# City of Chico Bidwell Park

## Effectiveness Monitoring in an Adaptive Management Framework

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# Executive Summary

Increasingly, governments utilize nongovernmental and community collaborations to address community needs. Community participation is considered a key component of many aspects of sustainable, local government management. In the City of Chico's Bidwell Park, hundreds of volunteers donate thousands of hours performing various management activities each year and non-profit partners have garnered over $2 million dollars for ecosystem management, research and development projects in and around the Park in 2007 alone. Guided by objectives in the City's Natural Resource Management Plan and through deliberate City leadership, key information gaps and management needs could be achieved through community participation.

This project has been an exploration into both adaptive management and participatory monitoring as a prospect for collaborative management in Bidwell Park. As a collaborative management project, the initial objectives for this project have been influenced by the input and accessibility of stakeholders, as well as a changing policy environment. What started out to be inquisition into existing natural resource management collaborative frameworks and monitoring methodology has turned into an assessment of how the City of Chico's Bidwell Park fits into collaborative, landscape-level adaptive management with focus on the application of the participatory resource to the City policy environment.

This graduate research report offers background information on mechanisms to enhance the application of community-driven research and restoration activities to the City of Chico's adaptive management objectives for Bidwell Park. Part I of this report describes the relationship between monitoring and assessment as critical to the adaptive management model. Part II of this report provides recommendations on the next steps for implementing participatory monitoring in an adaptive management framework for Bidwell Park. Part III describes the process of initiating effectiveness monitoring for key natural resource management objectives in the Park's Natural Resource Management Plan.

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# Introduction

If the potential for collaborative management success can be measured by stakeholder involvement and municipal participatory goals, then Bidwell Park has the trappings of a burgeoning, sustainable collaborative. Pursuant to the City of Chico's goal to establish adaptive management in Bidwell Park, this project has: researched the role of effectiveness monitoring in an adaptive management context, distilled monitoring objectives and management objectives in the current policy context, and reviewed literature to describe the application of principles of collaborative management to adaptive management in Bidwell Park.

The adaptive management approach is a contemporary concept in concept; it is bioregional in scope, collaborative in governance and adaptive in a managerial aspect (Keller et al, 2000). The establishment of adaptive management in Bidwell Park requires acknowledgement that adaptive management is a participatory approach; one that requires significant effort to maintain adequate stakeholder participation necessary for success. Stakeholder collaboration is a significant and strategic foundation to initiating the adaptive management process as it brings together interested parties to clarify and prioritize management issues. Collaboration continues to be a critical characteristic of adaptive management throughout implementation and assessment phases, as it brings varied expertise, financial resources and continuity to the effort.

Adaptive management and collaborative management are both very popular trends, occurring in all sectors of government (Agranoff, 2003). Both methodologies receive scrutiny for being more influential as ideas than in their implementation (Keller et al, 2000), as researchers debate the ability to measure the success of the partnerships or the influence the methods have on increased environmental quality. The value these methodologies have in engendering social learning and improving relationships between stakeholders have, however, been generally accepted (Gibbs and Jonas, 2000). Governing ecosystems in a social context is a new tenet for sustainable communities (Cheng and Daniels, 2003).

The first steps to establishing the adaptive approach are: shared understanding of the adaptive management model and knowledge of the principles of successful collaborative management. This report outlines both, with respect to its application to effectiveness monitoring in Bidwell Park.

# Part 1: Developing Monitoring Objectives in a Policy Environment

## Adaptive Management- An Introduction

Adaptive management can take one of two forms: passive and active (Wilhere, 2002). *Passive* adaptive management entails a process of formulating predictive models, basing policy on those models and revising models as needed as environmental data becomes available (Haney, et.al., 1992). Passive adaptive management takes a passive, opportunistic role in acquiring environmental data. Monitoring is done without the necessary elements of statistically-valid experimental design. As such, monitoring is not poised to establish casual relationships between management and observed changes in the environment (Wilhere, 2002).

To increase the level to which monitoring can address questions of what has caused observed effects, active adaptive management activities are deliberately conducted to address the need for controls, replication, and randomization (Haney et al, 1992). Different management strategies are therefore approached as different hypotheses and implemented by way of experimental design. Predictions of how the variables will respond to management actions can increase the ability to use the resulting data to refine and build on management strategies (Cheng, 2003). Thus, monitoring in active adaptive management strategies typically provides data which leads to better understanding of how the environment is responding to management.

Whether adaptive management takes the 'active' approach or not, monitoring remains a critical component to how environmental responses get fed back into the management decision-making. Monitoring in a management context requires data acquisition with clearly defined objectives which, ideally, are biologically meaningful, measurable, feasible and written with detail reflecting the current level of knowledge about the variable (CBI, 2007).

## Monitoring Defined

Monitoring is a key component to the adaptive management framework. There are a number of different types of monitoring and data collection activities. Monitoring in an active adaptive management setting, however, suggests repeated collection and analysis of vegetation data with which to evaluate changes in environmental conditions due to management actions (Barrows, 2007).

The literature review reveals that 'monitoring' is used consistently to describe any number of data-collecting activities. Field methods and analysis can be similar between these activities so some clarification is offered. The primary difference between the termed monitoring activities is the purpose of the data collection and the temporal scale of the study. For the purpose of this report, the following terms, inventory, ecological study, research and long-term ecological studies, are distinguished from monitoring (Elizinga et al, 1998).

*Inventory*

Inventories are measurements at a single point in time. Inventories are often done to assess the number and extent of species' populations, to assess habitat and/or threats. Data from an inventory can provide baseline information for a monitoring study. An inventory can also serve to inform monitoring design.

*Ecological study*

An ecological study defined as data collection structured to answer questions about the ecology of one or more species is not considered monitoring (Atkinson et al, 2004). This type of information is key to informing the monitoring design, but is not monitoring in itself.

*Research*

Ecological studies can be considered research as well, but research is described by Manly (1992) as a "study designed to determine the causes(s) of some observed ecological phenomena" (Elizinga et al, 1998).

*Baseline and long-term ecological studies*

Typically, baseline and long-term ecological studies measure a wide range of variables. When the study is a point-in-time effort, it is considered a baseline study; scheduled, periodic re-measurements become long-term ecological studies (Atkinson et al, 2004).

For the purpose for the purpose of adaptive management, monitoring is explicitly described as systematic, repetitive, objective-driven collection of information in a management context (Atkinson et.al., 2004). Monitoring programs are further differentiated into three main components: implementation monitoring, effectiveness monitoring, and targeted studies. *Implementation monitoring* focuses on whether implementation activities are in accordance with management planning. *Effectiveness monitoring* evaluates whether a management plan is effective in meeting its biological objectives (Atkinson et al, 2004). *Targeted studies* focus on improving the understanding of the systems under management and include management-specific ecological studies (plant succession, weed dynamics, etc.) and experimental management treatments.

Within each component, monitoring can focus on either a specific resource, such as a specific plant or animal, or it can focus on habitat quality (Atkinson et al, 2004). Although change detection as is a characteristic of monitoring, change detection itself can be conducted without identifying the information needs for decision-making (Perry et al, 1987).

# Objective-driven Monitoring Programs

A great deal of literature is available which provides step-by-step guidance on developing a monitoring strategy suited towards a management application. This section of the report summarizes the literature through a discussion on how monitoring is applied in an adaptive management environment.

## Monitoring in the Adaptive Management Model

Performance measures are critical to any organization's management plan (Allen and Curtis, 2003). Ecosystem monitoring is just one part of performance assessment in the adaptive management model. Like performance measures, ecosystem monitoring should include target setting, benchmarking, and objective-setting in a collaborative environment (Allen and Curtis, 2003). Operating in the face of fiscal scarcity, adaptive management need utilize resources for monitoring efficiently. Thus, monitoring efforts should be refined by specific management objectives. Employing statistically-valid experimental design provides more value to an adaptive management monitoring program as it provides a stronger basis to determine causal relationships, rather than simple associations, between management practices and the observed environment. Objective-driven monitoring further refines a monitoring effort by providing insight to aid in determining sampling size, frequency and the type of information necessary to collect at each site (Atkinson et al, 2004).

Monitoring is a critical component in the feedback loop between management decision-making and environmental responses. Monitoring in a management context requires data acquisition with clearly defined objectives which, ideally, are biologically meaningful, measurable, feasible and written with detail reflecting the current level of knowledge about the variable (Atkinson et al, 2004).

## The Policy Environment of Bidwell Park

In order to identify ecosystem monitoring objectives for Bidwell Park, a survey of the policy environment whereby the Park's management goals are articulated, is needed. Prior to seeking related policy documents, it is necessary to become familiar with the general and critical resources in Bidwell Park's landscape, ecosystems, habitats and species. For this information, California Environmental Quality Act and National Environmental Policy Act environmental documentation related to Park projects were consulted (Stuart, 2003; EDAW, 2008; CSUC, 2008). Additional species- and habitat- specific ecological information was derived from the draft Ecological Baseline Report for the Butte Regional Habitat Conservation Plan/Natural Community Conservation Plan (SAIC, 2007).

A brief listing of policy documents is provided for some context as to what comprehensive, effectiveness monitoring in Bidwell Park may entail in its entirety. A portion of Bidwell Park is included in both the critical habitat designation for several vernal pool branchiopods and plant species and identified in the vernal pool recovery plan for California and Southern Oregon as a core conservation area (USFWS, 2005). Currently, Butte County is developing a Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP). The HCP/NCCP is a cooperative and comprehensive plan developed to ensure recovery of special-status species and enhance conservation throughout the planning area. It is unclear at this point what role the Park will play in the overall picture of conservation and monitoring plan for the HCP/NCCP.

Adjacent to Bidwell Park is the Big Chico Creek Ecological Reserve (BCCER). The BCCER Master Management Plan was developed over two years by a Technical Advisory Committee (see the BCCER website http://www.csuchico.edu/bccer/Management/masterplan2003/MasterPlanSpring03.htm). The BCCER Master Management Plan has goals and objectives similar to that prepared for the City of Chico (EDAW, 2008).

Although there are a number of policy documents from which management priorities in Bidwell Park may originate, the premier management document for Bidwell Park is the Master Management Plan (MMP) (EDAW, 2008). The MMP features the Park's Natural Resource Management Plan (NRMP) as Appendix C. The NRMP provides a cursory management framework for the Park to support the goals and objectives in the MMP. With limited resources, management framework and environmental data with which to develop a comprehensive natural resource management document, the NRMP focuses on discrete, but not quantified, objectives for fire management, invasive species management and oak woodland management. As such, the discussion of objective-based, collaborative monitoring in this report is limited to invasive species and oak woodland regeneration.

The Bidwell Park NRMP explicitly lacks an objective to clearly identify the characteristics of the Park's natural resources. The NRMP further has disadvantage to a researcher seeking clarification on management objectives, as the NRMP lacks quantitative management goals. For example, the NRMP identifies the reduction of invasive species throughout the Park as a management objective, but would be better suited towards experimental design if the objective was stated as such: Invasive species reduced 10% throughout the Park.

## Monitoring Using Experimental Design

In an active adaptive management process, management objectives, potential management actions and monitoring objectives are considering concurrently in the selection of data acquisition methods. Monitoring in this context ideally takes the experimental approach and is designed to apply data specifically to management issues. Explicit, quantitative management objectives are critical in establishing proper management design and ensuring statistical power (see Sampling Statistics, below).

To create causal relationships between management and observation, the active adaptive management monitoring strategy need include the three elements of experimental design: replication of treatment, control and randomization (Elizinga, et al, 1998).

Experimentally-designed monitoring plans provide more value as data acquired through them allow for more than simple association and causation (CBI, 2008). Experimental design takes sampling statistics and data analysis methods into consideration to ensure that monitoring frequency, duration and intensity will yield statistically-significant data (Elizinga et al, 1998). Ecological information derived from research or ecological baseline studies is used in a retrospective analysis to determine that correlations are statistically significant and have biological meaning (Barrows, 2007).

## Introduction to Sampling Statistics

Sample statistics; descriptive measures from a sample to estimate population parameters (like total population, mean population density and sample standard deviation). The sampling plan is optimally designed to minimize experimental error, which can take the form as either sampling error or non-sampling error. Non-sampling errors can arise when using biased selection rules, when using measurement techniques which cannot accurately describe a resource, with field data collection acquisition and transcription errors. Non-sampling error leads to sampling error. Sampling error describes the resultant deviation from the real world and leads to missed-change errors and false-change errors (Elizinga et al, 1998). A primary goal of sampling design is to minimize standard error between replicate surveys (Atkinson et al, 2007).

*Designs for Null Hypothesis*

Change detection from a monitoring study can result in one of two conclusions, and both can be wrong (Turner, 2001). The study will find either change did or did not occur. The potential for a false-change error (detecting change when none has occurred) is called Type I error or α- error. Minimizing missed change or Type II error is usually of great importance to conservation planning as a failure to identify true change can result in serious declines to sensitive populations (Elizinga et al, 1998). The potential for missed-change error (detecting no change when change has occurred) is called Type II or β-error. Statistical power is the complement to the Type II error, so if Type II error is .25, than the statistical power is 0.75. Power can be used to describe Type II error; higher power is equated to lower potential for measuring false-change. The probability of detecting Type I error is the *P*-value and can be derived from empirical data (Turner, 2001). It is common that a *P*-value threshold for a statistical test is set arbitrarily to 0.5.

Experimental design ideally aims to achieve adequate statistical power (Elizinga et al, 1998). Power can be optimized by decreasing standard deviation in the datasets (ensuring replicate study size and locations are adequately similar), increasing the number of sampled units (in both replicate and repeat sites), increasing the level of acceptable Type II errors (usually an arbitrary measure of acceptable error) and increasing minimum detectable change (Turner, 2001).

Minimum detectable change is typically a stated management objective like, for example, a 10% increase in sapling coverage over time. Depending on the management variable, it may not be acceptable to increase the minimum detectable change to enhance statistical power. Statistical power is the level of confidence needed to detect change over time.

*Significance Tests for Change Detection*

In monitoring for adaptive management, the independent-sample *t* test can be used to test for difference in the means within the replicates, between managed plot replicates and control plot replicates and/or between plots over time. For management purposes, if detecting change as either an increase or decrease in a population mean is needed, then a two-tailed *t* test would be used. An analysis of variance, or

*ANOVA*, would be used for testing the differences between three or more samples using a statistics program (Sasaki, 2002).

# Part 2: Participatory Resource Management

As a general rule, adaptive management is a participatory method. To efficiently and effectively manage resources on an ecosystem level in the face of limited resources and scientific uncertainty, stakeholder involvement is critical. In Bidwell Park, City of Chico, natural resource management is shared largely by non-profit organizations. Although these groups invest a significant amount of financial and human resources in the Park, there are few planning and assessment activities occurring between constituents. Establishing a truly collaborative management relationship between the City and partner organizations has potential to not only enhance efficacy of project implementation, but result in an implementable and sustainable management strategy for the Park.

This section summarizes the movement towards increased stakeholder participation in environmental decision-making and describes the tenets of successful collaborative management strategies. The section includes recommendations as to how to implement a collaborative framework for natural resource management and monitoring in Bidwell Park.

## *The Movement towards Increased Public Participation*

Until the movement to centralization of pollution control, local governments were primarily accountable for environmental management, with the role of the federal government management limited to resource extraction on federal lands (Andrews, 2000). There was a lack of trust on the national level that local environmental management gave adequate incentives for local governments, businesses and individuals to protect resources from market forces leading to the increased industry and resource extraction. As such, a host of new environmental policies excluded local involvement. The establishment and management of national parks at this time exemplified this thinking (Gibbs, 2000).

Simultaneously, this era also marked expanded public access to regulatory decision-making. Early successful lawsuits, such as the *Storm King* case, created a precedent for the public to use offensive litigation to force the government's hand in implementing environmental laws. Citizen-suit provisions were added to the statutes to allow private citizens to bring environmental violators and the EPA itself to court to require them to follow the law (Andrews, 2000). The ability of a person to sue on behalf of the public interest and not to just recover personal damages was monumental for the environmental movement. Subsequently, grassroots and community organization on behalf of environmental management increased (Gibbs, 2000), and fueled the trend towards community participation in natural resource regulation at the local level.

At the present, community participatory management is a very popular trend, with increased collaborations with community groups occurring in all sectors of government (Agranoff, 2003). Public participation role in natural resource management has correspondingly experienced a steady increase.

## *Collaborative and Adaptive Management*

Adaptive management is by definition, a participatory method. The complexity, controversy, scientific uncertainty and policy environment surrounding natural resource management issues necessitate a multi-disciplinary and inclusive approach. In particular, adaptive management utilizes collaboration to develop problem statements and to select management and assessment approaches with to analyze management success (Keough, 2006).

As evidenced by the abundance of studies in recent literature, scientists and land managers increasingly recognize that improved environmental and social conditions require increased sensitivity and responsiveness to social concerns (Shindler, 1999). Specifically, adaptive management experimentation on the West Coast of the United States has revealed a strong interest among citizens to collaborate in policy processes and stewardship opportunities (Shindler 1999).

The benefits of collaborative management in any setting are reported as several-fold: to bring about creative solutions to complex issues; to enhance stakeholder acceptance of management decisions; to leverage financial and human resources between organizations (Agranoff,2003). Collaborative management calls for shared learning and capacity building, as well as improved stakeholder relationships as a means of promoting effective civic engagement in the policy context. Collaborative, adaptive management further elevates the benefits of collaboration as it frequently results in increased long-term, environmental stewardship (Keough, 2006).

Adaptive and collaborative management approach is a participatory strategy to address a number of interacting environmental issues on a broad temporal and spatial scale (Conley et al, 2003). Collaborative arrangements which enjoy greater participation and success do so by providing a framework for giving participants influence over the creation of collaborative goals, the rules governing its decision-making processes and by creating an environment of reciprocity and accountability. Giving participants of a collaborative group control over management decisions creates a sense of ownership to management recommendations and results in longer lasting arrangements.

Representation, reciprocity, accountability, leadership and continuity typically come with an investment in human and financial resources. Tapping the skills, knowledge and resources of participants and stakeholders in a collaborative arrangement is a fundamentally managerial act (Agranoff, 2003). Furthermore, doing such in a manner that promotes horizontal cooperation takes careful facilitation. As a result, collaborative, adaptive management strategies are often scrutinized for their potential to cost participants significant time and money. The promise of collaborative management, however, is that a collaborative environment engenders greater contributions and more efficient management solutions decided and implemented that what is able to be accomplished with one organization alone. As a result, research in public collaborative management and adaptive natural resource management continue to work to find ways to assess the cost and benefits of various agencies (Conley, 2003).

## *Principles of Collaborative Management*

Although the environmental and policy setting of each collaborative natural resource management collaborative vary and therefore vary collaborative methods, study findings agree that there are a number of definitive factors which contribute to success of collaborative management. Although the vocabulary used to describe these winning attributes, following Agranoff (2003), Sabatier et al (2005) and Shindler (1999), these traits are summarized below:

1) Representation: In theory, collaborative, adaptive management attempt to respond to ecosystem level issues spanning jurisdictional authority and interests. Collaborative ecosystem management projects typically include not just governing agencies, landowners and environmental strategists, but also consumers of natural resources and others with special interest in resources or resource use. Participating organizations are critical to integrated program success as they bring technical expertise, financial and

human resources to the table and are capable of encouraging and leveraging even greater community investment.

Thus, the intent of broad-based participation is to a) "arrive at decisions that better achieve resource management objectives" (Shindler, 1999, 3), b) leverage increased financial and institutional resources (Agranoff, 2003), and c) make decisions that enjoy increased public support. Thus, involving 'deal-breakers', or any individuals or groups likely to question or disagree with potential resource management strategies need be represented through the collaborative process.

The problems with inclusiveness become, 'how to manage broad and divergent involvement', and 'how to know when a collaborative arrangement has achieved adequate representation'. Taking lessons from the literature, well managed collaboratives benefit from streamlined and facilitated decision-making processes and accountability among partners. Working to minimize administrative processes for all involved is thought to enhance the goals of adequate representation. Careful facilitation also promises greater success in achieving consensus, despite diverging viewpoints (Agranoff, 2003).

2) Reciprocity: Successful collaborations have reciprocal rewards for all parties involved. Collaborative management arrangements succeeding wide-reaching and complex problem-solving activities require that all partners and stakeholders provide input into the process. A number of collaborative natural resource management arrangements require a certain level of participation from stakeholders in an effort to maintain their vestment and accountability to the group. Furthermore, reciprocity involves ensuring input from all sides is valued and addressed in conference.

   Reciprocity from agency partners is particularly important for collaborative and adaptive management. Often, scientific and policy expertise are contributed from other partners (such as University professors or national, non-governmental organizations), whereas agencies have ultimate jurisdiction on employing collaborative decisions. For a collaborative decision to succeed within overlapping and vertical hierarchical structures, agency partners need to provide substantive engagement throughout the decision-making process and to implement decisions as intended (Sabatier et al, 2005).

3) Accountability: Accountability entails creating the perception that partners are following through with commitments. A primary consideration in accountability is that collaborative decisions are executed as intended by the collaborative group. Accountability also implies that the input provided by stakeholders is representative of their constituency. Specifically, collaborative arrangements are found to be more successful when frequently by organizational representatives who are at liberty to make decisions on behalf of their organization.

   Although reciprocity and accountability vary in performance, their impact on the collaborative is the same. Reciprocity and accountability engender trust; a crucial trait in the collaborative environment.

4) Consensus-based decision-making: Many collaborative management theories and groups emphasize the need for consensus-based decision-making. In the diverse and complex problem setting of adaptive management, consensus is necessary to ensuring a meaningful decision-making. This process reinforces the values of reciprocity and accountability as it emphasizes the value of individual participants (Wondolleck and Yaffee, 2000).

   Understanding how to bring about consensus with broad participation is at the heart of the collaborative process. The difficulty of facilitating consensus with broad participation is further complicated by the prevailing culture that leaders and governments have the 'best' answers and that 'people' must be actively managed if the organization is to fulfill their goals. True collaborations and networks seek to accommodate all participants despite the presence of legitimate policy-makers. There is, however, a common perception for agencies to be concerned about the loss of authority or legitimacy when delegating decision-making and responsibility to external organizations or the community. A common concern is that collaborative decisions will run contrary to governmental interests.

   Although the practice of consensus-based decision-making receives criticism as providing imperfect representation others argue that this method achieves adaptive and collaborative management goals for representation and leads to more implementable, publicly-accepted decisions (Conley et al, 2003; Allen et al, 2003). Regardless, the literature agrees that achieving consensus is at the heart of the collaborative process and requires the most investment of time and skill. Expert or informed facilitation typically leads to quicker decision-making by this method (Sabatier et al, 2005).

5) Leadership: Leadership is a key dynamic force in a collaborative management strategy. Leadership in collaborative natural resource management instills confidence in the ability of the collaborative to achieve their goals and therefore the sustainability of the collaborative. A critical component to leadership is the investment of authorizing or mandating agencies or organizations into creating and moving forward the vision of the collaborative (Sabatier et al, 2005). It is critical that those authorized to make the decisions proposed by the collaborative group have shared goals, and that they participate in decision-making, further ensuring the decisions' success.

6) Continuity: Continuing research on successful public partnerships indicates that a critical factor to success is *endurance*. Wondolleck and Yaffee's (2000) research concludes that collaboratives are more likely to be sustained where there is continuity in personnel and philosophy, evidence of leadership commitment, clearly defined collaborative goals, and a mechanism in place to maintain communication.

## *Applying Collaborative Management to Bidwell Park*

The City of Chico is home to the second largest municipal park in California with over 3670 acres of publicly accessible recreation lands in Bidwell Park (Center for City Park Excellence, 2007). As described in Part I, Bidwell Park has a great deal of natural resource value. Parts of Bidwell Park have been designated as critical habitat and core habitat for vernal pool species, and Big Chico Creek is designated as critical habitat for spring-run Chinook salmon. The Park represents intact remnant riparian habitat and associated uplands, and has significant cultural value for the Mechoopda Indian Tribe (City of Chico, 2008).

Lack of funding and subsequent staffing and maintenance levels results in a management issues which are exacerbated as the annual numbers of visitors to the Park steadily increase. The City of Chico's organizational position is such that the City's natural resource expertise is limited to an urban forester, Park staff and land use planners. The City of Chico's budget woes project that budget cuts across the board and staff reductions are a part of the long-term strategy for reducing the budget deficit, so the employ of a natural resource manager, a natural resource department or expert consultants for active management of Bidwell Park's critical resources appear to be beyond the City's financial capabilities for some time.

Despite the City's resource limitations for management in Bidwell Park, community organizations and volunteers are comprising a majority of restoration and data collection activities in the Park with volunteer hours through the City's Volunteer Program totaling over 17,000 hours in 2006 alone (City of Chico, 2007). The amount of Park land managed by community participation is ever changing. In a coordinated effort with the Parks Division Volunteer Coordinator, Volunteer Program stewardship locations for 2008 were mapped (see Appendix A- *Volunteer Program Restoration Sites*). At that time (early 2008), the Volunteer Coordinator coordinated over 9-acres of participatory management in Bidwell Park.

Outside of the City's Volunteer Program, efforts are coordinated by a number of different groups, such as Friends of Bidwell Park, Big Chico Creek Watershed Alliance, Big Chico Creek Ecological Reserve and the local chapter of the California Native Plant Society. There is a degree of informal coordination between the groups, with some formal communication necessitated by grant funded projects; however the partnership lacks strategic leadership for participatory management at this time. Currently, there is no plan place or formal framework or infrastructure for participatory management with the City. For greater success in leveraging financial and human resources between organizations, and in order to employ a comprehensive approach to managing and monitoring ecosystem health in Bidwell Park, a collaborative management framework is key.

## City of Chico Participatory Goals and Objectives

The Bidwell Park Master Management Plan (BPMMP) is the premier guidance document for Bidwell Park. It provides the policy foundation for implementation measures outlined in the Plan. Adopted by the Chico City Council in November 2008, the BPMMP includes the Park's Natural Resource Management Plan (NRMP) as an appendix.

Under the City of Chico recently adopted Bidwell Park Master Management Plan (BPMMP), park-wide goals and objectives call for adaptive and participatory management:

- "Apply, evaluate, and refine diverse management procedures to protect natural resources and, where appropriate, to integrate them with human activity"

- "Management of the Park resources should draw from local experience and expertise and be based on the latest scientific information (EDAW, 2008, 3-10)"

The BPMMP further supports City leadership in coordinating participatory research in its implementation strategies:

- "Coordinate with and enable mutual support and learning with the Big Chico Creek Ecological Reserve and other nearby ecological reserves regarding management issues of both the Park, the Reserve, and adjacent areas"
- "Encourage CSU, Chico faculty and students to develop research projects within the Park aimed at understanding and protecting natural resources"
- "Consult with faculty at CSU, Chico on Park management issues, including vegetation management, prescribed fire... (NRMP, 2008, 3-10)"

The NRMP outlines specific natural resource management objectives and includes resource-specific information reflecting current Park management priorities; namely, oak woodlands, invasive plants and wildland fire. The NRMP calls specifically for the use of adaptive management monitoring, research and evaluation to assess ecosystem status and trends, and inform management actions. Specifically, adaptive management calls for stakeholder participation and acknowledges the distribution of responsibility among stakeholders needed to meet ecosystem management goals.

## Framework in Place- Parks Division Volunteer Program

Since its inception, the Volunteer Program has been highly successful in increasing stewardship and coordinated restoration in Bidwell Park. Restoration and vegetation management are just one of many components of the Volunteer Program, yet it comprises the bulk of the local governance with respect to natural resource management in the participatory context, with volunteer hours through the City's Volunteer Program totaling over 17,000 hours in 2006 alone (City of Chico, 2007).

The establishment of the Parks Division Volunteer Program has enhanced the coordination of the invasive plant management efforts of local non-profit and service organizations, and the City's management objectives with monthly Vegetation Management Partners meetings and an annual Vegetation Management Report to the Bidwell Parks and Playground Commission. As such, there is a degree of informal coordination between the groups through the Vegetation Management Partners, convened regularly by the Volunteer Program Coordinator to discuss projects pertaining to common goals. There is also some formal communication necessitated by grant funded projects; however partnerships lack informed and strategic leadership for participatory management by the City. In the absence of specific, quantifiable management objectives collaboratively developed by the City of Chico and stakeholders, dedicated groups continue to pursue their 'bottom up' approach.

This piecemeal project approach differs from a comprehensive approach in its ability to leverage financial and human resources between organizations towards greatest management priorities. It also makes it difficult to evaluate the effect of participatory management actions with respect to City management objectives. Yet another disadvantage to the current scenario is that lack of leadership in a formal collaboration between the City and active stakeholders results in decreased perception of legitimacy.

If the potential for collaborative management success can be measured by stakeholder involvement and municipal participatory goals, then Bidwell Park has the trappings of a burgeoning, sustainable collaborative. In an effort to further increase the application of public and agency involvement in the natural resource management of Bidwell Park, the following recommendations are made.

## Identify and Coordinate Stakeholders

While there are numerous community organizations working towards an effective and substantive collaboration with the City of Chico Parks Division through the Volunteer Program's Vegetation Management Partners, all relevant stakeholders have yet to be consistent in the management process. Recreationists, environmental groups and City of Chico citizens are obvious partners and to some extent they are involved in current opportunities for in recreation and natural resource planning. The City should look not only to community non-profit partners but also local agency partners and request their participation as an integral component to a collaborative natural resource management group for Bidwell Park. Horizontal partners are often key partners in successful adaptive management strategies as they come not only with various funding resources, but with relatively stable staffing and high levels of expertise (Sabatier et al, 2005).

Hosting annual symposia is a common way to both encourage new stakeholder involvement and to reconvene stakeholders who may be less frequently involved (Sabatier et al, 2005) and converges with the BCCER objective stated in their Master Management Plan. Additionally, adaptive management in Bidwell Park should be consistent with the goals and objectives in the developing HCP/NCCP being developed for the County. Developing partnerships in this scope can bring greater contemporary and place-based scientific knowledge and management strategies to the table. An annual Reserve-wide symposium late spring 2009 could be an excellent kick-off to refine a participatory monitoring strategy as well as well as garner greater partnerships to being collaborative, adaptive management in Bidwell Park. There are a number of groups currently involved in participatory natural resource management projects in Bidwell Park.

A cursory look at potential partners for adaptive and collaborative management group in Bidwell Park, a summary is provided in Table 1.

## Involve Appropriate Decision-makers

As the City is a core constituent in the partnerships as they: retain legal authority over implementation and future management of all Park projects, possess legitimacy in enacting policy solutions, and are capable of providing key information and financial backing to approaching and solving problems. The Vegetation Partners Meetings should incorporate leadership from City decision-makers, such as the General Services Director, City Council or Parks Commission representatives. Inclusive goals for the Partners need to be defined (and acknowledged/supported by City leadership) in order to create projects that partners' will want to work on with their resources.

## Adopt Ground-rules

The first order of business for a burgeoning collaborative is to determine ground-rules for decision-making and meeting facilitation. There are many case studies highlighting success and challenges of well-established collaboratives, however deciding which method will work for the group is a collaborative effort all in itself.

Meeting facilitation should be deliberate, with a focus on developing agenda topics pertinent to the group's overall goals and in achieving full participation from meeting participants. Each agenda items should be introduced with a specific desired objective resulting from its presentation and discussion at the meeting (Keller, 200). Focusing the groups energy towards desired outcomes will prevent meeting burn-out and increase efficacy of the group (init). After all, projects, policies and information-sharing resulting in solutions which further the group's goals is what a collaborative is all about.

In collaborative, adaptive management, a program need clearly document decisions based on input and review from scientists, managers and other stakeholders throughout the process (Atkinson et al, 2004). Record-keeping is essential in an environment where responsibility is spread in the participatory approach (Conley 2003).

## *Methods for Evaluating Adaptive Collaborative Management Efforts*

In following the adaptive management approach, the first order of work is for stakeholders to clarify and prioritize natural resource management issues. Bringing about effective community participation in management solutions is more difficult when the City does not have clear environmental quality goals and specific indicators set for the Park. Without these, it is difficult to quantify and coordinate community group and City efforts with respect to City management goals and objectives. Here, collaborative management has potential to greatly add to the value of the City's current MMP and NRMP.

Likewise following the adaptive management approach, a method for evaluating participant efforts with respect to City management objectives is a critical nexus. A dimension of success is a natural resource management collaborative is the commitment to collecting sufficient information to assess partners' impact on environmental conditions. This often entails collecting both pre-project baseline data and post-project outcome data. Partnerships should also monitor whether restoration projects are being implemented as planned. Thus, developing implementation and measures for monitoring environmental outcomes follows the prioritization of management issues. As discussed in the previous section, monitoring and assessment are essential for adaptive management—the process of adjusting management based on continuing experience (Sabatier et al, 2005).

Evaluations of a collaborative management endeavor can assess a variety of factors. They can focus on characteristics of the process, such as inclusiveness, decision-making methods, or outcomes like increased understanding and improved relationships. Other evaluation criteria can be a project level/project specific, see following sections on participatory monitoring for oak regeneration and invasive species management.

In Williams and Ellefson (1997) defines "a successful partnership as a group able to attract and keep individuals engaged in partnership activities". With the significant interest Bidwell Park commands in its community, organized collaborative management can yield success.

Table 1. Potential Stakeholders for Bidwell Park Adaptive, Collaborative Management

| Organization | Division | Interests |
|---|---|---|
| Natural Resource Conservation Service | | Invasive plants; restoration |
| Associated Students | Community Action and Volunteers in Education | Service learning; sustainable communities |
| Big Chico Creek Watershed Alliance | | Watershed-level natural resource issues; environmental education; restoration |
| Butte College | Environmental Sciences | Reserve management |
| | Physical Sciences | Field methods |
| | Environmental Horticulture | Native plant propagation |
| | Agriculture-Wildland-Range Science | Invasive species |
| Butte County Resource Conservation District | Weed Management Area | Invasive species eradication |
| California Native Plant Society | | Native plant conservation; invasive species eradication |
| CSU Chico | Center for Ecosystem Research | Interdisciplinary research; fiscal sponsorship |
| | Recreation Administration | Recreation opportunities and impacts |
| | College of Natural Sciences | Research in physical and biological science |
| | Geography and Planning Department | Landscape ecology; spatial analysis; fire ecology; conservation planning; field methods |
| | Big Chico Creek Ecological Reserve | Reserve management; watershed level resource issues; participatory management |
| | Butte Creek Preserve | Reserve management; participatory management |
| Elementary Schools | | Environmental education; service learning |
| Friends of Bidwell Park | | Natural resource management in Bidwell Park |
| High Schools | | Science education; service learning |
| Mechoopda Indian Tribe | | Cultural and environmental preservation; environmental education; traditional gathering |

# Part 3: Application to Oak Regeneration and Weed Eradication in Bidwell Park

There are copious resources for field sampling and monitoring protocols available for land managers and researchers. The development of *efficient* and *affordable* monitoring plans to inform management decision at the landscape level, however, remains a significant challenge (Reiner, 2002). Development is complex and multi-faceted, but taken in an active adaptive management approach, can provide important information on population trends, ecosystem conditions, hypotheses testing and management effectiveness (Elizinga et al, 1998; Reiner, 2002 and others). In a diverse and linear management area like Bidwell Park, monitoring is complicated by multiple anthropogenic effects and ecosystem factors (EDAW, 2008).

The Bidwell Park NRMP focuses on discrete, but not quantified, objectives for invasive species and oak woodland management. As such, the discussion of objective-based, collaborative monitoring in this report is limited to invasive species and oak woodland regeneration. This report section provides a discussion on the ecological context of oak woodland and invasive species management, and relevant sampling and analysis techniques to inform the section on recommendations for establishing collaborative monitoring for oak age class regeneration in Bidwell Park.

## *Monitoring and Assessment for Oak Regeneration; Lessons from the Literature*

### Oak Woodland Ecology

Management objectives for oak woodland age class diversity fall from the generally accepted concept that oak regeneration is an issue in California (SAIC, 2007). In studies across globe, oak woodland communities are reported to be composed of older oaks in the canopy, with few individuals in younger age classes. Woodlands and forests from Britain, Asia, and throughout North America, lack of regeneration has been reported (Tyler et al, 2006). As early as the 1900s, Jepson (1910) and Sudworth (1908) reported that oaks did not appear to be regenerating.

Other literature suggests, however, some scientists and land managers believe that concerns of inadequate oak regeneration are in need of scientific validation (Reiner et al, 2002). A study by Taylor et al summarized 116 studies pertaining to some aspect of demography of one or more of the arborescent oaks of California. They found that only about a third of the studies are published in peer-reviewed journals with only four focusing on the transition from seedling to sapling and even fewer studies investigating tree mortality on a landscape scale. Several researchers also suggest the existing body of oak regeneration is limited, as sampling durations and influence of site-specific variables make broad generalizations difficult (Phillips, 2007; Tyler, 2006; CBI, 2007). Similarly, researchers have indicated studies with short temporal sampling periods may have false measures of oak woodland population viability as short temporal periods may introduce sampling error, biasing towards high seedling mortality and slow growth in oak saplings (Phillips, 2007). Tyler et al (2006) suggests that the "regeneration problem" has largely been inferred from current stand structure rather than demographic analysis, which in part reflects the short-term nature of most oak research".

Oak regeneration studies with greater temporal scale, using historic aerial photo interpretation, for example, yields mixed findings for oak regeneration in the foothills of California. Although focused studies show high seedling mortality and limited sapling recruitment, studies of greater temporal duration do not show marked decline in tree density for species *Q. douglasii* and *Q. agrifolia*, except where sudden oak disease has impacted *Q. agrifolia* (Tyler et al, 2007). Limited research pertaining to *Q. lobata* does, however, suggest a declining trajectory (Reiner et al, 2002; Tyler et al, 2007). Oak woodland monitoring and research has been largely limited to documenting effects of habitat loss on oak population viability (Reiner et al, 2002).

## The Effectiveness Monitoring Approach

Disparate views on the oak regeneration issue are nevertheless reason to initiate scientifically-valid study methodology in Bidwell Park, Chico, California. The following oak woodland communities have been mapped as present in Bidwell Park (EDAW, 2008; unpublished map, E. Devost, CSUC, 2007):

- Blue oak (*Quercus douglasii*)
- Canyon live oak woodland (*Quercus chrysolepis*)
- Interior live oak woodland (*Quercus wislizeni*)

- Mixed oak woodland (*Quercus spp.*)
- Great Valley valley oak riparian forest (*Quercus lobata*)

From the Bidwell Park Natural Resource Management Plan (NRMP), the premier document for management priorities and objective in Bidwell Park, oak woodland management goals for the City of Chico can be interpreted as follows: adequate age class diversity to ensure oak woodland viability; increase natural regeneration and recruitment within vegetation communities (EDAW, 2008).

Oak woodlands in Butte County face multiple anthropogenic impacts on a landscape level; non-native species, habitat fragmentation, disruption of natural fire, grazing and hydrologic regimes and climatic changes all affect the population (Ballard et al, 2002; Tyler et al, 2006; SAIC, 2007; CBI, 2008). In more intensely landscaped areas of the Park ('Lower and Middle Park'), hardscapes such as concrete, pavement, playgrounds and compacted trails affect oaks, as well as mowing and watering in both horticulture and wild grass areas (EDAW, 2008). Control of invasive species, higher low-intensity fire frequency and protection from grazing may be key management strategies to favor oak regeneration. The NRMP state explicitly that the use of prescribed fire and appropriate horticultural practices to maintain oaks as key objectives of the management plan (EDAW, 2008). Additionally, the City of Chico Best Management Practices Technical Manual includes guidance for landscaping with oaks (City of Chico, 1998).

Effectiveness monitoring is ideally focused to three objectives: being closely tied to specific management issues, measures the impact of a management strategy, and be configured to "test and validate the assumptions made regarding how the natural community functions" (Reiner et al, 2002; The Nature Conservancy, Conservation by Design, available at http://conserveonline.org/workspaces/cbdgateway/). The City of Chico has a number of opportunities for designating effectiveness monitoring at management locations and comparable areas not under management (control sites). Effectiveness monitoring should be designated at oak woodland stands being managed, or will be managed, as follows:

- Prescribed fire
- Invasive weed removal locations
    - Periwinkle (*Vinca major*)

- ★ English ivy (*Hetera helix*)
- ★ Yellow starthistle (*Centaurea solstitialis*)
- Mechanical removal of brush and woody debris
- Acorn planting

Effectiveness monitoring needs to provide reasonable level of precision on population responses to management. The management objectives pertaining to oak regeneration provided in the Bidwell Park NRMP, however, lack components necessary to derive objective-driven monitoring strategy with the policy document alone (see Table 2). In Elizinga et al (1998), there are six components necessary for a stated objective to be clear: species or habitat indicator, location, attribute, action, quantity/status, and time. Table 2 distills the NRMP management objective, what is missing from the objective and identifies a potential, quantifiable monitoring objective.

## Monitoring Intervals

In general, monitoring strategies in an adaptive management framework should be re-examined after the first sampling events and subsequent data analysis; at minimum, every 5 years (Atkinson et al, 2004). Data may support changes in monitoring frequency, intensity, methods or ecological assumptions (CBI, 2008). In adaptive management, monitoring plans should be flexible enough and re-examined within a short enough time period. This is critical, so that the intensity, frequency and methods can be changed without adverse affect to a population (Ballard et al, 2002; Elizinga et al, 1998). If data analyses reveals that species-habitat-management interactions are contrary to assumptions which guided the monitoring plan development, focused ecological study or research (see Part I) should be designed to answer questions about ecological drivers or species-specific demography (Atkinson et al, 2004). In the Walnut Creek collaborative oak regeneration monitoring project (Ballard, 2002), the time interval between the two sampling events to date was five years. The document indicated that while there were increases in individuals in the sapling age class, the increases were not "significant". No data was provided to support this assertion.

In the review of available literature by Taylor et al (2006), blue oak seedling and saplings are reportedly present but "relatively rare in many stands, and absence from some. Some stands have no evidence of tree recruitment within the past 50 years. However, mortality rates of adults are also low: estimated to be 2-4% per decade". Seedling mortality in the first two years is high and sapling growth is slow. It has been estimated that it can take a seedling 50 years to reach 10 inches in diameter at breast height (Tyler et al, 2006). As such, short intervals between monitoring events appears to be out of step with the temporal scale of oak regeneration rates from seedling to maturity. Monitoring intervals of five years for long-term oak regeneration study is recommended.

## Monitoring Variables

A number of ecological variables are important to oak age class diversity as described in the section above. In addition to sapling survival rates, sampling for oak mortality is critical in determining whether seedling recruitment is sufficient to replace decadent trees in the canopy (Tyler et al, 2006). Thus, sapling and live adult tree individual frequency measurements should be included in the assessment. Canopy coverage is another factor in oak seedling survival, so canopy coverage should also be assessed.

Monitoring for active adaptive management needs to provide information on environmental condition with sufficient precision and accuracy to assess connections between observation and management actions (Reiner, 2002). Therefore, monitoring variables need to include measurements that can be correlated to management actions. Although the literature suggests that oak seedlings are predominantly ephemeral in oak woodlands and therefore are not the best monitoring variable (Phillips, 2007), seedling counts are important in areas which have or will have acorn plantings. Additionally, invasive species coverage should be captured in areas managed for invasives.

## Monitoring protocols

There are numerous field sampling and monitoring protocols available. As a part of the California Department of Parks and Recreation Inventory, Monitoring and Assessment Project, an inventory of forest and woodland composition at Wilder Ranch State Park was performed using five different methods (Sasaki, 2002). The methods assessed were California Native Plant Society relevé protocol, quadrats and point intercept-line transect methods to collect compositional data.

In the Sasaki study, the relevé was discontinued as it would not provide quantitative data with adequate statistical significance needed for a diversity study. Calculating a minimum sample size based on relative percent vegetative cover of all species yielded a very low size, which may have indicated that relative percent cover of all species may not be sufficient to detect change (Sasaki, 2002). The transect and the quadrat method were both used to measure the plant community, fuel load and tree density. Cover estimates in quadrats have been found to be nearly identical to those measured in comparable area of transect (Sasaki, 2002) and that standard error of the quadrat samples were relatively high. In another study (Hanley, 1978), transects were found to be more time efficient than quadrats in areas with relatively low vegetative cover (< 25%).

The modified-Whittaker plot were considered more efficient than quadrats and transects in detecting species richness in grasslands, as they detected the greatest amount of species per sampling location and provided data at different sampling scales (Leis et al, 2003). The modified-Whittaker plot is considered a widely-adopted multiscale method, better-suited to patchy environments (Stohlgren, 1995; Leis et al, 2003). Multiscale methods also reduce the concern about sampling at the right scale and the incorporation of subplots at different sizes has slowed the debate over appropriate sampling shapes (Sorrells et al, 1991). A simplified modified-Whittaker plot method is recommended for oak age class diversity plots in Bidwell Park.

## Statistical Approach to Sampling Site Selection

The Bidwell Park NRMP does not differentiate between which species of oak woodlands are of management priorities. As the literature reviewed pertaining to oak woodland regeneration issues focus predominantly on seedling survival and regeneration concerns for *Q. lobata* and *Q. douglassii*, it is recommended that monitoring be focused in these vegetation types. Sampling sites can be selected through stratified random sampling using ArcView. As discussed in Part I, random sampling is preferred as non-sampling errors are typically less than a deterministic approach.

Table 2. Management Objectives to Monitoring Objectives using Experimental Design
*Bidwell Park Oak Woodlands*

| NRMP Management Objective | Objective Components Missing | Example Management Objective | Proposed Monitoring Objective | Monitoring Hypothesis |
|---|---|---|---|---|
| I. Maintain age class diversity to ensure oak woodland sustainability<br><br>II. Increase natural regeneration and recruitment within vegetation communities | • Level or quantity of diversity<br>• Specific species<br>• Location (Lower, Middle, Upper Park)<br>• Time frame | Increase blue oak sapling density by 10% of blue oak woodlands in Middle and Upper Park by 2014 by invasive species removal, low intensity prescribed fire, herbivore exclusions and/or planting.<br><br>Increase valley oak sapling density in Great Riparian valley oak woodlands in Lower, Middle and Upper Park by 10% by 2014 by increasing invasive species removal, low intensity prescribed fire, herbivore exclusions and/or planting. | M1. Determine changes in oak age class structure over time<br><br>M2. Determine difference in oak age class structure between managed and control site | H1. Reduced competition from invasive species leads to increased blue/valley oak seedling survival<br><br>H2. Reduced stress from animal herbivory leads to increased blue/valley oak seedling survival<br><br>H3. Prescribed fire promotes increase of blue/valley oak seedling survival<br><br>H4. Planting acorns increases seedling |

First, soil, aspect and slope data should be compiled with a vegetation map of the park using ArcView "intersect" function. Select random points in oak woodland communities which have a) undergone treatment and b) have not undergone treatment (the controls), but have similar soil, aspect, slope, using the "simple random" tool for each set of site criterion. Following the procedure explained in Sasaki (2002), the "add XY" tool will assign latitude and longitudinal coordinates for each random point. Once the random point locations are exported to MS Excel software, points can be assign random, discrete numbers and then ranked. The sampling site locations for managed woodlands and controls can be selected based on rank once a number of sampling sites are determined.

## Introduction to Statistical Power

As discussed in Part I, experimental design in monitoring aims at maximizing statistical power. In conservation planning, minimizing Type II error is typically of higher importance that Type I error, and results in a need for a high statistical power. Statistical power is a function of the standard deviation in the datasets, the number of sampled units, and the Type II error (typically set to an arbitrary number of 0.5). A post-hoc power analysis can be done comparing sample means from frequency data taken in the same year from previous surveys of two different locations in a similar oak woodland type. At present, a monitoring objective of change detection would need to be assumed, perhaps at 20%, as no number was found in the literature.

A search of existing datasets on oak woodlands in Bidwell Park have not been successful in yielding adequate data with which to determine sampling power. As discussed in a section above, percent cover is not thought to provide sufficient information to conduct power analysis. To this end, pilot sampling is needed and subsequent data can be used in post-hoc power analysis.

There are a number of free statistical programs that can generate sample size numbers when given sample means, minimum detectible change, degrees of freedom and a $\beta$.

## *Monitoring and Assessment for Invasive Plants; Current Practices*

### Invasive Plant Ecology

The term *invasive, exotic, nonnative, alien* and *weed* are often used interchangeably. The term 'invasive plant' can refer to any number of plants in a region but 'invasive' refers to the shared characteristics of being a) non-native, or introduced as a result of human activity after European contact in California (Cal-IPC, 2006) and b) having morphological, reproductive or other characteristics which allow the plants to outcompete other plants in the same community. These characteristics usually include prolific reproduction (whether by abundant seeds, rhizomes or stolons), easy dispersal and long-lived seeds. Bidwell Park's NRMP recounts a widely established hypothesis that plant invasions are enabled by the presence of seed or propagules and a disturbance at a site. Once established, an invasive species will begin to dominate the site and crowd out natives (EDAW, 2008).

Cal-IPC identifies over 200 species as being invasive in California (Cal-IPC, 2006; www.cal-ipc.org/pdf/WebUpdate2007.pdf). The Cal-IPC Invasive Plant Inventory establishes a rating of each species' invasiveness based on 13 criteria grouped into three elements: ecological impacts, invasive potential and ecological distribution. Plants are rated either High, Moderate or Limited based on the Cal-IPC's Inventory Review Committee.

The effects of invasive plants on ecosystems can be dramatic and as such, are considered to be the second most serious threat to natural habitats, after habitat loss and habitat fragmentation (Randall, 1996). Invasive plants have been shown to affect ecosystem processes such as sediment deposition, nutrient and water cycling and native plant recruitment and native plant community succession (Randall, 1996). A summary of available literature by Tyler et al (2006) substantiates the hypothesis that the presence and persistence of invasive annual grass species has resulted in limitations for oak seedling recruitment in California.

In Bidwell Park, the presence of invasive plants in riparian and wetland habitats introduces competition for available water and can cause stress to more sensitive native species. Additionally, plants in these environments can modify the hydrologic regime, and cause erosion problems or sedimentation problems. In grasslands, there is evidence that increases in invasive annual grasses have resulted in significant decreases to native annual and perennial grass viability over time (Bartolome et al, 2007).

Economic impacts of invasive species, including terrestrial and aquatic animal species, are significant. Studies have estimated the economic losses caused by the terrestrial invasive plant tansy ragwort to over $6 million annually to the state of Oregon in 1998 and 1999. Another study estimated over $42 million annual loss to rangeland capacity in Montana, North and South Dakota due to three *Centaurea* species (Radtke, 2000).

Adaptive management distinctly requires an understanding of ecosystem processes and patterns that affect management objectives. In managing invasive plants, it requires an understanding of the target plant's biology and ecology of its interacting with habitat. It also requires educated assumptions of a plant's response to management manipulations. For example, disturbance (i.e., restoration) of invasive plant species can invigorate growth from the seed bank or release seed or propagules into the environment and provide opportunity for a different invasive to dominate (Jordan et al, 2003). Restoration activities have further challenges in the *legacy* issue some invasive species present. Some species can continue to affect a system after their removal; like the lasting effects of a nitrogen fixer on ecosystem biogeochemistry. In the case of the *Myrica faya*, an invasive faya tree in Hawaii, nitrogen is fixed at a rate four times that of the natural ecosystem. The resulting high soil N poses benefits to introduced perennial grasses which complicates restoration efforts (Antonio and Meyerson, 2003).

Effectiveness monitoring after invasive plant removal is an essential component in adaptive management. The many invasive plants in Bidwell Park exhibit different morphological and reproductive characteristics and can also exhibit behaviors that are specific to the Park environment. Many require repeated treatment, sometimes for several years (Antonio and Meyerson, 2003). As community participation in restoration increases, likewise, efforts to monitor the effects of invasive plant removal need increase.

## Invasive Plant Management Objectives and Effectiveness Monitoring

The Bidwell Park NRMP identifies just 21 invasive species in Bidwell Park. A matrix of invasive plants provided by to the City of Chico by Friends of Bidwell Park identifies over 115 invasive plants known to occur in Bidwell Park.

In Bidwell Park, the presence and persistence of invasive plants pose recreation and safety issues in addition to ecological issues. Thorny species like Himalayan blackberry (*Rubus discolor*), yellow starthistle (*Centaurea solstitialis*) and puncturevine (*Tribulus terrestris*) are a nuisance to recreationists. Proliferation of woody species in the understory has long been a vegetation management priority in Bidwell Park as it reduces visibility for public safety officers patrolling Lower Bidwell Park and increases fire potential. Past management strategies included hand cutting and pile burning of understory vegetation in Lower Bidwell Park and broadcast burning for starthistle control in Upper Bidwell Park (see Appendix B- *Vegetation Management History*).

Many nonnative species, like Himalayan blackberry, are commonplace in Bidwell Park. Other herbaceous plants, yellow star thistle (*Centaurea solstitialis*) and medusahead grass (*Taeniatherum caput-medusae*) dominate large regions in the arid grasslands of Upper Bidwell Park (Stuart, 2003; EDAW, 2008). In Lower Bidwell Park, ivy (*Hedera spp.*), periwinkle (*Vinca major*) and privet (*Privet spp.*) are nearly ubiquitous as they occur throughout the riparian corridor.

The Bidwell Park NRMP identifies the following four objectives for invasive plant management in Bidwell Park:

- Reduction of existing invasive plant infestations
- Prevention of the spread of invasives to adjacent uninfested areas
- Reduction of invasive plant invasion from Park neighbors
- Enhance/maintain sensitive/special status plant and animal populations.

There is abundant literature on species-specific weed management technologies (Bossard et al, 2000; DiTomaso and Johnson, 2006). Current volunteer management activities consist of mainly hand pull for herbaceous weeds like yellow starthistle (*Centaurea solstitialis*), puncturevine (*Tribulus terrestris*), ivy (*Hedera spp.*), periwinkle (*Vinca major*), bur chervil (*Anthriscus caucalis*), and garden burnet (*Sanguisorba minor*). Volunteers treat woody species most commonly by hand cutting or pulling using a Weed Wrench. An application of herbicide applied as a basal bark treatment or a broadcast herbicide spray sometimes follows after hand cutting.

As discussed previously, effectiveness monitoring should measure the impact of a management strategy, and be configured to "test and validate the assumptions made regarding how the natural community functions" (Reiner et al, 2002; The Nature Conservancy, Conservation by Design, available at http://conserveonline.org/workspaces/cbdgateway/). The majority of restoration projects in Lower Bidwell Park are invasive plant removal projects so there are a number of opportunities for effectiveness monitoring.

Again, the NRMP management objectives for invasive species management are not well defined. As described in Elizinga et al (1998), there are six components necessary for a stated objective to be clear: species or habitat indicator, location, attribute, action, quantity/status, and time. Table 3 relates the NRMP invasive plant management objective, what is missing from the objective and identifies a potential, quantifiable monitoring objective.

NRMP management objective to prevent the spread of invasive species to adjacent, uninfested areas is a typical management objective for natural resource managers. Since invasive species can be costly to extremely difficult to remove, determining whether it is spreading to new territories is a critical monitoring objective (SF RPD, 2006; Stuart, 2003). For example, Stuart (2003) identifies Spanish broom and olive as currently having relatively small populations that are more easily managed. In adaptive invasive plant management, preventing further invasions is a foundation to scientifically-sound ecological management (Jordan et al, 2003).

Following experimental design concepts, effectiveness monitoring consists of monitoring at both invasive plant management locations and in comparable areas not under management (control sites). Effectiveness monitoring can have a number of different objectives. Monitoring could determine if a population should be considered invasive or if it is the source of new invasions. Monitoring could also be designed to determine the impact of invasive species on management objectives in the surrounding ecosystem; the impact of management on non-target species or ecosystems (Jordan et al, 2003).

Sample objectives based on NRMP focus and relative monitoring ease is proposed in Table 3.

Table 3. Management Objectives to Monitoring Objectives using Experimental Design

*Invasive Plant Management*

| NRMP Management Objective | Objective Components Missing | Example Management Objective | Proposed Monitoring Objective | Monitoring Hypothesis |
|---|---|---|---|---|
| I. Reduce existing infestation of invasive plants<br><br>II. Prevent the spread of invasive plants into adjacent uninfested areas | ▸ Level to maintain or quantity to reduce<br>▸ Specific species<br>▸ Location (Lower, Middle, Upper Park)<br>▸ Time frame | Decrease (specific) target species in Lower Bidwell Park by 10% by 2014 through hand cut and spray method or herbivory.<br><br>Maintain 0% growth or overall reduction in (specific) target species coverage (like *Vinca major*) by 2014 in Lower Bidwell Park volunteer stewardship locations (picnic sites) hand pull and native revegetation. | M1. Determine difference in (specific) target species coverage over time<br><br>M2. Determine difference in target species coverage in Lower Bidwell Park volunteer stewardship locations over time | H1. Removal techniques result in decreased target species coverage over time |

## Monitoring for Invasive Plants

The California Weed Mapping Handbook (DiPietro et al, 2002) provides recommendations for minimum field data to be taken when mapping weeds which, outside of general information like date, observer, site name, photo locations and geographic location (taken by GPS or from paper map), requires only the name of weed present or absent, the patch area and the percent cover of the invasive species in the patch. There is little peer-reviewed scientific literature regarding protocols for monitoring invasive plant population dynamics. Monitoring methods actually employed by land managers, however, are as abundant as invasive species are numerous.

Research on reference volunteer monitoring programs (listed in Table 4) shows several shared characteristics of volunteer invasive species monitoring programs. One common characteristic of the programs is that the monitoring is opportunistic, occurring at the convenience of the volunteer and performed in areas chosen by volunteers. Whether opportunistic or by pre-determined sampling location, another common characteristic is that volunteer monitoring occurs along linear corridors (waterways, roads or trails) and typically along recreational routes.

Table 4. Reference Volunteer Monitoring Programs

| Organization | Monitoring Variable | Monitoring Method | Reference |
|---|---|---|---|
| Southern Appalachian Volunteer Environmental Monitoring | Invasive species; identified primary plants of concern | GPS to identify occurrence; visual estimates of # stems; growing season | http://www.samab.org/Focus/Monitor/Invasives/invasives.html |
| Illinois EcoWatch | Forest dominant tree species; seven invasive shrub species | 50-m fixed transects monitored every other year; seedling/sapling > 1m and trees with most identified to species (with exception of *Crataegus, Carya and Fraxinus)* and counted; stem counts of indicator shrubs and vines; collection of herbarium specimens of each plant | Brandon, A. et al. 2003. Can volunteers provide reliable data for forest vegetation surveys? Natural Areas Journal. 23(3):254-262.<br>National Great River Research and Education Center<br>http://www.ngrrec.org/= |
| Adirondack Chapter of The Nature Conservancy | Invasive plants | Presence and abundance of 13 invasive species along major roadways in one section of Adirondack Park, NY; hand-drawn occurrence mapping. | |
| Fairfax County Park Authority | 10 targeted invasive plant species | A site leader initiates a site for long-term stewardship by creating a fixed plot (approximately 1/2 acre in size) and individual records relative percent cover of invasive species within plot. Change in invasive species cover is monitored by site leader. | http://www.fairfaxcounty.gov/parks/resources/ima/<br>*Notes:* Training program involves hosting ecosystem, volunteer protocol and plant identification workshops throughout the year. Workshops are free and open to all interested parties, with volunteers having precedence. |
| NatureMapping Program | Wildlife, plants | Opportunistic data gathering by trained volunteers; any species incidence is recorded and geographic coordinates taken | http://depts.washington.edu/natmap/about/NatureMapping_pamphlet_2007.3.pdf<br>A multi-state GAP effort |
| National Wildlife Refuge Association Volunteers and Invasives Program | Invasive species | WIMS | Online training modules<br>http://www.fws.gov/invasives/volunteersTrainingModule/index.html |
| Hell's Canyon SWAT (Strategic Weed Accelerated Treatment) TEAM | Invasive species | Opportunistic data collection; locate invasive species in the field and hand-draw extent of invasives on printed aerial imagery maps; GPS locations taken | The Nature Conservancy, Art Talsma, Invasive Species Program<br>atalsma@tnc.org<br>*Notes:* Weed identification training book given to volunteers and two 3-hr training sessions to identify 3 or 4 invasive species in Hell's Canyon. Recommends bringing in weed management associations for enriching volunteer experience to include ecological considerations. |
| Midewin National Tallgrass Prairie | Native and invasive plants of concern | Plant occurrence, numbers and area covered; record locations with GPS or drawn maps and aerials | http://www.planatsofconcern.org/<br>*Note*: Class estimates for number of plants. Protocol requests for additional, dominant native plant associates and percent cover of threats. |

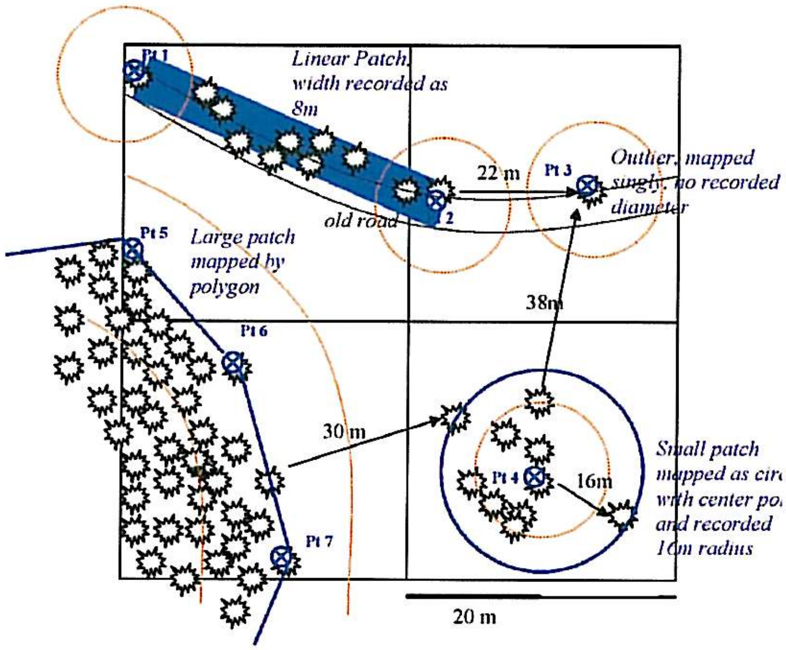


**Figure 1.Invasive Plant Mapping Example.** Illustrates patch characterization as linear, outlier, small or large patch, to be mapped as a linear, dimension-less point, point or polygon. *From Mendocino Coast Cooperative Weed Management Area.*

The Mendocino Coast Cooperative Weed Management Area established a simple, reconnaissance-level, strategic survey protocol adapted from the California Department of Food and Agriculture Weed Mapping Protocols and the California State Parks Inventory, Monitoring and Assessment Protocol. This reconnaissance-level protocol has volunteers identify the species of invasive plant that occurs, GPS either points, lines or polygons (depending on the size of the patch), and estimate a coverage area estimation based on the generalized shape and size of the patch. The MCWMA approach is illustrated in Figure 1. For individual outliers or extremely small patches, dimensionless points are taken. For smaller patches, GPS location is taken at the center of the patch. The diameter and density of the invasive plant within the patch is then estimated. For large patches, a GPS polygon is marked around the perimeter of polygon and the density or relative percent cover of invasive species within the patch area is estimated. This 'boundary' or perimeter approach is a common approach to informal invasive plant mapping and monitoring, used by federal Refuge systems, Weed Management Areas and others.

Perimeter or boundary monitoring to determine the rate of spread, or the increase or decrease in vegetation cover using GPS should take into consideration GPS accuracy due to satellite coverage and to equipment precision as well as the surveyors capacity to capture the population boundary. The several feet of error that will likely be introduced could be considered significant if the plant population is small or if the plant disperses slowly. Patch delineation needs to take into consideration the plant's dispersal mechanisms (is it one patchy population, sharing rhizomes) and whether outliers are resolvable at the sensitivity of the GPS to be used.

In a study by Anderson and Lavender (2006), perimeter mapping was used to monitor several herbaceous target invasive species with discrete populations where identifying the edge of the occurrence is possible. Perimeter mapping was preferred to quadrat sampling for infestations which were discontinuous and patchy, where analysis would lead to very low coefficients of variance and thus require a higher sampling intensity needed to achieve the desired minimum detectable change. Perimeter mapping within 10-meter wide, systematically placed belt transects was used to monitor spread of key management infestation into surrounding, uninvaded areas. The systematic belt transects are planned to be monitored annually.

In the study by Anderson and Lavender (2006), photo monitoring at monumented, permanent locations were used as the sole tool for monitoring non-rhizomatous species with low densities and scattered populations (musk thistle, bull thistle). ArcView is used to distribute random sampling sites (transects) throughout the study area. Percent cover of invasives were estimated along the transect and used to assess rhizomatic species cover (hoary cress, St. Johnswort, and Russian knapweed, among others).

The point method (point map for each occurrence) may be better suited for large shrub, understory tree or large tree species like catalpa or privet management monitoring. Stumps with regrowth, root sprouts, saplings and seedlings can be quantified by estimating stems within the diameter of the patch (see Figure 1 above). For substantial woody seedling and sapling recruitment, invasive plant regeneration is likely better measured using seedling, stump or root sprouts within a given area, such as a set quadrat on a fixed transect (EDAW, 2008). Counts of individuals, or abundance measurements, over a significant distance can be time consuming.

## Applying Collaborative Management to Participatory Monitoring

The goal of participatory monitoring can be two-fold: monitoring to help define, detect and predict ecosystem health as well as to increase public involvement in environmental stewardship. Within the existing, cooperating groups, enthusiasm and emphasis on restoration should be encouraged to shift towards long-term stewardship and thereby monitoring.

Developing high quality monitoring programs requires creativity as well as sufficient environmental information. The potential audience for monitoring data need also be considered prior to finalizing data collection specifics. Each audience has different information needs and thus would otherwise be collecting data on different temporal scales with differing level of technical detail and through different modes of communication (Conley, 2003).

Studies of volunteer-based environmental monitoring recommend additional considerations when developing monitoring methodology to be used by volunteers (US EPA Volunteer Water Quality Monitoring Programs; RWQCB Stream Team Programs; Ballard et al, 2002; Welsh, 1995):

1) Organize data collection such that volunteers are capable of sampling several sites in one day. Data typically becomes more consistent over longer period spent collecting (Wondolleck, 2000). Additionally, volunteers are more comfortable having ample time with which to muse over data collected, before leaving a site (Brown et al, 2001).
2) Simple methodologies (such as sampling just a few attributes for only a few species) make for more popular programs.
3) Write detailed instructions and clearly understandable forms.
4) Regular quality control, such as monitoring with skilled field biologists will be needed.
5) Training for volunteers is necessary, and where estimation are required, conducting iterative calibration between observers is needed.
6) Sampling should be able to be done in groups, as group events are reported to be more satisfying for volunteers.
7) Schedule regular meetings or other opportunities for volunteers to provide feedback on progress and results.

Other considerations for enhancing the value of participatory monitoring:

1) Illustrate clear nexus between monitoring and conservation goals.

2) Educate volunteers on oak ecology and population viability issues and contemporary conservation strategies.

3) Newsletters to identify program progress, opportunity and periodic findings are found to encourage long-term support and participation in participatory monitoring strategies.

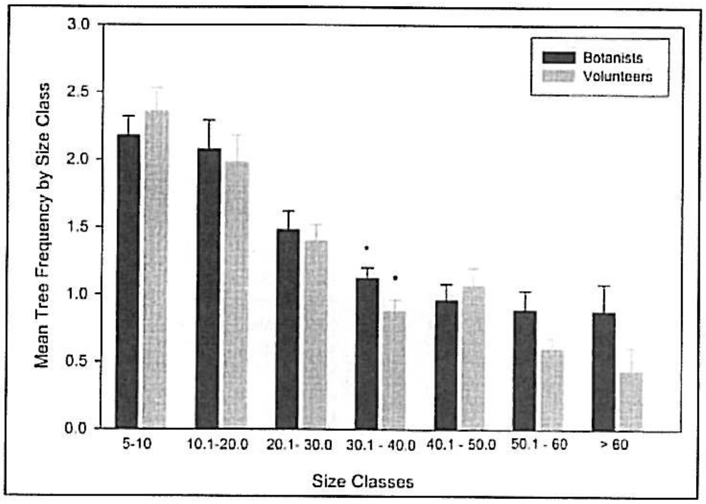


**Figure 2. Differences between botanists and volunteers** in assigning tree size classes (diameter at breast height in centimeters) (Brandon et al, 2003).

In a study comparing volunteer and botanist vegetation survey data by Brandon et al (2003), Using paired t-tests between volunteer and botanist datasets, the study confirmed that botanists would record significantly greater numbers of species than volunteers when survey protocols required measurement of species richness. Botanist and volunteer counts for various size classes were satisfactory, however, both datasets ranking closely, including standard deviations (see Figure 1). In particular, seedling and sapling counts showed no significant statistical difference. In the same study, the presence of different *Quercus spp.* seedlings were thought to introduce more error in volunteer identification as they were difficult to discern. Other study findings useful for consideration in designing participatory monitoring programs is that volunteers were consistently providing credible forest stand structure data for readily identifiable trees. Volunteer plots had 15 or fewer tree species and the majority of volunteers had less than one year experience in field studies.

## *Recommendations for Participatory Monitoring in Bidwell Park*

Participatory monitoring should begin, as with any monitoring in adaptive management, as a pilot project so as to evaluate effectiveness of the method on providing management information while efficiently utilizing monitoring resources.

The first steps in initiating a monitoring program in Bidwell Park are to a) identify priority monitoring species and b) determine management objectives or minimum detectable change levels. These steps are a responsibility of the managing agency, the City of Chico, but can be done in collaboration with key stakeholders who are aware of current environmental conditions in the Park and who are aware of contemporary weed management technologies and/or plant/ecosystem ecology. A stakeholder workshop would be a solid start to identifying potential collaborators and to begin establishing specific goals necessary to put together a sound and comprehensive monitoring strategy.

In the interim, or simultaneously, monitoring data can begin at volunteer stewardship sites while more monitoring variables, quantifiable management objectives and necessary exploratory sampling is undertaken to determine statistical sampling size and appropriate control sites. The City should make a decision to install fixed monitoring locations at long-term stewardship sites within the Park. At minimum, photo monitoring can begin at monumented locations in the stewardship sites. Determining changes in relative percent cover of common invasives like ivy, and periwinkle can begin at permanent stewardship areas, like the Adopt-a-Picnic Site areas, by mapping the stewardship area boundaries and estimating percent cover, then repeating seasonally or annually, depending on the amount of removal efforts associated at each site. These simple and attainable strategies are described in some more detail below.

The City of Chico Parks Division Volunteer Program has a number of programs and projects initiated that bring significant energy and resources to stewardship activities in the Park. In the future, monitoring as a stewardship activity can be emphasized, as its value in environmental and science education is exceptional. Several volunteer monitoring programs reviewed (see Table 4) had either paid or un-paid monitoring assistants that were given prestigious titles like "Vegetation Monitor", "Lead Ecological Monitor" or "Ecology Technician". The time commitments required were minimal and limited to the monitoring season. The assistants' responsibilities included coordinating the volunteer monitor training, including advertising for instructors and participants, and in assisting in coordinating volunteers by monitoring location.

In several programs, monitoring occurred just 3 or 4 days a year. Acquiring low-tech assistants is a cost-efficient approach to bringing together participatory resources and enabling key monitoring activities each year.

## Oak Woodland Volunteer Monitoring in Oak Regeneration Plots

Volunteer monitoring in oak regeneration plots could consist primarily of setting up simplified modified-Whittaker plots and measuring oaks. Permanent monument should be installed at one corner of the plot and directions for establishing the plot and subplot boundaries should be clearly described as orienting and measuring this type of plot can be confusing. To simplify data collection activities, volunteers could focus their efforts on recording only the number of oak seedling, saplings and trees within the plot. Other species would be otherwise ignored, unless the volunteer has sufficient training in identifying other plants, particularly invasive species. As oak regeneration plots are long-term monitoring locations, maps numbering monitoring site locations can be printed on the reverse of the data form for locating the plot. Alternatively, geographic coordinates for each location could be given and the plot located using a GPS. GPS protocols and training should be developed for volunteers. This would result in a fairly simple protocol that could be performed by volunteers from a wide range of experience and ages.

Initiating a pilot sampling project is recommended in order to determine the sampling size to evaluate oak age class structure change over time. This pilot sampling, however, can also be considered baseline inventory and should be designed to include volunteer monitors from the onset. Sampling size is the number of management plots and replicate plots needed to detect change over time and between management and control sites. Known data for oak woodland areas are relative percent cover data which has been considered to be unsuitable for power analysis. Thus, to determine sampling size, simplified modified-Whittaker plots could be established in any number of management and control locations in Lower or Middle Park. Oaks could be sampled in those plots using size and height class categories. In the study by Brandon et al (2003), researchers found volunteer data acquisition of tree size class information to be acceptable. A post-hoc power analysis using size class means can be conducted to determine if more or less sampling locations are needed in order to detect change. Remember that a number for desired minimum detectable change is needed, in addition to the Type II error.

## Volunteer Monitoring of Invasive Plant Eradiation Plots

A study by Brown et al (2001) indicates that although using volunteers for invasive species monitoring has many beneficial effects including increased awareness and increased ability to detect new invasions, volunteer monitoring consistently provides a high probability for false identifications. As discussed in the section on statistical methods above, potential for false identifications are less problematic in conservation than potential for false negatives. The quantity of observer efforts and increased spatial scale of the monitoring project can 'make up' for the decreased monitoring intensity, i.e. decreased number of precision of variables collected during monitoring events (Brown et al, 2001).

Specific monitoring methodology depends largely on specific species ecology. There are numerous managed invasive species in Bidwell Park and equally numerous monitoring strategies to consider. Effectiveness monitoring for invasive plants following the NRMP can be focused at determining the spread of a population to uninfested areas and determining effectiveness of management strategies in reducing plant coverage. These monitoring objectives can involve high or lower amounts of effort depending on the species. For example, monitoring to determine if an invasive population is infesting adjacent areas needs to span a distance from the current population boundary similar to the plants dispersal/reproductive extent (Hogle et al, 2007). Following Anderson and Lavender (2006), this can be accomplished using permanent belt transects through key invasive species management areas with transects extended a sufficient distance from the edge of the current population boundary to be able to a) be detected using GPS equipment accuracy and resolution, b) be outside the patch, but not extending into another patch or outlier (i.e., distinct), and c) be able to detect dispersal from the current population.

For some plants, such as *Vinca major*, dispersal distances are not discussed in literature as its primary dispersal mechanism is through propagules carried by water and through trailing ends. To implement invasive species monitoring at site stewardship locations, species-specific ecology should be researched using the Cal-IPC Invasive Plant Management Profiles (http://www.cal-ipc.org/ip/inventory/) or in J. DiTomaso's Weeds of California and Other Western States (University Press: Davis, CA) to determine appropriate extents for belt transects and appropriate monitoring intervals. Again, effectiveness monitoring for adaptive management using experimental design require simultaneous data collection at control and management sites.

Determining the monitoring intervals depend largely on the rate of spread of a species as well as monitoring resources. Typically, invasive species monitoring occurs either seasonally (during the plants early phrenology and after its seasonal removal), or during the same month each year.

A key consideration in volunteer monitoring is that protocols should require as little effort and technical training as is feasible (Ballard et al, 2002; Welsh, 1995). To that end, it is recommended that invasive plant mapping and monitoring protocols be focused on a small number of target species and training on identifying the small number of invasive plants be provided. In the study by Anderson and Lavender (2000) and in the protocols of the MCWMA, perimeter mapping of invasive plant populations were considered adequate to determine change in coverage of target plants over time. Perimeter mapping with generalized information on plant cover may be considered adequate for monitoring rhizomatic or vigorous reseeding invasive plants in Bidwell Park (periwinkle, ivy, giant reed, etc).

This boundary mapping and relative percent cover mapping approach was used in the pilot surveys taken at five (5) long-term site stewardship locations in Lower Bidwell Park. The perimeter map and accompanying field sheets are located in Appendix C. The perimeter of the stewardship area is uncertain, and although the sampling yields interesting information about the presence and relative coverage of natives and non-natives in each stewardship location, the information is cursory as fixed plot boundaries have not yet been assigned to the areas. Thus, percent cover has little meaning for providing a baseline monitoring if the plot boundaries change.

# Reference

## Collaborative and Adaptive Management

Allen, C., and A. Curtis. 2003. Learning to implement adaptive management. *Natural Resource Management 6(1):25-31.*

Agrawal, A. and C.C. Gibson. 1999. Enchantment and disenchantment: The role of community in natural resource conservation. *World Development* 27(4): 629-649.

Andrews, Richard N. L. 2006. *Managing the environment, managing ourselves: A history of American environmental policy*. New Haven: Yale University Press.

Ballard, H., R. Kraetsch, and L. Huntsinger. 2002. Collaborative monitoring in Walnut Creek, California. *USDA Forest Service Gen. Tech. Rep.* PSW-GTR-184:617- 624.

Bartolome, et al. 2007. *Working Draft Outline: Monitoring California Grasslands for Native Perennial Grasses Workshop Handbook.* http://www.elkhornsloughctp.org/uploads/1184008843Monitoring%20Handbook%20Outline_LF3.pdf (accessed April 28, 2008)

Center for City Park Excellence. 2007. *Complete Database of Park Facts.* Online. Available from Internet, http://www.tpl.org/ccpe2007, accessed 1 May 2008.

Cheng, A. S. and S. E. Daniels. 2003. Examining the interaction between geographic scale and ways of knowing in ecosystem management: a case study of place-based collaborative planning. *Forest Science* 49(6): 841-854.

City of Chico. 2007. *2006-08 Biennial Budget*. Online. Available on the Internet, http://www.chico.ca.us/Finance/Budget_Documents/Operating_Expenditures_by_Department.pdf, accessed 6 April 2008.

Economic & Planning Systems. 2003. Key Findings for Park Maintenance and Financial Analysis. December 18, 2003.

Gibbs, D. and A. Jonas. 2000. Governance and regulation in local environmental policy: the utility of a regime approach. *Geoforum* 31:299-313.

Haney, A. and R. L. Power. 1996. Adaptive management for sound ecosystem management. *Environmental Management* 20:879-886.

Keller, S. R. et al. 2000. Community natural resource management: promise, rhetoric, and reality. *Society and Natural Resources* 13:705-715.

Keough, H.L. and D.J. Blahna. 2006. Achieving integrative, collaborative ecosystem management. *Conservation Biology* 20(5):1373-1382.

McLain, R. J. and R.G. Lee. 1996. Adaptive management—promises and pitfalls. *Environmental Management* 20(4): 437-448.

Shindler, B. and K.A. Cheek. 1999. Integrating citizens in adaptive management: a propositional analysis. *Conservation Ecology* 3(1): 9-14

Sit, V. and B. Taylor (eds.). 1998. Statistical methods for adaptive management studies. *Res. Br.*, B.C. Ministry of Forests, Res. Br., Victoria, BC, Land Manage. Handb. No. 42.

U.S. Geological Survey. *Vegetation Monitoring Program Review for Channel Islands National Park.* Western Ecological Research Station, 2001.

Wondolleck, J.M. and S.L. Yaffee. 2000. *Making Collaboration Work: Lessons from Innovation in Natural Resource Management.* New York: Island Press.

## Natural Resources

Antonio, C.D. and L.A. Meyerson. 2003. Exotic plant species as problems and solutions in ecological restoration: a synthesis. *Restoration Ecology* 10(4):703-713.

Barrows, C.W. and M.F. Allen. 2007. Biological monitoring bridging the gap between land management and science. *Natural Areas Journal* 27: 195-197.

Bossard, C.C., Randall J.M. and Hoshovsky M.C., editors. 2000. *Invasive Plants of California's Wildlands.* Berkeley, CA: University of California Press. Available on the Internet at: http://www.cal-ipc.org/ip/management/ipcw/online.php. Accessed September, 2008.

Conservation Biology Institute (CBI). *Report of Independent Science Advisors for Butte County Habitat Conservation Plan/Natural Community Conservation Plan.* Report to the Butte County Association of Governments. Revised November 2007.

DiTomaso, J.M. and D.W. Johnson (eds.). 2006. *The use of fire as a tool for controlling invasive plants.* Cal-IPC Publication 2006-01. California Invasive Plant Council: Berkeley, CA. Available on the Internet at: http://www.cal-ipc.org/ip/management/UseofFire.pdf. Accessed July, 2008.

EDAW. 2008. *Bidwell Park Master Management Plan.* Prepared for City of Chico CA.

Jepson, W. L. 1910. *The Silva of California.* Berkeley (CA): University Press.

Jordan, N. et al. 2003. "Ecological Management of Invasive Plants-Four Key Premises," from Knowledge networks: an avenue to ecological management of invasive weeds. *Weed Science* 51(2):271-277.

Randall, J.M. 1996. Weed control for the preservation of biological diversity. *Weed Technology* 10:370-383.

San Francisco Recreation and Park Department (SFRPD). *Final Draft: Significant Natural Resource Areas Management Plan.* February 2006.

Science Applications International Corporation (SAIC). *Draft Ecological Baseline Report for the Butte Regional Habitat Conservation Plan/Natural Community Conservation Plan.* Report to the Butte County Association of Governments. May 2007.

Stuart, K. *Survey for Threatened and Endangered Botanical Species for Selected Areas of Annie Bidwel land Yahi Trails of the City of Chico's Upper Bidwell Park Butte County, CA- Spring & Summer Surveys.* Prepared for City of Chico, Park Department, Chico CA. August 2003.

Turner, M.G., R.H. Gardner and R.V. O'Neill. 2001. Landscape Ecology in Theory and Practice. New York: Springer-Verlag.

## Monitoring Methodology

Anderson, D.G. and A. Lavender. *Noxious Weed Monitoring at the U.S. Air Force Academy – Year 1 Results.* Prepared for U.S. Air Force Academy Department of Natural Resources. Colorado State University: Fort Collins. March 2006.

Atkinson, A.J., P.C. Trenham, R.N. Fisher, S.A. Hathaway, B.S. Johnson, S.G. Torres, and Y.C. Moore. 2004. Designing monitoring programs in an adaptive management context for regional multiple species conservation plans. Sacramento (CA): USGS Western Ecological Research Center. *U.S. Geological Survey Technical Report*. 69 pages.

Ballard, H., R. Kraetsch and L. Huntsinger. 2002. Collaborative monitoring in Walnut Creek, California. *USDA Forest Service Gen. Tech. Rep.* PSW-GTR-184. 2002. 617- 624.

Brandon, A. et al. 2003. Can volunteers provide reliable data for forest vegetation surveys? *Natural Areas Journal* 23(3):254-262.

Brown, W.T., M.E. Krasny and N. Schoch. 2001. Volunteer monitoring of nonindigenous invasive plant species in the Adirondack Park, New York, USA. *Natural Areas Journal* 21(2):189-196.

Cal-IPC. 2006. California Invasive Plant Inventory. Cal-IPC Publication 2006-02. California Invasive Plant Council: Berkeley, CA. Available: www.cal-ipc.org.

DiPietro, D., M. Kelly, S. Schoenig, D. Johnson, and R. Yacoub. California Weed Mapping Handbook. California Department of Food and Agriculture. Draft, September 2002.

Cambell, P. et al. 2002. Modified-Whittaker plots as an assessment and monitoring tool for vegetation in a lowland tropical rainforest. *Environmental Monitoring and Assessment* 76: 19–41.

Elzinga, C. L., D. W. Salzer and J.W. Willoughby. 1998. Measuring and monitoring plant populations. *BLM Technical Reference* 1730-1. BLM/RS/ST-98/005+1730.

Goslee, Sarah C. 2006. Behavior of vegetation sampling methods in the presence of spatial autocorrelation. *Plant Ecology* 187:203-212.

Hall, Frederick C. 2001. Photo point monitoring handbook: part A—field procedures. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. *Gen. Tech. Rep.* PNW-GTR-526. 48 p. 2 parts.

Hall, Frederick C. 2001. Photo point monitoring handbook: part B—concepts and analysis. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. *Gen. Tech. Rep.* PNW-GTR-526. 86 p. 2 parts.

Hogle, I., R. Spenst, S. Leininger, and G. Block. 2007. San Pablo Bay National Wildlife Refuge *Lepidium latifolium* Control Plan. U. S. Fish and Wildlife Service, San Pablo Bay National Wildlife Refuge, Petaluma, Calif.

Leis, S.A., D.M. Engle, D.M., Leslie, J.S. Fehmi and J. Kretzer. 2003. Composition of vegetation sampling procedures in a disturbed mixed-grass prairie. *Proc. Okla. Acad. Sci.* 83:7-15.

McDougald, D., D. McCreary and E.R. Atwill. 2007. Blue oak seedling age influences growth and mortality. *California Agriculture* 61(1):11-15.

McKay, N. 1987. How the statewide hardwood assessment was conducted. Pgs. 298-303 in *Multiple-use management of California's hardwood resources.* San Luis Obispo. Pacific Southwest Forest and Range Experiment Station. *USDA Forest Service. General Technical Report* PSW-100.

McPherson, G. 1993. Monitoring urban forest health. *Environmental Monitoring and Assessment* 26: 165-174.

Phillips, R.L., N.K. McDougald, D. McCreary and E.R. Atwill. 2007. Blue oak seedling age influences growth and mortality. *California Agriculture* 61(1):11-15.

Reiner, R., E. Underwood and J. Niles. 2002. Monitoring conservation success in a large oak woodland landscape. *USDA Forest Service Gen. Tech. Rep.* PSW-GTR-184. pp 639-650.

Sasaki, T. *Forest and woodland composition monitoring at Wilder Ranch State Park.* Report to the California Department of Parks and Recreation. March 2002.

Sorrells L, Glenn S. 1991. Review of sampling techniques used in studies of grassland plant communities. *Proc. Okla. Acad. Sci.* 71:43-45.

Stohlgren, T.J., M.B. Falkner and L.D. Schell. 1995. A modified-Whittaker nested vegetation sampling method. *Vegetatio* 117: 113-121.

Sudworth G. B. 1908. *Forest Trees of the Pacific Slope.* Washington (DC): Government Printing Office.

Tyler, C.M., B. Kuhn, and F.W. Davis. 2006. Demography and recruitment limitations of three oak species in California. *Quarterly Review of Biology* 81(2):127-152.

U.S. Fish and Wildlife Service. 1996. *Guidelines for conducting and reporting botanical inventories for federally listed, proposed, and candidate plants.* Sacramento, California. Online. Available on the Internet at http://www.fws.gov/sacramento/es/documents/Listed_plant_survey_guidelines.PDF

Welsh, D. 1995. An overview of the Forest Bird Monitoring Program in Ontario, Canada. *U.S.D.A. Forest Service Gen. Tech. Rep.* PSW-GTR-149.