sampled using this example would be 3 $m^2$. Record these density data on the Herbaceous density data sheet (FMH-18).

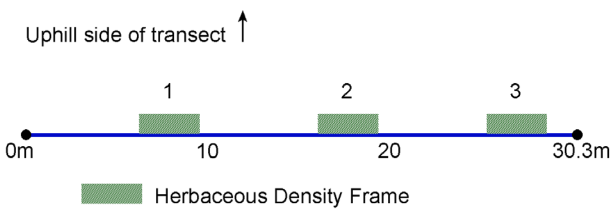



**Figure 23. Density sampling frames (1 $m^2$) for herbaceous species in a grassland or brush plot.**

**Forest plots—**For forest plots the procedure is the same as for grassland and brush plots; the only difference is frame placement. Place the frame on the plot side (interior) of the shrub and herbaceous layer transect (Q4–30 m or Q4–Q1 and/or Q3–Q2) every 10 m (unless you are using a belt transect because the vegetation is sparse). The highest corner of the first frame would be at the 10 m mark; therefore, the first sampling frame would fall between 6 and 10 m on the tape if you use a 0.25 × 4 m (1 $m^2$) frame; the next sampling areas would be from 16 to 20 m (frame 2), 26 to 30 m (frame 3) (stop here for Q4–30 m plots), 36 to 40 m (frame 4), and 46 to 50 m (frame 5). Repeat this process on the Q3–Q2 line in frame numbers 6–10, if you are reading the Q3–Q2 line with the point intercept transect (see Figure 24). The total area sampled using the above example would be 10 $m^2$ (5 $m^2$ sampled on each transect). Record these density data on the Herbaceous density data sheet (FMH-18).

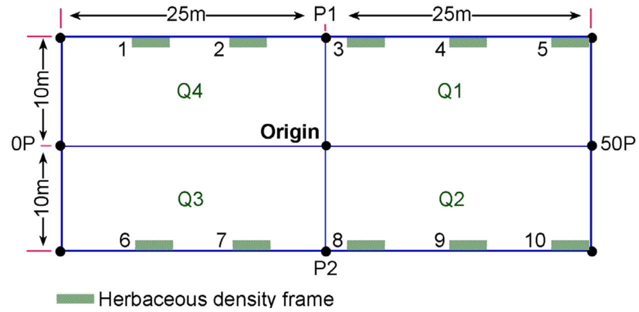



**Figure 24. Density sampling frames (1 $m^2$) for herbaceous species in a forest plot.**

### *Brush fuel load*

Total biomass (fuel) and percent dead (live to dead ratio) may be determined in brush types with sufficient accuracy to make fire behavior predictions. When required for smoke management, total brush biomass must also be measured. Use standard biomass estimating techniques or existing species-specific estimating equations to determine fuel load.

### *Brush biomass*

Use standard biomass estimating techniques or existing biomass estimating equations to estimate the biomass of each shrub in the plot. There are several other methods to estimate biomass, height-weight curves, capacitance meters, and double sampling; see Elzinga and Evenden 1997 under the keyword biomass for an excellent list of references, or review the references on page 237 (Appendix G).

### *Percent dead brush*

There are three techniques to estimate percent dead brush: visual estimates; estimates based upon existing publications such as a photo series; or direct measurement of live-dead ratio using the following procedure:

- Randomly select a sample shrub of each species of concern within a 1 acre area, outside of your monitoring plot.
- Remove all branches 0.25 in or less in diameter, and place in separate airtight bags according to whether they are alive or dead. Take a subsample of the shrub if the shrub is very large.
- Determine the net weight of the live portion and the dead portion.
- Dry at 100°C.
- Determine oven dry weight of live portion and dead portion. Use a subsample if necessary. If you use a subsample, take care to weigh the sample and subsample at the same time before drying.
- After determining the dry weights separately, calculate the biomass in kilograms/hectare or tons/

acre for live and dead portions (see page 216, Appendix D).

***Grass biomass***

When smoke management is a specific concern, or hazard fuel reduction is the primary burn objective, you need to estimate biomass. For information on other methods see the note under "Brush Biomass" above. Use this procedure to qualitatively determine grass biomass:

Randomly toss a rigid quadrat of known area into the plot. Do this six times. Each time:

- Clip all the vegetation to within 1 cm of the ground.
- Place the clipped vegetation into paper bags. Each quadrat should have one bag.
- Label each container with the plot identification code, the bag number, and the collection date.
- Determine the sample dry weight by drying the material in their bags until the weight stabilizes. The oven temperature should be 100°C. Check your samples 24 hours after they have been in the oven.
- Calculate the kilograms/hectare or tons/acre for each sample (see page 216, Appendix D).

**Table 16. Accuracy standards for herbaceous (RS) variables.**

| Herbaceous Layer | | |
|---|---|---|
| Herbaceous Density | # of Individuals | ± 5% |
| Shrub Density | # of Individuals | ± 5% |
| Herb Height | | ± 0.5 decimeters |

Park/Unit 4-Character Alpha Code: ___________

**FMH-15** **50 m TRANSECT DATA SHEET**

Plot ID: ______________________________ B/C (Circle One) Date: ____/____/____

Burn Unit: ______________________________ Recorders: ______________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___

Phenological Stage:___________________________________ (Circle One) Q4–Q1 w Q3–Q2 w 0P–50P

| Pnt | Tape | Hgt (m) | Spp; Species or Substrate Codes (tallest to lowest) | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.3 | | | | | | | |
| 2 | 0.6 | | | | | | | |
| 3 | 0.9 | | | | | | | |
| 4 | 1.2 | | | | | | | |
| 5 | 1.5 | | | | | | | |
| 6 | 1.8 | | | | | | | |
| 7 | 2.1 | | | | | | | |
| 8 | 2.4 | | | | | | | |
| 9 | 2.7 | | | | | | | |
| 10 | 3.0 | | | | | | | |
| 11 | 3.3 | | | | | | | |
| 12 | 3.6 | | | | | | | |
| 13 | 3.9 | | | | | | | |
| 14 | 4.2 | | | | | | | |
| 15 | 4.5 | | | | | | | |
| 16 | 4.8 | | | | | | | |
| 17 | 5.1 | | | | | | | |
| 18 | 5.4 | | | | | | | |
| 19 | 5.7 | | | | | | | |
| 20 | 6.0 | | | | | | | |
| 21 | 6.3 | | | | | | | |
| 22 | 6.6 | | | | | | | |
| 23 | 6.9 | | | | | | | |
| 24 | 7.2 | | | | | | | |
| 25 | 7.5 | | | | | | | |
| 26 | 7.8 | | | | | | | |
| 27 | 8.1 | | | | | | | |
| 28 | 8.4 | | | | | | | |
| 29 | 8.7 | | | | | | | |
| 30 | 9.0 | | | | | | | |
| 31 | 9.3 | | | | | | | |
| 32 | 9.6 | | | | | | | |
| 33 | 9.9 | | | | | | | |
| 34 | 10.2 | | | | | | | |
| 35 | 10.5 | | | | | | | |
| 36 | 10.8 | | | | | | | |
| 37 | 11.1 | | | | | | | |

Date Entered: ____/____/____

Plot ID:____________________ Date:____/____/_____ (Circle One) Q4–Q1 • Q3–Q2 • 0P–50P

| Pnt | Tape | Hgt (m) | Spp; Species or Substrate Codes (tallest to lowest) | | | | | |
|---|---|---|---|---|---|---|---|---|
| 38 | 11.4 | | | | | | | |
| 39 | 11.7 | | | | | | | |
| 40 | 12.0 | | | | | | | |
| 41 | 12.3 | | | | | | | |
| 42 | 12.6 | | | | | | | |
| 43 | 12.9 | | | | | | | |
| 44 | 13.2 | | | | | | | |
| 45 | 13.5 | | | | | | | |
| 46 | 13.8 | | | | | | | |
| 47 | 14.1 | | | | | | | |
| 48 | 14.4 | | | | | | | |
| 49 | 14.7 | | | | | | | |
| 50 | 15.0 | | | | | | | |
| 51 | 15.3 | | | | | | | |
| 52 | 15.6 | | | | | | | |
| 53 | 15.9 | | | | | | | |
| 54 | 16.2 | | | | | | | |
| 55 | 16.5 | | | | | | | |
| 56 | 16.8 | | | | | | | |
| 57 | 17.1 | | | | | | | |
| 58 | 17.4 | | | | | | | |
| 59 | 17.7 | | | | | | | |
| 60 | 18.0 | | | | | | | |
| 61 | 18.3 | | | | | | | |
| 62 | 18.6 | | | | | | | |
| 63 | 18.9 | | | | | | | |
| 64 | 19.2 | | | | | | | |
| 65 | 19.5 | | | | | | | |
| 66 | 19.8 | | | | | | | |
| 67 | 20.1 | | | | | | | |
| 68 | 20.4 | | | | | | | |
| 69 | 20.7 | | | | | | | |
| 70 | 21.0 | | | | | | | |
| 71 | 21.3 | | | | | | | |
| 72 | 21.6 | | | | | | | |
| 73 | 21.9 | | | | | | | |
| 74 | 22.2 | | | | | | | |
| 75 | 22.5 | | | | | | | |
| 76 | 22.8 | | | | | | | |
| 77 | 23.1 | | | | | | | |
| 78 | 23.4 | | | | | | | |
| 79 | 23.7 | | | | | | | |
| 80 | 24.0 | | | | | | | |
| 81 | 24.3 | | | | | | | |

Plot ID:______________________ Date:_____/_____/______ (Circle One) Q4–Q1 • Q3–Q2 • 0P–50P

| Pnt | Tape | Hgt (m) | Spp; Species or Substrate Codes (tallest to lowest) | | | | | |
|---|---|---|---|---|---|---|---|---|
| 82 | 24.6 | | | | | | | |
| 83 | 24.9 | | | | | | | |
| 84 | 25.2 | | | | | | | |
| 85 | 25.5 | | | | | | | |
| 86 | 25.8 | | | | | | | |
| 87 | 26.1 | | | | | | | |
| 88 | 26.4 | | | | | | | |
| 89 | 26.7 | | | | | | | |
| 90 | 27.0 | | | | | | | |
| 91 | 27.3 | | | | | | | |
| 92 | 27.6 | | | | | | | |
| 93 | 27.9 | | | | | | | |
| 94 | 28.2 | | | | | | | |
| 95 | 28.5 | | | | | | | |
| 96 | 28.8 | | | | | | | |
| 97 | 29.1 | | | | | | | |
| 98 | 29.4 | | | | | | | |
| 99 | 29.7 | | | | | | | |
| 100 | 30.0 | | | | | | | |
| 101 | 30.3 | | | | | | | |
| 102 | 30.6 | | | | | | | |
| 103 | 30.9 | | | | | | | |
| 104 | 31.2 | | | | | | | |
| 105 | 31.5 | | | | | | | |
| 106 | 31.8 | | | | | | | |
| 107 | 32.1 | | | | | | | |
| 108 | 32.4 | | | | | | | |
| 109 | 32.7 | | | | | | | |
| 110 | 33.0 | | | | | | | |
| 111 | 33.3 | | | | | | | |
| 112 | 33.6 | | | | | | | |
| 113 | 33.9 | | | | | | | |
| 114 | 34.2 | | | | | | | |
| 115 | 34.5 | | | | | | | |
| 116 | 34.8 | | | | | | | |
| 117 | 35.1 | | | | | | | |
| 118 | 35.4 | | | | | | | |
| 119 | 35.7 | | | | | | | |
| 120 | 36.0 | | | | | | | |
| 121 | 36.3 | | | | | | | |
| 122 | 36.6 | | | | | | | |
| 123 | 36.9 | | | | | | | |
| 124 | 37.2 | | | | | | | |
| 125 | 37.5 | | | | | | | |

| Pnt | Tape | Hgt (m) | Spp; Species or Substrate Codes (tallest to lowest) | | | | | |
|---|---|---|---|---|---|---|---|---|
| 126 | 37.8 | | | | | | | |
| 127 | 38.1 | | | | | | | |
| 128 | 38.4 | | | | | | | |
| 129 | 38.7 | | | | | | | |
| 130 | 39.0 | | | | | | | |
| 131 | 39.3 | | | | | | | |
| 132 | 39.6 | | | | | | | |
| 133 | 39.9 | | | | | | | |
| 134 | 40.2 | | | | | | | |
| 135 | 40.5 | | | | | | | |
| 136 | 40.8 | | | | | | | |
| 137 | 41.1 | | | | | | | |
| 138 | 41.4 | | | | | | | |
| 139 | 41.7 | | | | | | | |
| 140 | 42.0 | | | | | | | |
| 141 | 42.3 | | | | | | | |
| 142 | 42.6 | | | | | | | |
| 143 | 42.9 | | | | | | | |
| 144 | 43.2 | | | | | | | |
| 145 | 43.5 | | | | | | | |
| 146 | 43.8 | | | | | | | |
| 147 | 44.1 | | | | | | | |
| 148 | 44.4 | | | | | | | |
| 149 | 44.7 | | | | | | | |
| 150 | 45.0 | | | | | | | |
| 151 | 45.3 | | | | | | | |
| 152 | 45.6 | | | | | | | |
| 153 | 45.9 | | | | | | | |
| 154 | 46.2 | | | | | | | |
| 155 | 46.5 | | | | | | | |
| 156 | 46.8 | | | | | | | |
| 157 | 47.1 | | | | | | | |
| 158 | 47.4 | | | | | | | |
| 159 | 47.7 | | | | | | | |
| 160 | 48.0 | | | | | | | |
| 161 | 48.3 | | | | | | | |
| 162 | 48.6 | | | | | | | |
| 163 | 48.9 | | | | | | | |
| 164 | 49.2 | | | | | | | |
| 165 | 49.5 | | | | | | | |
| 166 | 49.8 | | | | | | | |

Species observed within ___ m of either side of the transect but not intercepted: ______________________

Park/Unit 4-Character Alpha Code: ___________

**FMH-16** **30 m TRANSECT DATA SHEET**

Plot ID: ______________________________ B/C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ______________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr___; ____-mo___

Phenological Stage: ________________________________ (Circle One) Q4–30 m w 0P–30P

| Pnt | Tape | Hgt (m) | Spp; Species or Substrate Codes (tallest to lowest) | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.3 | | | | | | | |
| 2 | 0.6 | | | | | | | |
| 3 | 0.9 | | | | | | | |
| 4 | 1.2 | | | | | | | |
| 5 | 1.5 | | | | | | | |
| 6 | 1.8 | | | | | | | |
| 7 | 2.1 | | | | | | | |
| 8 | 2.4 | | | | | | | |
| 9 | 2.7 | | | | | | | |
| 10 | 3.0 | | | | | | | |
| 11 | 3.3 | | | | | | | |
| 12 | 3.6 | | | | | | | |
| 13 | 3.9 | | | | | | | |
| 14 | 4.2 | | | | | | | |
| 15 | 4.5 | | | | | | | |
| 16 | 4.8 | | | | | | | |
| 17 | 5.1 | | | | | | | |
| 18 | 5.4 | | | | | | | |
| 19 | 5.7 | | | | | | | |
| 20 | 6.0 | | | | | | | |
| 21 | 6.3 | | | | | | | |
| 22 | 6.6 | | | | | | | |
| 23 | 6.9 | | | | | | | |
| 24 | 7.2 | | | | | | | |
| 25 | 7.5 | | | | | | | |
| 26 | 7.8 | | | | | | | |
| 27 | 8.1 | | | | | | | |
| 28 | 8.4 | | | | | | | |
| 29 | 8.7 | | | | | | | |
| 30 | 9.0 | | | | | | | |
| 31 | 9.3 | | | | | | | |
| 32 | 9.6 | | | | | | | |
| 33 | 9.9 | | | | | | | |
| 34 | 10.2 | | | | | | | |
| 35 | 10.5 | | | | | | | |
| 36 | 10.8 | | | | | | | |
| 37 | 11.1 | | | | | | | |
| 38 | 11.4 | | | | | | | |
| 39 | 11.7 | | | | | | | |
| 40 | 12.0 | | | | | | | |
| 41 | 12.3 | | | | | | | |
| 42 | 12.6 | | | | | | | |
| 43 | 12.9 | | | | | | | |
| 44 | 13.2 | | | | | | | |
| 45 | 13.5 | | | | | | | |
| 46 | 13.8 | | | | | | | |
| 47 | 14.1 | | | | | | | |

Date Entered: ____/____/____

| Pnt | Tape | Hgt (m) | Spp; Species or Substrate Codes (tallest to lowest) | | | | | |
|---|---|---|---|---|---|---|---|---|
| 48 | 14.4 | | | | | | | |
| 49 | 14.7 | | | | | | | |
| 50 | 15.0 | | | | | | | |
| 51 | 15.3 | | | | | | | |
| 52 | 15.6 | | | | | | | |
| 53 | 15.9 | | | | | | | |
| 54 | 16.2 | | | | | | | |
| 55 | 16.5 | | | | | | | |
| 56 | 16.8 | | | | | | | |
| 57 | 17.1 | | | | | | | |
| 58 | 17.4 | | | | | | | |
| 59 | 17.7 | | | | | | | |
| 60 | 18.0 | | | | | | | |
| 61 | 18.3 | | | | | | | |
| 62 | 18.6 | | | | | | | |
| 63 | 18.9 | | | | | | | |
| 64 | 19.2 | | | | | | | |
| 65 | 19.5 | | | | | | | |
| 66 | 19.8 | | | | | | | |
| 67 | 20.1 | | | | | | | |
| 68 | 20.4 | | | | | | | |
| 69 | 20.7 | | | | | | | |
| 70 | 21.0 | | | | | | | |
| 71 | 21.3 | | | | | | | |
| 72 | 21.6 | | | | | | | |
| 73 | 21.9 | | | | | | | |
| 74 | 22.2 | | | | | | | |
| 75 | 22.5 | | | | | | | |
| 76 | 22.8 | | | | | | | |
| 77 | 23.1 | | | | | | | |
| 78 | 23.4 | | | | | | | |
| 79 | 23.7 | | | | | | | |
| 80 | 24.0 | | | | | | | |
| 81 | 24.3 | | | | | | | |
| 82 | 24.6 | | | | | | | |
| 83 | 24.9 | | | | | | | |
| 84 | 25.2 | | | | | | | |
| 85 | 25.5 | | | | | | | |
| 86 | 25.8 | | | | | | | |
| 87 | 26.1 | | | | | | | |
| 88 | 26.4 | | | | | | | |
| 89 | 26.7 | | | | | | | |
| 90 | 27.0 | | | | | | | |
| 91 | 27.3 | | | | | | | |
| 92 | 27.6 | | | | | | | |
| 93 | 27.9 | | | | | | | |
| 94 | 28.2 | | | | | | | |
| 95 | 28.5 | | | | | | | |
| 96 | 28.8 | | | | | | | |
| 97 | 29.1 | | | | | | | |
| 98 | 29.4 | | | | | | | |
| 99 | 29.7 | | | | | | | |
| 100 | 30.0 | | | | | | | |

Species observed within ___ m of either side of the transect but not intercepted: ____________________

Park/Unit 4-Character Alpha Code: ___________

**FMH-17** **SHRUB DENSITY DATA SHEET** Page ___ of ___

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___

Transect: Q4–Q1 w Q3–Q2 w 0P–50P w Q4–30 m w 0P–30P (Circle One)

For living and dead plants within the transect, count each individual having >50% of its rooted base in the belt. The optional interval field (Int) can be used to divide the belt into subunits to facilitate species counts. Record Age Class (Age) code (see below).

Belt Width:_____m Length:_____m Side of transect monitored facing 30P (Brush Plots Only):________

| Int | Spp | Age | Live | Num / Tally | Int | Spp | Age | Live | Num / Tally |
|---|---|---|---|---|---|---|---|---|---|
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
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| | | | Y N | | | | | Y N | |
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| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |
| | | | Y N | | | | | Y N | |

AgeClassCodes: **I** Immature–Seedling **R** Resprout **M** Mature–Adult

Date Entered: ____/____/____

Park/Unit 4-Character Alpha Code: ___________

**FMH-17A** **ALTERNATE SHRUB DENSITY DATA SHEET** Page __ of __

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ______________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___

Transect: Q4–Q1 w Q3–Q2 w 0P–50P w Q4–30 m w 0P–30P (Circle One)

For living and dead plants within the transect, count each individual having >50% of its rooted base in the belt. The optional interval field (Int) can be used to divide the belt into subunits to facilitate species counts. Record Age Class (Age) code (see below).

Belt Width:____m Length:____m Side of transect monitored facing 30P (Brush Plots Only):________

| Int | Spp | Age | Live | Num | Tally |
|---|---|---|---|---|---|
| | | | Y N | | |
| | | | Y N | | |
| | | | Y N | | |
| | | | Y N | | |
| | | | Y N | | |
| | | | Y N | | |
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| | | | Y N | | |
| | | | Y N | | |
| | | | Y N | | |
| | | | Y N | | |

AgeClassCodes: **I** Immature–Seedling **R** Resprout **M** Mature–Adult

 Date Entered: ____/____/____

**FMH-18** **HERBACEOUS DENSITY DATA SHEET** Page __ of __

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ____________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

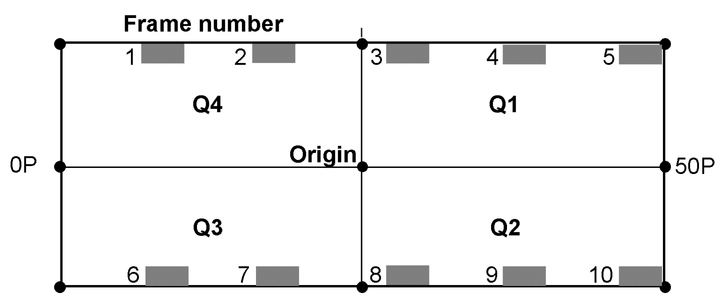
00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___

Transect: Q4–Q1 w Q3–Q2 w 0P–50P w Q4–30 m w 0P–30P (Circle One)

For living and dead plants within the transect, count each individual having >50% of its rooted base in the sampling area.

Frame Size:______m²    Side of transect monitored facing 30P (Brush Plots Only):__________

| Frame # | Spp | Live | Num | Frame # | Spp | Live | Num |
|---|---|---|---|---|---|---|---|
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |




Date Entered: ____/____/____

| Frame # | Spp | Live | Num | Frame # | Spp | Live | Num |
|---|---|---|---|---|---|---|---|
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
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| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |
| | | Y N | | | | Y N | |

Park/Unit 4-Character Alpha Code: ___________

**FMH-4** **MONITORING TYPE DESCRIPTION SHEET**

Monitoring Type Code: ________________________ Date Described: __/__/__

Monitoring Type Name: ________________________

FGDC Association(s): ________________________

Preparer(s) (FEMO/RMS/FMO): ________________________

Burn Prescription (including other treatments: ________________________

Management Objective(s): ________________________

Monitoring Objective(s): ________________________

Objective Variable(s): ________________________

Physical Description: ________________________

Biological Description: ________________________

Rejection Criteria: ________________________

Notes: ________________________

Date Entered: ____/____/____

# PLOT PROTOCOLS

| GENERAL PROTOCOLS | | (Circle One) | | | (Circle One) | |
|---|---|---|---|---|---|---|
| Preburn | Control Treatment Plots (Opt) | Y | N | Herb Height (Opt) | Y | N |
| | Herbaceous Density (Opt) | Y | N | Abbreviated Tags (Opt) | Y | N |
| | OP/Origin Buried (Opt) | Y | N | Herb. Fuel Load (Opt) | Y | N |
| | Voucher Specimens (Opt) | Y | N | Brush Fuel Load (Opt) | Y | N |
| | Count Dead Branches of Living Plants as Dead (Opt) | | | | Y | N |
| | Width Sample Area Species Not Intercepted But Seen in Vicinity of Herbaceous Transect(s): | | | | | |
| | Length/Width Sample Area for Shrubs: | | | Stakes Installed: | | |
| | Herbaceous Frame Dimensions: | | | | | |
| | Herbaceous Density Data Collected At: | | | | | |
| Burn | Duff Moisture (Opt) | Y | N | Flame Depth (Opt) | Y | N |
| Postburn | 100 Pt. Burn Severity (Opt) | Y | N | Herb. Fuel Load (Opt) | Y | N |
| | Herbaceous/Shrub Data (Opt): FMH- 15/16/17/18 | | | | | |

| FOREST PLOT PROTOCOLS | | (Circle One) | | | (Circle One) | |
|---|---|---|---|---|---|---|
| Overstory (>15 cm) | Live Tree Damage (Opt) | Y | N | Live Crown Position (Opt) | Y | N |
| | Dead Tree Damage (Opt) | Y | N | Dead Crown Position (Opt) | Y | N |
| | Record DBH Year-1 (Opt) | Y | N | | | |
| | Length/Width of Sample Area: | | | Quarters Sampled: Subset ⬩ Q1 ⬩ Q2 ⬩ Q3 ⬩ Q4 | | |
| Pole-size (≥2.5≤15) | Height (Opt) | Y | N | Poles Tagged (Opt) | Y | N |
| | Record DBH Year-1 (Opt) | Y | N | Dead Pole Height (Opt) | Y | N |
| | Length/Width of Sample Area: | | | Quarters Sampled: Subset ⬩ Q1 ⬩ Q2 ⬩ Q3 ⬩ Q4 | | |
| Seedling (<2.5 cm) | Height (Opt) | Y | N | Seedlings Mapped (Opt) | Y | N |
| | Dead Seedlings (Opt) | Y | N | Dead Seedling Height (Opt) | Y | N |
| | Length/Width of Sample Area: | | | Quarters Sampled: Subset ⬩ Q1 ⬩ Q2 ⬩ Q3 ⬩ Q4 | | |
| Fuel Load | Sampling Plane Lengths:___ 1 hr ⬩ ___ 10 hr ⬩ ___ 100 hr ⬩ ___ 1,000 hr-s ⬩ ___ 1,000 hr-r | | | | | |
| Herbaceous | Cover Data Collected at: Q4–Q1 ⬩ Q3–Q2 ⬩ 0P–50P ⬩ Q4–30 m | | | | | |
| Postburn | Char Height (Opt) | Y | N | Poles in Assessment (Opt) | Y | N |
| | Collect Severity Along: Fuel Transects ⬩ Herbaceous Transects | | | | | |

(Opt) = Optional

Park/Unit 4-Character Alpha Code: __________

**FMH-5** **PLOT LOCATION DATA SHEET**

Plot ID: ____________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ____________________________________ Recorder(s): ____________________

Topo Quad: ______________________ Transect Azimuth: ____ Declination: _______

| | | | |
|---|---|---|---|
| UTM ZONE: _____ | Lat: __________ | Section: ________ | Slope (%) along Transect Azimuth: _______ |
| UTMN: _________ | Long: _________ | Township: _______ | Slope (%) of Hillside: __________ |
| UTME: _________ | | Range: _________ | Aspect: ________ Elevation: ___________ |

Location Information Determined by (Circle One): Map & Compass / GPS

If determined by GPS: Datum used: ____________________________ (Circle One) PDOP/EHE: ______

Fire History of the Plot (including the date of the last known fire):____________________________________

______________________________________________________________________________

1. Road and trail used to travel to the plot:______________________________________________

______________________________________________________________________________

______________________________________________________________________________

2. True compass bearing at point where road/trail is left to hike to plot: _____°

3. Describe the route to the plot; include or attach a hand-drawn map illustrating these directions, including the plot layout, plot reference stake and other significant features. In addition, attach a topo, orthophoto, and/or trail map.

4. Describe reference feature: ____________________________________________________

5. True compass bearing from plot reference feature to plot reference stake: _________°

6. Distance from reference feature to reference stake: __________m

7. Problems, comments, notes:______________________________________________________

______________________________________________________________________________

______________________________________________________________________________

Date Entered: ____/____/____

**FMH-5A**

# HISTORY OF SITE VISITS

Plot ID: ________________ B / C (Circle One) Burn Unit: ________________________

| Date | Burn Status | Purpose | Comments |
|---|---|---|---|
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Date Entered: ____/____/____

Park/Unit 4-Character Alpha Code: ___________

**FMH-6** **SPECIES CODE LIST** Page ___ of ___

Use this form to record unknowns and official species codes. **Tip:** Place an asterisk next to each species you voucher.

| Species Code | Life Form | Genus/Species (spell out full name) | Native (Circle One) | Annual/ Biennial/ Perennial |
|---|---|---|---|---|
| | | | Y N | |
| | | | Y N | |
| | | | Y N | |
| | | | Y N | |
| | | | Y N | |
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**Life Forms Codes:**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **A** | Fern or Fern Ally | **G** | Grass | **R** | Grass-like | **T** | Tree | ***** | Substrate |
| **F** | Forb | **N** | Non-vascular | **S** | Shrub | **U** | Subshrub | **V** | Vine |

Date Entered: ____/____/____

## VOUCHER SPECIMEN DATA COLLECTION FORMS

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

---

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

---

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

---

Date: Plot ID: Collected by: Coll. #

Latin Name: Family:

Common Name:

Description: ann/bien/per Life form: ht.: Habitat:
flr. color: other:
fruit type:

Topo Quad: Assoc. spp.:

Location (UTM, lat/long): Elev.: Slope: Aspect:

Comments:

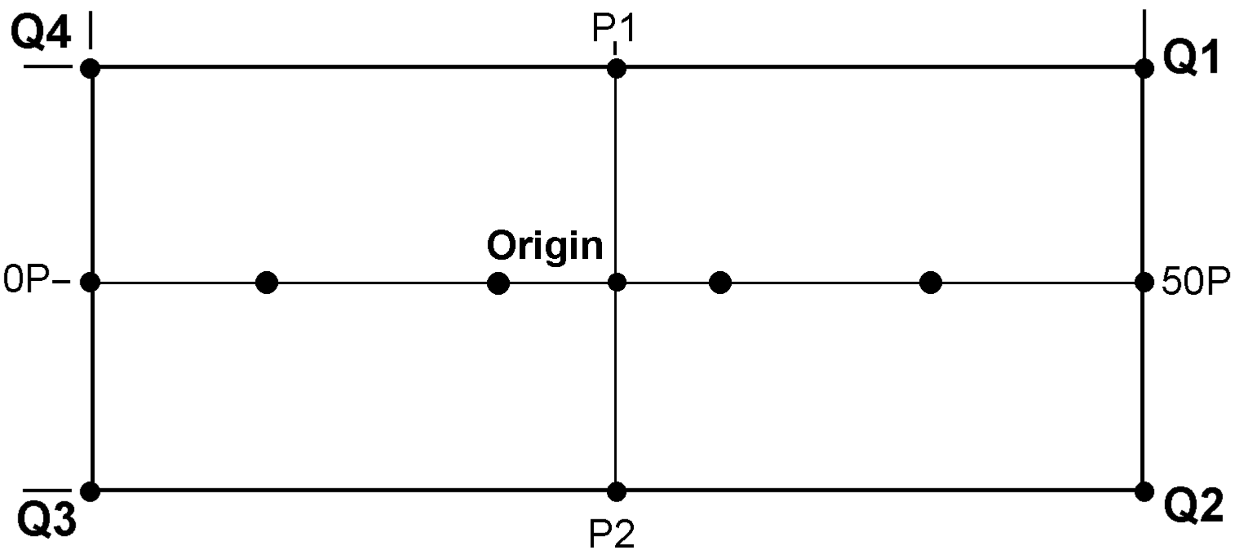
**FMH-7** **FOREST PLOT DATA SHEET**

Plot ID: ______________________________ B / C (Circle One) Date: ____/____/____

Burn Unit: ________________________________ Recorders: ________________________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr____; ____-mo___




**Sampling Areas:**

Overstory: _____$m^2$ in Q ____ Pole: _____$m^2$ in Q _____ Seedling: _____$m^2$ in Q ____

Shrub: _____$m^2$ along Q4–Q1 ⬩ Q3–Q2 ⬩ 0P–50P ⬩ Q4–30 m

Shade in the sampling areas for each tree class and for the shrub sampling area(s) on the plot layout above.

**Photo Subject Order**

| | |
|---|---|
| 1. 0P ➔ Origin | 6. Q2 ➔ Q3 |
| 2. Q4 ➔ Q1 | 7. P2 ➔ Origin |
| 3. P1 ➔ Origin | 8. Q3 ➔ Q2 |
| 4. Q1 ➔ Q4 | 9. Origin ➔ REF |
| 5. 50P ➔ Origin | 10. REF ➔ Origin |

Record photo documentation data for each visit on FMH-23, Photographic record sheet

**Fuel Load Transects**

| | Azimuth | Slope |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |

Draw in fuel load transect lines on the plot layout above.

Date Entered: ____/____/____

# Fire – Weather

This document describes general weather observations for wildland and prescribed fires including ambient air temperature, relative humidity, and wind speed and direction. For detailed protocols, refer to Fischer and Hardy 1976, and Finklin and Fischer 1990. This protocol was developed for the National Park Service's (NPS) fire monitoring program but may be adapted for other monitoring purposes. For background information on the fire monitoring program, including the purpose and overview of the program, related policy, and personnel responsibilities, refer to Chapter 1, pages 1-5 of the NPS Fire Monitoring Handbook (FMH, http://www.nps.gov/fire/fmh/FEMHandbook.pdf). An overview of management objectives and the process for developing corresponding monitoring program objectives is reviewed in Chapter 3, pages 19-32 of the FMH.

Sampling design, including defining the population of interest, pilot sampling, calculating minimum sample size, and addressing potential design problems, is described in FMH Chapter 4, pages 33-54. Methods for generating and selecting plot locations and installing plots are found in FMH Chapter 5, pages 59-79. The schedule for monitoring prior to and following fire treatment is located in FMH Chapter 5, pages 55-58, although the schedule may be revised for other purposes. For a list of field equipment needs recommended for implementing this protocol, see FMH Appendix E, pages 221-224.

Information about monitoring program file maintenance and data storage is found in FMH Chapter 5, pages 112-113. To review data quality procedures, see FMH Chapter 5, pages 114-117.

The field methods for the protocol described below are taken from FMH Chapter 2, pages 11-12 (http://www.nps.gov/fire/fmh/FEMHandbook.pdf). Specific forms developed for field data collection follow the protocol description.

# Fire Conditions Monitoring

The second portion of level 2 monitoring documents fire conditions. Data on the following variables can be collected for all fires. Your park's fire management staff should select appropriate variables, establish frequencies for their collection, and document these standards in your burn plan or Wildland Fire Implementation Plan–Stage II: Short-term Implementation Action and Wildland Fire Implementation Plan–Stage III: Long-term Implementation Actions.

- Topographic Variables
- Ambient Conditions
- Fuel Model
- Fire Characteristics
- Smoke Characteristics
- Holding Options
- Resource Advisor Concerns

## MONITORING SCHEDULE

The frequency of Fire Conditions monitoring will vary by management strategy and incident command needs. Recommended Standards are given below.

## PROCEDURES AND TECHNIQUES

Collect data from aerial or ground reconnaissance and record them in the Wildland Fire Implementation Plan. These procedures may include the use of forms FMH-1, -2, and -3 (Appendix A). Topographic variables, ambient condition inputs, and fire behavior prediction outputs must follow standard formats for the Fire Behavior Prediction System (Albini 1976; Rothermel 1983). **For specific concerns on conducting fire conditions monitoring during a prescribed fire in conjunction with fire effects monitoring plots, see page 106.**

Collect data on the following fire condition (RS) variables:

### Topographic Variables

***Slope***
Measure percent slope using a clinometer (for directions on using a clinometer, see page 203). Report in percent. A common mistake is to measure the slope in degrees and then forget to convert to percent; a 45° angle is equal to a 100% slope (see Table 34, page 211 for a conversion table).

***Aspect***
Determine aspect. Report it in compass directions, e.g., 270° (for directions on using a compass, see page 201).

***Elevation***
Determine the elevation of the areas that have burned. Elevation can be measured in feet or meters.

### Ambient Conditions

Ambient conditions include all fire weather variables. You may monitor ambient weather observations with a Remote Automatic Weather Station (RAWS), a standard manual weather station, or a belt weather kit. More specific information on standard methods for monitoring weather can be found in Fischer and Hardy (1976) or Finklin and Fischer (1990). Make onsite fire weather observations as specified in the Fire-Weather Observers' Handbook (Fischer and Hardy 1976) and record them on the Onsite weather data sheet (form FMH-1) and/or the Fire behavior–weather data sheet (FMH-2). Samples of these forms are in Appendix A.

Fuel moisture may be measured with a drying oven (preferred), a COMPUTRAC, or a moisture probe, or may be calculated using the Fire Behavior Prediction System (BEHAVE) (Burgan and Rothermel 1984). Record in percent.

***Dry bulb temperature***
Take this measurement in a shady area, out of the influence of the fire and its smoke. You can measure temperature with a thermometer (belt weather kit) or hygrothermograph (manual or automated weather station), and record it in degrees Fahrenheit or degrees Celsius (see Table 33, page 209 for conversion factors).

***Relative humidity***
Measure relative humidity out of the influence of the fire using a sling psychrometer or hygrothermograph at a manual or automated weather station. Record in percent.

***Wind speed***
Measure wind speed at eye level using a two-minute average. Fire weather monitoring requires, at a minimum, measurement of wind speed at a 20 ft height, using either a manual or automated fire weather station. Record wind speed in miles/hour, kilometers/

hour, or meters/second (see Table 33, page 209 for conversion factors).

***Wind direction***
Determine the wind direction as the cardinal point (N, NE, E, SE, S, SW, W, or NW) from which the wind is blowing. Record wind direction by azimuth and relative to topography, e.g., 90° and across slope, 180° and upslope.

***Shading and cloud cover***
Determine the combined cloud and canopy cover as the fire moves across the fire area. Record in percent.

***Timelag fuel moisture (10–hr)***
Weigh 10-hr timelag fuel moisture (TLFM) sticks at a standard weather station or onsite. Another option is to take the measurement from an automated weather station with a 10-hr TLFM sensor. If neither of these methods is available, calculate the 10-hr TLFM from the 1-hr TLFM—which is calculated from dry bulb temperature, relative humidity, and shading. Record in percent.

***Timelag fuel moisture (1-, 100-, 1000-hr)***
If required for fire behavior prediction in the primary fuel models affected, measure 1-hr, 100-hr, and 1000-hr TLFM as well, in the same manner as 10-hr using an appropriate method. If you decide to determine fuel moisture by collecting samples, use the following guidelines:

- Collect most of your samples from positions and locations typical for that type of fuel, including extremes of moistness and dryness to get a suitable range.
- Take clear concise notes as to container identification, sample location, fuel type, etc.
- Use drafting (not masking or electrical) tape or a tight stopper to create a tight seal on the container. Keep samples cool and shaded while transporting them.
- Carefully calibrate your scale.
- Weigh your samples as soon as possible. Weigh them with the lid removed, but place the lid on the scale as well. If you cannot weigh them right away, refrigerate or freeze them.
- Dry your samples at 100° C for 18–24 hours.
- Remove containers from the oven one at a time as you weigh them, as dried samples take up water quickly.
- Reweigh each dried sample.
- Use the formula on page 215 to calculate the moisture content.

You can find further advice on fuel moisture sampling in two publications written on the subject (Countryman and Dean 1979; Norum and Miller 1984); while they were designed for specific geographic regions, the principles can be applied to other parts of the country.

***Live fuel moisture***
Fuel models may also require measurement of woody or herbaceous fuel moisture. Follow the sampling guidelines described under "Timelag fuel moisture (1-, 100-, 1000-hr)" on page 12. Live fuel moisture is measured in percent.

***Drought index***
Calculate the drought index as defined in your park's Fire Management Plan. Common drought indices are the Energy Release Component (ERC) or the Keetch-Byram Drought Index (KBDI). Other useful indices are the Palmer Drought Severity Index (PDSI) and the Standardized Precipitation Index (SPI).

***Duff moisture (optional)***
Monitor duff moisture when there is a management concern about burn severity or root or cambial mortality. Duff moisture affects the depth of the burn, resonance time and smoke production. Measure duff samples as described above for Timelag fuel moisture (1-, 100-, 1000-hr). Duff moisture is measured in percent.

**Duff Moisture**

Duff moisture can be critical in determining whether fire monitoring plots are true replicates, or they are sampling different treatments. It is assumed that if plots within a monitoring type identified in a five-year burn plan are burned with the same fire prescription, they are subject to the same treatment. These plots should only be considered to have been treated the same if the site moisture regimes, as influenced by long term drying, were similar. Similar weather but a different site moisture regime can result in significant variation in postfire effects, which can be extremely difficult to interpret without documentation of moisture. This is particularly important when studying prescribed fires.

***State of the weather (optional)***
Monitor state of the weather when there is a management recommendation for this information. Use a one-digit number to describe the weather at the time

of the observation. 0-clear, less than 10% cloud cover; 1-scattered clouds, 10–50% cloud cover; 2-broken clouds; 60–90% cloud cover; 3-overcast, 100% cloud cover; 4-fog; 5-drizzle or mist; 6-rain; 7-snow; 8-showers; 9-thunderstorms.

Only use state of the weather code 8 when showers (brief, but heavy) are in sight or occurring at your location. Record thunderstorms in progress (lightning seen or thunder heard) if you have unrestricted visibility (i.e., lookouts) and the storm activity is not more than 30 miles away. State of the weather codes 5, 6, or 7 (i.e., drizzle, rain, or snow) causes key NFDRS components and indexes to be set to zero because generalized precipitation over the entire forecast area is assumed. State of weather codes 8 and 9 assume localized precipitation and will not cause key NFDRS components and indexes to be set to zero.

### Fuel Model

Determine the primary fuel models of the plant associations that are burning in the active flaming front and will burn as the fire continues to spread. Use the Fire Behavior Prediction System fuel models #1–13 (Anderson 1982) or create custom models using BEHAVE (Burgan and Rothermel 1984).

#### Fireline Safety

If it would be unsafe to stand close to the flame front to observe ROS, you can place timing devices or firecrackers at known intervals, and time the fire as it triggers these devices.

Where observations are not possible near the monitoring plot, and mechanical techniques such as firecrackers or in-place timers are unavailable, establish alternate fire behavior monitoring areas near the burn perimeter. Keep in mind that these substitute observation intervals must be burned free of side-effects caused by the ignition source or pattern.

### Fire Characteristics

**For specific concerns on monitoring fire characteristics during a prescribed fire in conjunction with fire effects monitoring plots, see page 106.** Collect data on the following fire characteristics (RS):

#### *Rate of spread*

Rate of Spread (ROS) describes the fire progression across a horizontal distance; it is measured as the time it takes the leading edge of the flaming front to travel a given distance. In this handbook, ROS is expressed in chains/hour, but it can also be recorded as meters per second (see Table 33, page 209 for conversion factors).

Make your observations only after the flaming front has reached a steady state and is no longer influenced by adjacent ignitions. Use a stopwatch to measure the time elapsed during spread. The selection of an appropriate marker, used to determine horizontal distance, is dependent on the expected ROS. Pin flags, rebar, trees, large shrubs, rocks, etc., can all be used as markers. Markers should be spaced such that the fire will travel the observed distance in approximately 10 minutes.

If the burn is very large and can be seen from a good vantage point, changes in the burn perimeter can be used to calculate area ROS. If smoke is obscuring your view, try using firecrackers, or taking photos using black-and-white infrared film. Video cameras can also be helpful, and with a computerized image analysis system also can be used to accurately measure ROS, flame length, and flame depth (McMahon and others 1987).

#### *Perimeter or area growth*

Map the perimeter of the fire and calculate the perimeter and area growth depending upon your park's situational needs. As appropriate (or as required by your park's Periodic Fire Assessment), map the fire perimeter and calculate the area growth. It's a good idea to include a progression map and legend with the final documentation.

#### *Flame length*

Flame length is the distance between the flame tip and the midpoint of the flame depth at the base of the flame—generally the ground surface, or the surface of the remaining fuel (see Figure 1, next page). Flame length is described as an average of this measurement as taken at several points. Estimate flame length to the nearest inch if length is less than 1 ft, the nearest half foot if between 1 and 4 ft, the nearest foot if between 4 and 15 ft, and the nearest 5 ft if more than 15 ft long. Flame length can also be measured in meters.

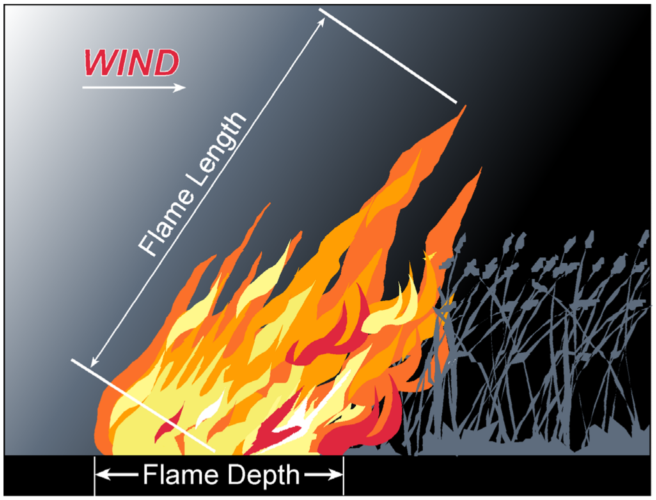



**Figure 1. Graphical representation of flame length and depth.**

***Fire spread direction***

The fire spread direction is the direction of movement of that portion of the fire under observation or being projected. The fire front can be described as a head (H), backing (B), or flanking (F) fire.

***Flame depth (optional)***

Flame depth is the width, measured in inches, feet or meters, of the flaming front (see Figure 1). Monitor flame depth if there is a management interest in residence time. Measure the depth of the flaming front by visual estimation.

### Smoke Characteristics

These Recommended Standards for smoke monitoring variables are accompanied by recommended thresholds for change in operations following periods of smoke exposure (Table 2, page 17). **These thresholds are not absolutes, and are provided only as guidelines.** The following smoke and visibility monitoring variables may be recorded on the "Smoke monitoring data sheet" (FMH-3 or -3A) in Appendix A.

***Visibility***

This is an important measurement for several reasons. The density of smoke not only affects the health of those working on the line but also can cause serious highway concerns. Knowing the visibility will help law enforcement personnel decide what traffic speed is safe for the present conditions, and help fire management personnel decide the exposure time for firefighters on the line.

Visibility is monitored by a measured or estimated change in visual clarity of an identified target a known distance away. Visibility is ocularly estimated in feet, meters or miles.

***Particulates***

Park fire management plans, other park management plans, or the local air quality office may require measurement of particulates in order to comply with federal, state, or county regulations (see Table 2, page 17). The current fine particulate diameter monitoring standards are PM-2.5 and PM-10, or suspended atmospheric particulates less than 2.5 (or 10) microns in diameter.

***Total smoke production***

Again, measurement of total smoke production may be required by your fire management plan, other park management plans, or the local air quality office to comply with federal, state, or county regulations. Use smoke particle size–intensity equations, or an accepted smoke model to calculate total smoke production from total fuel consumed or estimates of intensity. Record in tons (or kilograms) per unit time.

***Mixing height***

This measurement of the height at which vertical mixing occurs may be obtained from spot weather forecast, mobile weather units, onsite soundings, or visual estimates. The minimum threshold for this variable is 1500 ft above the elevation of the burn block.

***Transport wind speeds and direction***

These measurements also can be obtained from spot weather forecasts, mobile weather units, or onsite soundings. The minimum threshold for this variable is 5 to 7 mph at 1500 ft above the elevation of the burn block.

***Ground wind speeds and direction***

See wind speed and direction on page 11.

***Documented complaints from downwind areas***

Your local air quality office will forward any written or verbal complaints to your park headquarters. The maximum allowable number of "recordable" complaints per treatment is defined by each air quality office.

***Carbon monoxide (optional)***

You can measure carbon monoxide on the fireline using a badge sampler or dosimeter (Reinhardt and others 2000), or by extrapolating from visibility measurements. Burn crew-members should not be exposed to areas of <100 ft visibility any longer than two hours.

***Observer location and elevation (optional)***
Recording the location and elevation of the observer can be important, as your view can be affected by your position. For example, visibility at 1,000 m may be fairly clear, but down at 500 m an inversion may be trapping smoke, and thus causing a greater concern to people living at that elevation. If you don't include the fact that your observation was made above that zone, it may appear that your records are inaccurate. Naturally, if you can see the inversion below you, and can approximate its ceiling, that should also be reported. Elevation can be recorded in feet or meters.

***Elevation of smoke column above ground (optional)***
The elevation of the top of the smoke column should be recorded in feet or meters above ground level. Features such as nearby mountains of known heights can be useful in making such an estimate.

***Smoke column direction (optional)***
The direction in which the column is pointed can be important, as this will help to predict possible smoke concerns downwind. Noting any breaks or bends in the column can also help predict possible spot fire conditions that may result.

***Smoke inversion layer elevation (optional)***
Information on inversion layers is critical to air quality and fire behavior management. Again, the top of the layer should be reported in feet or meters above the ground. Inversions can be identified by dark, "heavy" bands of air that are obviously clouded by smoke. Very often, this dense air will have an abrupt ceiling to it, above which the air is clear. Objects of known height can help you to accurately estimate the elevation of that inversion layer.

***Smoke column (optional)***
It may be pertinent to describe the characteristics of the smoke column. Is the column bent or leaning in a particular direction, or does it rise straight up for several thousand feet? Is it sheared, and if so, at what height? What color is the column? All of this information will help to quantify how the fire was burning and under what atmospheric conditions. Using the guide on the back of FMH-3A, describe the observed smoke column characteristics and atmospheric conditions.

***Use of the Smoke monitoring data sheet (FMH-3)***
The Smoke monitoring data sheet (FMH-3, in Appendix A) is intended for use on both wildland and prescribed fires. Each box on the data sheet is divided in two; place the time of your observation in the top portion of the box, and the observation value in the lower portion of the box. When you use this form, it is important to note the following:

- Formulas for determining appropriate highway visibilities (variable #2 on the form) can be found in the RX-450 Training Manual (NWCG 1997).
- Monitor the number of public complaints (monitoring variable #4) by time interval (two to four hours post-ignition), rather than at any specific time. "Recordable complaints" can be monitored via the local air quality office, park information desk or telephone operator.
- The monitoring frequency for surface winds (variable #8) should be determined by each park since this parameter is a frequent and critical source of data collection. At a minimum, however, collect these data once every 24 hours. Record monitoring frequencies along with wind speed in miles per hour (mph) or meters/sec (m/s) (see Table 33, page 209 for conversion factors).
- The formula for computing total emissions production (TEP) is found on the back of the FMH-3 form. TEP, in tons/acre is recorded under "OTHER," line 1. You can derive the emission factors included in this formula from factors available in the RX-450 training manual (NWCG 1997).

### Holding Options
Identify areas or features that will slow the spread of the fire. Also identify vegetative conditions that provide for rapid fireline construction, should that become the appropriate management response.

### Resource Advisor Concerns
The Resource Advisor may indicate specific variables that need to be observed as part of the monitoring process. This might include fire behavior upon contact with certain species, disturbance of wildlife, fire management impacts, etc.

***Fire severity mapping (optional)***
The postburn effects of a large fire are numerous and may include plant mortality, mud slides, and flooding. A quick assessment of the ecosystem can help you determine whether rehabilitation measures are needed. Managers may use this assessment to understand future patterns of vegetation and faunal distribution.

One critical step in this analysis is burn severity mapping. This type of survey can be done using any of several methods, including data from LANDSAT (White and others 1996), or from digital cameras (Hardwick and others 1997). For more specific information see the Burned Area Emergency Handbook (USDA Forest Service 1995), or call your regional or national BAER coordinator.

**POSTBURN REPORT**

Fire managers often need a summary of information immediately following a fire. While detailed information on fire effects are not immediately available, detailed information regarding fire observations and fire conditions can and should be summarized soon after the fire. This information may be used to refine prescriptions, strategy, and tactics over both the short and long term. **Decide in advance who is responsible for preparing this report.** A fire monitor can collect most of the information recommended. Consultation with the Burn Boss or Incident Commander is recommended.

Currently there is no standardized format for post burn reporting; the following list contains items to consider including in this report.

- Fire name
- Resource numbers and type (personnel and equipment)
- Burn objectives
- Ignition type and pattern
- Holding strategy
- Fuel moisture information (e.g., 1000-hr, live woody and herbaceous, foliar)
- Drought index information
- Fire behavior indices information (e.g., ERC)
- Precipitation information
- Test burn description
- Chronology of ignition
- Chronology of fire behavior
- Chronology of significant events
- Chronology of smoke movement and dispersal
- Temperature (range, minimum and maximum)
- Relative humidity (range, minimum and maximum)
- Accuracy of spot weather forecast
- Initial qualitative assessment of results (were short-term objectives achieved?)
- Future monitoring plan for area (e.g., plots, photo points)
- Acres burned
- Additional comments

Attachments:

- Map of area burned
- Fire weather observations data sheets
- Fire behavior observations data sheets
- Smoke observations data sheets
- Weather station data
- Fire severity map

**Table 2. Smoke monitoring variables (RS) with techniques, frequencies, and recommended thresholds.**

| Variable | Location | Technique | Frequency | Threshold |
|---|---|---|---|---|
| **Visibility:**<br>**Duration of impairment by distance** | Fireline | • Visual estimate | 30 minutes | Exposure of burn crew-members to areas of <100 ft visibility not to exceed 2 hours |
| | Vicinity of fire (highways, concessions, residential areas, schools, etc.) | • Visual estimate | 30 minutes | Exposure dependent on state Minimum Acceptable Visibility (MAV) standards |
| **Duration of impairment by distance; no. people and sensitive areas affected** | Downwind | • Visual estimate using known milestones or photographic standards | 2 hours | Pop. / Min. distance (miles):<br>1K–5K: 2–5<br>>5K–50K: 4–7<br>>50K: 7–9 |
| **Particulates:**<br>**PM-2.5/10; amount and duration[1]** | Fireline, population centers and critical areas where smoke contribution is presumed to be significant | • PM-2.5/10 sampler<br>• Established state and agency monitoring programs | 24 hours/Annual | PM-2.5: $65\mu g/m^3$, $15\mu g/m^3$<br>PM-10: $150\mu g/m^3$, $50\mu g/m^3$ |
| **Total Smoke Production:**<br>**Tons (kilograms)/ unit time** | Burn site or office | • Calculated from total fuel consumed<br>• Intensity estimate<br>• Smoke particle size–intensity equations | Preburn estimate followed by postburn reaffirmation | May be determined by state or local permit |
| **Mixing Height:**<br>**Height-Temperature Gradient** | Ground | • Spot weather forecast<br>• Mobile weather unit<br>• Onsite sounding<br>• Visual estimate | 1 hour | 1500 ft above burn elevation; do not violate for more than 3 h or past 1500 hours |
| **Transport Winds:**<br>**Speed** | Burn site | • Spot weather forecast<br>• Mobile weather unit<br>• Onsite sounding | 1 hour | 5 to 7 mph at 1500 ft above burn elevation; do not violate for more than 3 hours or past 1500 hours |
| **Ground Winds:**<br>**Speed** | Ground | • Wind gauge held at eye level<br>• Mobile weather unit | 1 to 6 hours (depending upon threat to safety and proximity of roads) | 1 to 3 mph—day<br>3 to 5 mph—night |
| **Complaints:**<br>**Number** | Received at headquarters or from an air quality resource district | • Written<br>• Verbal | NA | The maximum allowable number of “recordable” complaints per treatment, as defined by the local air quality control district. |
| **CO Exposure:**<br>**ppm or duration of visibility impairment** | Fireline | • Badge sampler or extrapolation with visibility<br>• Dosimeter | 30 minutes | Exposure of burn crew members to areas of <100 ft visibility not to exceed 2h. If exceeded, 24 hour detoxification is required before crew members can return to fireline duty |

[1]PM-2.5 and PM-10 monitoring is mandatory only if a critical target exists within park boundaries or within 5 miles of a park boundary, and may be impacted by smoke of unknown quantities. The controlling air quality district may provide a PM-2.5 or PM-10 monitor in the surrounding area under any circumstances. The key is that the air quality district has the ultimate authority for determining when particulate matter standards are violated and when land managers must take appropriate actions to comply with established district, state and federal standards. A variety of occupational exposure limits exist, ranging from the OSHA Permissible Exposure limits to the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold limit values and the NIOSH Recommended Exposure Limits.

# Additional Information for Monitoring Fire Behavior Characteristics

## Collecting Fire Behavior and Weather Data

Previous editions of the Fire Monitoring Handbook (USDI NPS 1992) recommended that monitors record fire weather and behavior characteristics at each plot using Fire Behavior Observation Circles (FBOC) or Intervals (FBOI). The revised recommendations follow.

For the monitoring plots to be representative, they must burn under the same conditions and ignition techniques used in the rest of the prescribed fire block. **Fire monitor safety, however, must always be foremost.**

Forest monitoring types may include a dense understory layer, while brush and grassland fuel types are usually flashy; all of them may be unsafe to move through during a fire. The monitoring procedure presented here is an ideal and will be impossible to implement in some situations. The objective of monitoring fire characteristics in forest, brush or grassland types, therefore, is to do whatever is necessary to be safe while simultaneously obtaining representative fire behavior measurements wherever possible.

Take fire weather and behavior observations (rate of spread, flame length, and flame depth (optional), and other level 2 variables described in Chapter 2) in the same monitoring types represented by your plots, in an area where the fire behavior is representative of fire behavior on the plots. Where safe, you can make fire behavior observations near a monitoring plot.

## Fire Behavior Accuracy Standards

Accuracy standards for each variable discussed in this section are listed in Table 29, page 111.

### RATE OF SPREAD

To estimate Rate of Spread (ROS), you can use a Fire Behavior Observation Interval (FBOI). An FBOI consists of two markers placed a known distance apart, perpendicular to the flame front. Five feet is a standard length for the FBOI; however, you may shorten or lengthen the FBOI to accommodate a slower or faster moving flame front.

If you expect an irregular flaming front, set up another FBOI, perpendicular to the first FBOI. That way you will be prepared to observe fire behavior from several directions. If the fire moves along either FBOI, or diagonally, you can calculate ROS, because several intervals of known length are available. To distribute the FBOIs, use a setup that you think makes sense for your situation.

As the fire burns across each FBOI, monitor the recommended Fire Conditions (level 2) variables, and record observations on the Fire behavior–weather data sheet (FMH-2, in Appendix A). The time required for the fire to travel from one marker to the other divided by the distance (5 ft) is recorded as the observed rate of spread. For further information on ROS, see page 13.

## Rate of Spread

You may use metric intervals to measure ROS. However, a possible problem with using metric ROS intervals is that you may forget to convert the metric into English units to get a standard linear expression for ROS, which is chains per hour or feet per minute. To avoid potential errors, it may be better to pre-measure and mark the ROS intervals in feet.

### FLAME LENGTH AND DEPTH

During the fire, estimate flame length (FL) and flame depth (FD; optional) (see page 13) at 30-second intervals (or more frequently if the fire is moving rapidly), as the flaming front moves across the ROS observation interval. Use the Fire behavior–weather data sheet (FMH-2) to record data. If possible, make five to ten observations of FL and FD per interval. **Note:** Where close observations are not possible, use the height (for FL) or depth (for FD) of a known object between the observer and the fire behavior observation interval to estimate average flame length or flame depth.

Fire weather observations should be recorded at 30-minute intervals. Sample more frequently if you detect a change in wind speed or direction, or if the air temperature or relative humidity seems to be changing significantly, or if directed to do so by the prescribed burn boss.

### Fireline Safety

- For safety, inform all burn personnel at the preburn briefing that the unit contains monitoring plots. It is recommended that you provide a brief discussion on the value of these plots, and your role on the burn.
- Inform all ignition personnel that they are to burn as if the plots do not exist. This will help avoid biased data, e.g., running a backing fire through a plot while using head fires on the rest of the unit.

Park/Unit 4-Character Alpha Code: ___________

**FMH-1** **ONSITE WEATHER DATA SHEET** Page ___ of ____

Plot ID: ____________________________

Burn Status (Indicate number of times treated, e.g., 01 Burn, 02 Burn, etc.): ________-Burn

Burn Unit/Fire Name–Number: ________________________ Recorder(s): _______________

Circle Units for: Wind Speed (mph, m/s) Dry Bulb Temperature (°F, °C)

| Obs. Date | Obs. Time | Wind Speed | Wind Dir. | D. B. (°) | R. H. (%) | Location / Comments |
|---|---|---|---|---|---|---|
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Date Entered: ____/____/____

Park/Unit 4-Character Alpha Code: ______________

**FMH-1A** **ALTERNATE ONSITE WEATHER DATA SHEET** Page _____ of _____

Plot ID: ________________________ Burn Status (Indicate number of times treated, e.g., 01 Burn, 02 Burn, etc.): _______-Burn

Burn Unit/Fire Name–Number: ______________________________ Recorder(s): ____________________________________

Circle Units for: Wind Speed (mph, m/s) Dry Bulb Temperature (°F, °C)

| Date | Time | Location | Elevation | Aspect | *State of WX | Temperature Dry Bulb | Temperature Wet Bulb | RH | Wind Speed | Wind Direction | **Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
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|---|---|---|---|---|
| *Codes State of the Weather: | 0-clear, <10% cloud cover | 1-10–50% cloud cover | | **Comments include: |
| 2-broken clouds, 60–90% cloud cover | 4-fog | 6-rain | 8-showers | - ppt amount/duration |
| 3-overcast, 100% cloud cover | 5-drizzle or mist | 7-snow or sleet | 9-thunder-storm | - erratic winds |

 Date Entered: ____/____/____