ACTIONS
FOR THE CONSERVATION
OF COASTAL DUNES WITH
JUNIPERUS spp. IN CRETE
AND THE SOUTH AEGEAN
(GREECE)

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junicoast

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A COMPENDIUM WITH MONITORING PROTOCOLS TO EVALUATE THE EFFECTIVENESS OF CONCRETE CONSERVATION AND DISSEMINATION ACTIONS

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"Actions for the conservation of coastal dunes with Juniperus spp. in Crete and the South Aegean (Greece)"

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Action A.7: Elaboration of long term monitoring protocols and selection of indicators

Deliverable A.7: "A compendium with monitoring protocols to evaluate the effectiveness of concrete conservation and dissemination actions"

Responsible beneficiary: Mediterranean Agronomic Institute of Chania (MAICh)

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ΠΕΡΙΛΗΨΗ

Ένα σημαντικό εργαλείο για την προστασία και τη διαχείριση ευαίσθητων ή σημαντικών περιοχών είναι ο ορισμός τους ως «Προστατευόμενες Περιοχές». Επιπλέον, η παρακολούθησή τους είναι σημαντική για την προστασία τους. Μέσω της παρακολούθησης παρέχονται οι απαραίτητες πληροφορίες για τη λήψη αποτελεσματικών αποφάσεων διαχείρισης, η εφαρμογή αποτελεσματικών μέτρων προστασίας και παράλληλα προσδιορίζεται αν τα μέτρα που εφαρμόζονται έχουν το επιθυμητό αποτέλεσμα. Χωρίς την παρακολούθηση η διαχείριση των περιοχών αυτών, ουσιαστικά γίνεται στο σκοτάδι.

Οι παράκτιες θίνες με είδη Κέδρων αποτελούν οικότοπο προτεραιότητας της Οδηγίας των Οικοτόπων (κωδικός 2250*). Στην Ελλάδα, μέχρι σήμερα, δεν έχουν καταγραφεί στοιχεία εφαρμογής αποτελεσματικών μέτρων για την προστασία και αποκατάσταση του οικοτόπου αυτού. Επίσης δεν υπάρχουν πρωτόκολλα παρακολούθησης και υπάρχει περιορισμένη γνώση για τον οικότοπο και την κατάσταση διατήρησης του. Το πρόγραμμα JUNICOAST υλοποιεί δράσεις προστασίας σε ένα νέο γεωγραφικό και κοινωνικό-οικονομικό πλαίσιο. Ως εκ τούτου, είναι αναγκαίο να αξιολογηθεί η αποτελεσματικότητα των δράσεων προστασίας χρησιμοποιώντας πρωτοκόλλα παρακολούθησης.

Η παρακολούθηση και η αξιολόγηση της αποτελεσματικότητας των δράσεων προστασίας και ενημέρωσης- ευαισθητοποίησης του κοινού, είναι σημαντική για να προσδιοριστεί αν τελικά οι δράσεις αυτές εκπλήρωσαν τους στόχους για αποκατάσταση και βελτίωση του οικοτόπου, ενώ παράλληλα λειτουργούν ως οδηγός για μελλοντικές μελέτες στις περιοχές του προγράμματος.

Η παρούσα μελέτη, παρέχει πρακτικές συμβουλές για τον σχεδιασμό και την εφαρμογή οικολογικών και κοινωνικο-οικονομικών πρωτοκόλλων παρακολούθησης, τα οποία αποσκοπούν στην αντιμετώπιση των παραπάνω ζητημάτων. Τα πρωτόκολλα αυτά διαμορφώθηκαν αφού ολοκληρώθηκε η συλλογή των αρχικών δεδομένων μέσω των προπαρασκευαστικών δράσεων του προγράμματος (Α1, Α2, Α3, Α4, Α5 και Α6) και

προσδιορίζουν τους κατάλληλους περιβαλλοντικούς και κοινωνικο-οικονομικούς δείκτες που πρέπει να παρακολουθούνται.

Το αντικείμενο αυτού του παραδοτέου είναι **1)** να προτείνει το γενικό πλαίσιο βάσει του οποίου θα αξιολογείται η αποτελεσματικότητα των δράσεων προστασίας, **2)** να προσδιορίσει τους κατάλληλους περιβαλλοντικούς και κοινωνικο-οικονομικούς δείκτες που θα παρακολουθούνται και **3)** να προτείνει μακροχρόνια πρωτόκολλα παρακολούθησης για τη συλλογή αυτών των δεδομένων.

Στο πρώτο κεφάλαιο παρουσιάζεται μια σύντομη ανασκόπηση σχετικά με την αξιολόγηση της αποτελεσματικότητας της διαχείρισης, **στο δεύτερο κεφάλαιο** προσδιορίζονται και περιγράφονται τα διάφορα είδη παρακολούθησης, **στο τρίτο κεφάλαιο** προσδιορίζονται οι εξής περιβαλλοντικοί και κοινωνικο-οικονομικοί δείκτες που θα παρακολουθούνται: **1)** Η ποσότητα, η σύνθεση και η διασπορά των απορριμμάτων εντός του οικοτόπου, **2)** Ο αριθμός των σπασμένων κλαδιών, το ποσοστό των εκτεθειμένων ριζών, η φυτοκάλυψη και ο συνολικός αριθμός ειδών, **3)** Ο αριθμός αρτίβλαστων του Κέδρου ως δείκτης αναγέννησης, **4)** Η φυτοκάλυψη των θεμελιωδών ειδών, η αναλογία φύλου τους είδους *Juniperus macrocarpa* και η παρουσία ειδών εισβολέων και **5)** Το επίπεδο περιβαλλοντικής ευαισθητοποίησης. **Στο τέταρτο κεφάλαιο** προσδιορίζονται και προτείνονται μακροχρόνια πρωτόκολλα παρακολούθησης για κάθε έναν από τους δείκτες και τέλος **στο πέμπτο κεφάλαιο** παρουσιάζεται η μελέτη των Salafsky και Margoluis 1999 για την αξιολόγηση της μείωσης των απειλών (Threat Reduction Assessment), ως μία συμπληρωματική, πρακτική και οικονομική προσέγγιση για την αξιολόγηση των σχεδίων προστασίας.

Τα πρωτόκολλα παρακολούθησης θα αξιολογήσουν α) τη βελτίωση της κατάστασης του οικοτόπου και β) τον περιορισμό των απειλών. Αν και τα πρωτόκολλα παρακολούθησης έχουν σχεδιαστεί ειδικά για τον οικότοπο 2250* στην Κρήτη, προβλέπεται ότι, εφόσον θα δοκιμαστούν στα πλαίσια της δράσης Ε2, θα συμβάλουν στη δημιουργία τυποποιημένων τεχνικών και τρόπων παρακολούθησης, οι οποίες μπορούν να χρησιμοποιηθούν για την αξιολόγηση του οικοτόπου 2250* σε όλη την Ελλάδα. Τα πρωτόκολλα αυτά θα κοινοποιηθούν στους υπεύθυνους διαχείρισης των περιοχών και στους αρμόδιους εμπλεκόμενους φορείς στα πλαίσια των δράσεων D.4 και D.5 του προγράμματος.

Introduction

Conservation has won considerable support over the last few decades to the extent that it now appears on many political agendas. In many countries there are increasing funds for conservation action from government and non-governmental sources. Projects marketed under the banner of conservation emanate from many and varied quarters and gain support from an increasingly sympathetic public. Along with the science of conservation biology, conservation practice has come of age. A significant gap remains between science and practice, however, which results in many actions being taken in the name of conservation that have not been tested or monitored, leaving questions about whether objectives have been achieved. Much more difficult, are three messy but fundamental questions whose answers must be sought in the biological, social and economic of conservation practice: **(1)** What should our goals be and how do we measure progress in reaching them? **(2)** How can we most effectively take action to achieve conservation? **(3)** How can we do conservation better? To date, the professional conservation community has answered these questions inadequately. Collectively, we have not been very successful in defining clear, measurable goals for our work to guide us in our endeavors. We have not been able to systematically develop operational principles that can help us understand which actions work, which do not work, and why (Pullin & Knight 2001), and we have not enabled most individuals and institutions to develop the knowledge and skills needed to make conservation more effective.

Two other consistent problems in conservation biology are the difficulty of converting scientific knowledge into conservation practice (Pickett et al. 1997) and the lack of monitoring and evaluation of conservation actions. Because conservation involves combining both natural ecosystems and human societies, conservation practitioners are dealing with systems that are extremely complex. Furthermore, the urgent nature of the problem demands that they take immediate action despite the risks inherent in our lack of certainty about how best to proceed. Over the past few decades, different fields dealing with complex systems have developed convergent approaches for deciding how to take action in the face of risk and uncertainty (Salafsky et al. 2001). Examples include **adaptive management** of ecosystems (Lee 1993; Gunderson et al. 1995), reflective practice (Schön 1983), and the theory of learning organizations (Senge 1994). Adaptive management combines research and action. Specifically, it is the integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn (Salafsky et al. 2001). Given the complex nature of the systems in which conservation operates, the urgent need for action, and the current lack of information as to how to best proceed, we take as a given that effective conservation ultimately requires an adaptive management approach.

Conservation biologists must be concerned that their actions are supported by the best available evidence. Conservation practitioners are commonly faced with situations where action is needed but where information about the system with which they are dealing is inadequate or conflicting. Equally, conservation practitioners may be unaware of or disinclined to search for available evidence. The result is that the majority of conservation actions are experience-based, in that they are based on personal experience or disseminated information illustrating that they have worked before, rather than evidence-based, or based on scientific experimentation indicating that they are effective. Experienced-based action is not necessarily bad, but it is less likely to be effective and does not provide a framework upon which knowledge can develop. In developing an operational definition of conservation success, it is helpful to consider as an analogy the practice of medicine. Over the past centuries, doctors have developed operational definitions of what it means for an individual to be healthy. With this goal in mind, doctors then use various **indicators** such as temperature and blood pressure to determine whether a person is healthy or sick. For example, a doctor can take a patient's temperature to see if the patient is above the norm and requires intervention such as administering aspirin. Once the intervention has been applied, the doctor can then retake the patient's temperature to see if the intervention worked as anticipated. If it hasn't, the doctor must try a different intervention. The key to this process is to have indicators that are **measurable**, **precise**, **consistent**, and **sensitive** to the phenomenon being tracked (Margoluis & Salafsky 1998). It is also equally important to have methods for collecting the indicator that are **feasible**, **cost-effective**, and **appropriate** (Margoluis & Salafsky 1998).

Like doctors, conservation practitioners have their own indicators, but they generally do not meet the above criteria very well. Traditional conservation indicators have focused on the condition of the conservation target. Some projects initially attempt to measure elements of biodiversity directly, such as looking at the change in the number of species in a given area over time. These efforts are theoretically problematic and practically next to impossible to carry out. As a result, most projects now focus on looking at changes in the population levels of key resource or indicator species and in ecosystem area and functioning. Unfortunately, many of these biologically based indicators and methods are not feasible, cost-effective, or appropriate (Salafsky & Margoluis 1999b).

Funds should not be provided for carrying out biodiversity action that has no scientific basis or no evidence to support its effectiveness unless appropriate trials and monitoring activities are built into the action.

To date, there are no standardized monitoring protocols to monitor coastal dune with *Juniperus* spp. habitats, resulting in limited knowledge on the habitat and its status. Junicoast is a demonstration project which implements concrete conservation actions in new geographical and socio-economic contexts. Therefore, there is a need to evaluate the effectiveness of the concrete conservation actions using targeted monitoring protocols. Monitoring and evaluation of the results of the concrete conservation actions is critical in determining if the actions taken are meeting restoration/recovery objectives, and for guiding future work within the project area.

The **specific objectives** of this deliverable are to **(1)** propose a general outline against which effectiveness would be evaluated, **(2)** identify an appropriate set of environmental and socio-economic indicators to be monitored and **(3)** recommend long-term monitoring protocols for collecting those data.

Section 1 Background on evaluation

1.1 Definition of Evaluation

Evaluations should "*assess success and failure in terms of goal achievement and accountability for outcomes, gather information on how past decision functions worked, assess quality of performance and disseminate findings and recommendations to appropriate people and publics*" (Clark and Brunner's, 1996:4). Evaluations require starting with a comprehensive definition of the problem that includes an understanding of the associated context (Dery 1985; Weiss 1989; Margoluis & Salafsky 1998). Good evaluations go beyond assessing whether goals were reached to assess the adequacy of the goals and the reasons for success or failure. Many programs have poorly defined goal or none at all because goal definitions are either controversial or implicit (Clark 1996a). Alternatively, goals may be developed within political and socioeconomic constraints but then may be inappropriately presented as biologically based (Scott et al. 1995). Evaluations of conservation programs should include assessment of both the substance of a program (what the program accomplished) and the process used (how effectively and efficiently the program functioned). For example, a program may reach its scientific goals but may do so inefficiently or with negative secondary effects, such as loss of local support, inter-organizational conflict, or negative effects on non target species (Miller et al. 1996; Clark 1997). Similarly, a program may operate smoothly but fail to reach its stated biological goals.

1.2 Internal and External Evaluations

Many program evaluations are internal, informal affairs (Backhouse et al. 1996), precipitated by the preparation of progress reports or new proposals for funding. These reviews monitor activities and performance in the short term but usually do not question the overall values or long-term focus of a program. Regular, more formal internal evaluations, in which participants review all or some aspects of their program and change their activities as new knowledge and understanding are acquired, should be standard for most conservation programs. Internal evaluations should include specific questions concerning the adequacy of the program goals and the process. They should also monitor the effect of management practices so that the program may be adjusted continuously in the face of new information (i.e., adaptive management; Holling 1978).

External evaluations tend to be less frequent, to be broader in focus, and to involve peer review. They are also usually highly structured (Backhouse et al. 1996). External evaluations have the potential to benefit a program greatly because peer reviewers, if well chosen, are less constrained by (1) rewards or sanctions associated with program success or failure, which removes pressure to distort findings; (2) dominant paradigms of thought or even "group think," which may influence program participants (Janis 1972); (3) fear of negatively influencing personal or working relationships; (4) conflict of interest; or (5) peer pressure.

There is great value in integrating internal and external evaluation (Backhouse et al. 1996) and in using structures for evaluation that will reveal the more complicated aspects of a program. Program participants often have in-depth understanding of a program, many important aspects of which are complex, difficult to express, poorly realized or understood, and/or highly sensitive. Much of this information is not included in written reports or even expressed during interviews and other less formal review processes. Other program participants may have a narrow view of the purposes of a conservation program. A well-structured review, whether internal or external, can extract and integrate these separate components.

The decision over whether to use an internal or external evaluation depends on several factors, including the purpose and focus of the evaluation, available resources, and frame of reference. An evaluation may cover a month, a year, or several years. It may appraise all aspects of the program, selected parts, or a few more isolated actions. More frequently conducted evaluations with a narrower focus should probably be internal and informal, including participation only from those individuals directly involved. Indeed, resource constraints often require this. Broader, less frequent, and more formal evaluations (conducted, for example, every 5 years) usually justify spending resources to bring in high-quality external reviewers.

1.3 Evaluation Scale and Focus

Both internal and external evaluations can focus on different levels within a program. For example, an evaluation may examine only one aspect of an endangered species conservation program (e.g., numbers of animals existing in the wild or outreach efforts), or it may look at the entire program (Yaffee 1994; Miller et al. 1996). Evaluations may focus on limited time scales (1-2 years) or over the life of a program (15-20 years). Evaluations may review the strategic plan (e.g., a recovery plan), the budget (Kleiman et al. 1991), or the performance of individual participants. Especially for the latter, many agencies have regular performance-appraisal systems in place for staff; as such, participants in conservation programs may receive separate internal evaluations relating to their activities within these programs.

Conservation programs involving several geographic or political areas (different states, different nations or different continents) may be especially difficult to review because the more agencies and actors involved the more complex the organization and process. Broader evaluations look across programs to assess particular approaches within one aspect of conservation (e.g., Gunderson et al. 1995), such as general approaches to endangered species recovery (Kohm 1990; Clark et al. 1994). Other approaches may focus on a single species or specific methodologies. For example, an evaluation could appraise the usefulness of a single tool used in several conservation efforts, such as species reintroduction (Griffith et al. 1989; Snyder et al. 1996; Wolf et al. 1996) or it could pass judgment on entire recovery efforts (Tear et al. 1993, 1995; Schemske et al. 1994).

1.4 Criteria for Evaluation

Evaluations must develop criteria for defining success based on the goals defined by the conservation program. Ultimate goals usually specify when a population (or habitat) is "recovered" or how much loss of biodiversity, genetic heterogeneity, or population size is acceptable. More commonly, each conservation program develops its own criteria, often based on subjective, albeit scientifically informed, opinions. Criteria for success must cover more than simply biological considerations (Clark & Wallace 1998). Because socioeconomic and political forces are at the root of most conservation problems, these important considerations must be addressed (Kellert 1985; Brussard 1991). Truly interdisciplinary approaches to conservation incorporating both biological and social science considerations have a better chance for success. Definitions of success should reflect this by explicitly including interdisciplinary criteria (Margoluis & Salafsky 1998).

Moreover, because a program's ultimate goals often cannot be reached for decades, measures of success must be defined in a stepwise fashion. Intermediate level criteria permit managers and reviewers to evaluate progress toward ultimate goals and can illuminate the interdependency of biological and social measures of success (Margoluis & Salafsky 1998).

1.5 Substance versus Process Criteria

Substantive criteria for evaluating program success are more easily assessed than are process criteria. It is easier to measure whether a conservation program has accomplished its objective of achieving 500 individuals of a species or 20,000 ha of habitat than to estimate the degree of reduction in conflict between scientists, government officials, and developers. Substantive criteria are crucial if programs are to remain focused on specific goals, but they can be both biological and social. Important biological criteria in endangered species recovery programs include indices of population abundance, demography, and density; size of a species range; habitat quality and protection; degree of genetic diversity; and trends in all these indices over time. Broader biological goals, such as maintaining biological diversity, ecological processes, ecological communities, unique biological phenomena (e.g., migration), and evolutionary potential are also important but are more difficult to measure.

Some substantive biological measures of success may be inadequate because they do not consider appropriate temporal and geographic scales. For example, a species reintroduction program that assesses success by looking at survivorship and dispersal requires biologically meaningful measures of these variables, such as number surviving to reproduction and dispersal that maintain contact with co-specifics.

Substantive social criteria refer to indices such as public support; inter-organizational relations; the support of conservation-program practitioners and involved agency personnel; relevant values, attitudes, and knowledge of key stakeholders; and trends in each of these variables (Reading & Kellert 1993). Conservation programs that address biological issues but fail to assess and address the attitudes of the local public may ultimately fail or have a negative effect on future conservation opportunities (Reading & Miller 1994; Margoluis & Salafsky 1998). Too many programs fail to educate the public or confront the sociopolitical roadblocks to conserving biodiversity in general.

Process refers to the organization and function of conservation programs. All programs that achieve their goals are not equally sound in their methods of operation. Also, conditions are constantly changing and resources are too scarce for the overabundance of urgent conservation problems. Thus, there should also be concern over the efficiency and speed with which objectives are reached.

Understanding organizational structures is critical to evaluating the conservation process properly. Conservation programs can make substantial progress despite poor, inadequate, and ineffective organization. Problems with process are more obvious and more easily described by external peer review. Issues to focus on include how information is shared among involved stakeholders, the frequency and quality of communication among all parties, the management skills of the program leader, the decision-making procedure (consensus, majority vote, etc.), and the standards or norms for the function of the group.

Indices of success in terms of a substance or process should include measures of the degree to which learning has occurred (Lee 1993; Clark 1996b). Recovery programs may progress without rigorous hypothesis testing, experimental design, or adequate documentation. The number of animals may increase with little understanding of the mechanisms involved, so there may be no scientific basis on which to make adjustments when problems arise (Miller et al. 1996). A solid knowledge base provides opportunities to improve efforts and to apply techniques to other species. Managers, especially in bureaucratic cultures, might not risk applying new methods because the fear of failure is stronger than the potential rewards of in- creased efficiency and effectiveness (Miller et al. 1996).

At any stage in the development and implementation of an action plan for solving a conservation problem, scientists face uncertainty over the precision and accuracy of their data and scientific techniques. Conservation biologists must constantly redefine their criteria, goals, and measures of success because scientific standards and expectations will change over time. Science will advance our understanding of biological processes; technical innovations will permit deeper or fundamentally different analyses.

Within conservation science, as in all aspects of human life, there are different levels of learning (Clark 1996b; Lee 1993). Individual learning is important and is the first step in adjusting strategies toward better results. Each time individuals in a program share their new knowledge with team members and convince colleagues to act on the new information, it becomes easier for everyone to make the next cognitive leap. Participants can then move beyond the dominant paradigm and question the basic assumptions underlying a problem (Argyris 1992). We need to ask not only "how well are we doing?" but also "does it make sense to do it, even if it is being done well?" (Leeuw et al. 1994:9). Clark (1996a) suggests the use of prototypes as a method of developing "model" conservation programs that proceed by constant evaluation and learning. Similar to adaptive-management approaches (Holling 1978; Gunderson et al. 1995), prototyping represents a conscious effort to learn and improve performance through relatively small-scale, exploratory approaches that are systematically and regularly evaluated (Clark et al. 1995b). Flexibility, innovation, and creativity are key to successful prototypes. Lessons obtained from such model programs often can be applied to other programs because, despite their differences, the problems facing conservation programs are often similar (Clark 1996a).

1.6 The Evaluation of Conservation Programs

Although practitioners in almost any field agree that periodic review and evaluation is vital to improved program performance, conservation programs rarely receive comprehensive, in-depth, peer-reviewed evaluations. The evaluation of conservation actions is rare but increasingly important in improving their effectiveness. Regular evaluations of conservation actions and the implementation of recommendations resulting from such assessments are infrequent (Backhouse et al. 1996) because of resistance by participants and lack of funding (Clark 1996a). Moreover, they may provide unwanted suggestions, and their recommendations may be difficult to implement. Evaluations determine how well an action has performed and assign responsibility and accountability for success or failure (Clark 1996a).

Evaluation is critical to improving the effectiveness and efficiency of conservation programs. Without proper evaluation, learning and change are difficult. Periodic evaluations followed by program alteration can result in adaptive conservation management programs that continually improve prospects for success. To be comprehensive, evaluations should address not only whether the primary biological goals were met, but also (1) how well science was employed; (2) how efficiently resources were used; (3) the degree to which public support was garnered for the program (and for conservation in general); (4) how well the program was organized and functioned to address the conservation challenge; (5) the degree to which the program was characterized by innovative problem solving and individual and organizational learning; and (6) to what extent economic, biological, and social considerations were distinguished when goals and objectives were established (Reading & Miller 1994; Scott et al. 1995). Programs that improve in function as a result of periodic reviews may then be used as prototypes to guide future conservation efforts and their evaluation (Clark et al. 1995a; Clark 1996a).

No matter what specific procedure is used, evaluations of effectiveness should be institutionalized in every conservation program. Backhouse et al. (1996) discuss the need and means for integrating mechanisms of internal and external appraisals into conservation programs. Less formal internal evaluations should occur regularly and frequently among all groups involved in the program as a part of routine operations. These evaluations should take place at all levels, from the individual to the working group to the programmatic level. More formal external reviews should occur less frequently (probably at 5-year intervals). Such reviews, however, should be formally mandated by governments, NGOs, and funding agencies.

1.7 Evaluating management effectiveness

Evaluating management effectiveness is defined as the assessment of how well a protected area is being managed, primarily the extent to which it is protecting values and achieving goals and objectives. It consists of reviewing the degree to which management or conservation actions are achieving the goals and objectives of the protected area. The evaluation of management effectiveness provides a formal way to learn from successes and failures and help people understand how and why management practices are being adapted. This allows for the improvement of protected area management through learning, adaptation, and the diagnosis of specific issues influencing whether goals and objectives have been achieved. Evaluating the management effectiveness of protected areas is not an easy task. For example, despite the best management efforts, natural disturbances can radically alter ecosystems regardless of how well a protected area is being managed. The evaluation needs to be appropriate and accurate in assessing the degree of achievement directly linked to management actions. Four major purposes drive evaluation of management effectiveness, it can:

- Lead to better management in a changing environment;
- Assist in effective resource allocation;
- Promote accountability and transparency; and
- Help involve the community, build constituency and promote protected area values.

1.8 How can management effectiveness be assessed?

The importance of evaluation in effective management and project cycles has been progressively recognized in many fields of endeavor, including health and international development as well as conservation over the past fifteen to twenty years. New methodologies and approaches have developed in a number of fields, with many common issues and some productive exchange of ideas across the sectors (Foundations of Success et al., 2003). Protected area management involves biophysical, cultural, socio-economic and managerial factors as well as numerous stakeholders, so monitoring and evaluation must draw on tools from a wide range of disciplines. Approaches such as participatory rural appraisal and project cycle management have offered many useful ideas. A common framework for management effectiveness was developed by the IUCN World Commission for Protected Areas was published in a first version of a best practice guideline (Hockings et al. 2000). This common framework provides a consistent basis for designing assessment systems; gives guidance about what to assess and provides broad criteria for assessment. It is based on the idea that protected area management follows a process with six distinct stages, or elements:

- It begins with reviewing **context** and establishing a vision for site management (within the context of existing status and pressures),
- Progresses through **planning** and
- Allocation of resources (**inputs**), and
- As a result of management actions (**process**),
- Eventually produces goods and services (**outputs**),
- That result in impacts or **outcomes**.

All six elements (shown in Figure 1) are important in developing an understanding of how effectively protected areas are being managed. They reflect three large "themes" of management: **design** (context and planning), **appropriateness/adequacy** (inputs and processes) and **delivery** (outputs and outcomes). This approach is summarized in Table 1.

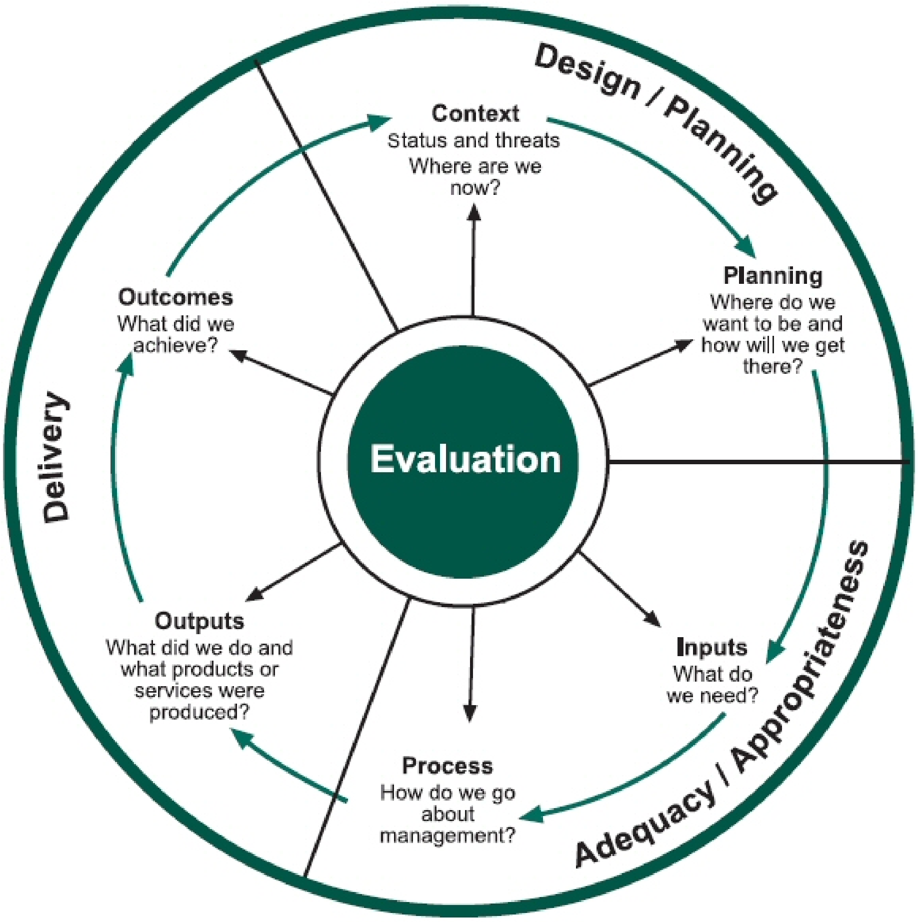


Figure 1 The management cycle and evaluation protected area management (from Hockings et al., 2006)

Table 1 IUCN-WCPA Framework for assessing management effectiveness of protected areas (from Hockings et al., 2006)

	Design		Appropriateness/Adequacy		Delivery	
Elements of management cycle	**Context**	**Planning**	**Inputs**	**Process**	**Outputs**	**Outcomes**
Focus of evaluation	Assessment of importance, threats and policy environment	Assessment of protected area design and planning	Assessment of resources needed to carry out management	Assessment of the way in which management is conducted	Assessment of the implementation of management programmes and actions; delivery of products and services	Assessment of the outcomes and the extent to which they achieved objectives
Criteria that are assessed	Significance/ values Threats Vulnerability Stakeholders National context	Protected area legislation and policy Protected area system design Protected area design Management planning	Resources available to the agency Resources available to the protected area	Suitability of management processes and the extent to which established or accepted processes are being implemented	Results of management actions Services and products	Impacts: effects of management in relation to objectives

In summary, methodologies for evaluating management effectiveness of protected areas should be:

- **Useful and relevant in improving protected area management**; yielding explanations and showing patterns; and in improving communication, relationships and awareness;
- **Logical and systematic**: working in a logical and accepted framework with balanced approach;
- **Based on good indicators**, which are holistic, balanced, and useful;
- **Accurate**: providing true, objective, consistent and up-to-date information;

- **Practical to implement** within available resources, giving a good balance between measuring, reporting and managing;
- **Part of an effective management cycle**: linked to defined values, objectives and policies and part of strategic planning, park planning and business and financial cycles;
- **Cooperative**: with good communication, teamwork and participation of protected area managers and stakeholders throughout all stages of the project wherever possible; and
- **Focused** on positive and timely communication and application of results

1.9 Adaptive Management-Integrating Monitoring and Management

Adaptive management is the cyclical process of systematically testing assumptions, generating learning by evaluating the results of such testing, and further revising and improving management practices. The result of adaptive management in a protected area context is improved effectiveness and increased progress towards the achievement of goals and objectives. If your goal is to evaluate, regulate, guide, or investigate your land or wildlife management actions then you will want to collect data in a way to both monitor the success of those actions and to help you learn how to improve your management over time. Long-term monitoring programs are usually unsuitable for those specific kinds of objectives.

There are 2 main approaches to addressing how management actions affect land or wildlife populations:

- Traditional short-term research project.
- Adaptive management approach.

While both approaches investigate the same thing, there are differences to consider. Most research projects have a defined budget available only for a short period of time. Any manipulations of habitats are done once on a discrete set of plots and when the study is competed, there is no additional follow-up unless new studies begun. Adaptive management is usually accomplished over a series of years. The same plots are used over and over with management actions being altered over time as results are analyzed and those findings plugged back into the next round of management and surveys. Management is adaptive when management actions are measured and evaluated before and after they occur and the resulting information is then used to refine the next round of management questions. Within this system, monitoring is incorporated to collect data that will gauge the relative success of the management actions.

1.10 Why do we need adaptive management?

We need adaptive management because the outcome of most land or wildlife management actions is shrouded in uncertainty and unpredictability. We can learn to be better managers by approaching these management uncertainties with a system of learning *combined with* management. Farming is a good example of simple adaptive management system. A farmer manages a plot of land using any of a variety of available soil preparation, planting, fertilizing, and pest removal approaches. The farmer then harvests the crops at the end of the year and monitors the results by counting how many bushels the plot produced. Each year the farmer varies these approaches based on advice from neighbors and the agricultural extension agent, information from crop bulletins, and instincts and past experiences. Based on years of trials, the farmer will have learned something about what combination of management approaches yields more bushels per acre and uses that learning to adapt to new climatic and economic conditions.

Managers of habitats, wildlife, and natural ecosystems have similar goals to those of the farmer. The goal of management is to produce a certain condition of the land (habitat), or to increase or decrease a commodity such as the number of deer or forest-dependent birds. However, compared to farming, ecosystem management is surrounded by a much greater degree of uncertainty. It is much to define the goals, conditions and habitat are more complicated, and success can be difficult to define and measure.

Section 2 Overview on monitoring

2.1 Definitions and types of habitat monitoring

The term '*habitat'*" is used in a wide sense when generally referring to the physical, chemical and biological components of a defined geographical area (cf. Blondel 1995). The term '*habitat type*' is used for specific kinds of habitats that have been described as separate from other such entities in habitat classification systems (e.g. Annex I of the 'Habitats' Directive: Council of the European Communities 1992; CORINE: Devillers et al. 1991, EUNIS: http://eunis.eea.europa.eu). Habitats are characterized by a typology relating the various habitats to a specific classification and a given habitat patch to a specific type, where each type has a set of defining characteristics.

Monitoring is not a new concept in ecosystem management. The environmental literature contains a wide range of definitions for this term (e.g., Spellerberg 1991, Canter 1993). The term '*monitoring'* refers to collecting information on indicators repeatedly over time to discover trends in the status of the protected area and the activities and processes of management. In other words, monitoring is '*the collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective*' (Elzinga et al. 1998:1). Monitoring focuses on temporal changes in the biota and should be used by resource managers to evaluate the success of their policies in meeting conservation objectives (Figure 2). Some in the scientific community view monitoring as a management activity unrelated to scientific research (e.g. Hellawell, 1991). Conversely, we believe that long-term monitoring is both science and research (Nichols and Williams, 2006; Yoccoz et al., 2001).

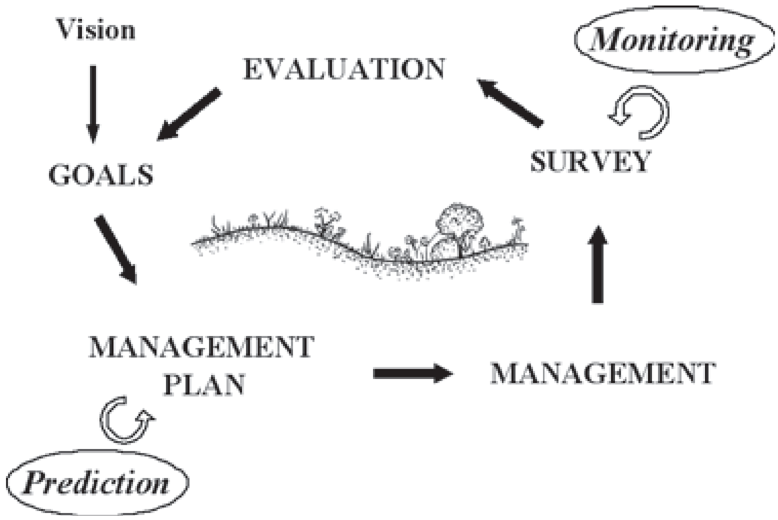


Figure 2 Cyclic processes of planning, management and monitoring in nature conservation

Over the years, the broad label of monitoring has been freely applied to justify an assortment of primarily scientific, technical, and analytical efforts launched under a variety of domestic and international natural resource programs (Hirsch 1980). These divergent interests led to more explicit definitions of monitoring applied to specific management functions. Thus, it is important to recognize the perspectives from which monitoring is viewed in order to fully appreciate the role it plays in ecosystem management. The examination of a long list of environmental programs where monitoring efforts have been prominent, at the national and regional levels in the United States, reveals alternative nomenclature and refinements of the general concept of monitoring discussed above. A few monitoring objectives are briefly identified here, to further illustrate this variety in approaches, techniques, and terminology:

- **Trend Monitoring**: trend monitoring involves measurements taken at regular time intervals in order to assess the long-term trend in a particular parameter. Usually, the measurements are not taken specifically to evaluate management practices. Rather, they serve to describe changes in the parameter over time and rely on obtaining data from revisits to a single site.

- **Baseline monitoring** may be necessary to define existing conditions and cyclical variability before and after a particular management intervention (or a natural event) impacts the system under consideration (e.g., Canter 1993, Kondolf 1995).
- **Survey or status monitoring** consists of a snapshot inventory of conditions in a defined geographic area, but usually does not address variations over time (e.g., Hirsch 1980, Cavanagh et al. 1998).

Architects of survey and trend monitoring approaches have recognized the interplay between spatial and temporal variability and developed unified methodologies where trends are recorded on a network of sites that best represents the spatial variability of the parameter of interest, and surveys incorporate sampling over time at a given location (e.g., Urquhart et al. 1998, Stevens and Olsen 1999).

- **Implementation Monitoring**: this type of monitoring assesses whether activities were carried out as planned. This is generally carried out as an administrative review and does not require any parameter measurements. This type of monitoring cannot directly link management actions to physical/environmental responses, as no physical/environmental parameters are measured.
- **Effectiveness monitoring** is designed to determine if the goals and objectives of a given management plan are being attained, by establishing the magnitude of physical, biological, and/or management benefits from a particular restoration strategy (e.g., Mulder et al. 1999). By definition, this type of monitoring may involve the collection of information from multiple projects conducted under representative conditions across several geographic and temporal scales.
- **Model verification or validation monitoring** (e.g., McCullough and Espinosa 1996, CMARP Steering Committee 1999) attempts to verify the validity of assumptions and predictions formulated through modeling, and to analyze causality relationships.

- **Effects or response monitoring** involves the repetitive measurement of environmental variables to detect changes caused by external influences (e.g., NRC 1977). Other types of monitoring that are complementary to response monitoring have been referred to as effluent monitoring (e.g., Branson et al. 1981) or ambient monitoring (e.g., NRC 1977). In many instances, a distinction is made between physical/chemical variables and biotic variables in reference to response monitoring. Consequently, the terms chemical/physical monitoring and biological monitoring (e.g., Cairns 1980, Loeb and Spacie 1994) are also utilized.
- **Compliance or regulatory monitoring** (e.g., Cavanagh et al. 1998) consists of periodic collections of data describing the state of a specific parameter that are then compared against a benchmark or standard describing a target limit or permit condition of the same parameter.

The meaning of any of these and other monitoring possibilities cannot be completely understood unless the definition and relevance of evaluation are discussed as well. Evaluation recognizes a crucial, although often neglected, element of ecosystem management, closely intertwined with monitoring. It involves (1) interpreting the information gathered from monitoring, (2) assessing the deviation from particular target goals or anticipated results, and (3) utilizing this fresh knowledge to modify policy practices or theoretical concepts (Shadish et al. 1991, Hockings 1998). The evaluation phase must be applied to any monitoring practice, not only as a means to analyze and interpret new information, but also as a central determinant of future configurations of a monitoring plan. In fact, the intimate links between monitoring and evaluation rest on their fundamental mutual dependency: much as an evaluation cannot be performed without monitoring, monitoring alone neither makes sense nor is it justified without an evaluation component. It is clear that different institutions and stakeholders ascribe different meanings to these and other versions of the term monitoring based on (1) institutional objectives, mandates, and values; (2) their management needs; (3) the disciplines and methodologies called into practice; and (4) the evaluation of the collected information.

2.2 Reasons why monitoring programs and long-term studies can fail or be ineffective

Monitoring programs can be ineffective or fail for many reasons (Table 2). These characteristics mean that it can be difficult to determine when it is appropriate for a monitoring program to continue, to cease, or when a program can be modified and made more effective. Well-designed and implemented monitoring programs that do not have these characteristics may still fail for other reasons such as lack of funding, or an unforeseen event like a major human or natural disturbance (although both can sometimes provide research and monitoring opportunities).

Table 2 Reasons why monitoring programs and long-term studies can fail or be ineffective

Problem	**Key reference**
Mindless, lacking questions	Lindenmayer and Likens (2009)
Poor experimental design	Bernhardt et al. (2005)
Monitoring too many things poorly rather than fewer things well	Zeide (1994)
Failure to agree on what entities to monitor	Lindenmayer and Likens (2009)
Flawed assumption that all monitoring programs can be the same	Lindenmayer and Likens (2010)
Scientific disengagement from monitoring programs	Franklin et al. (1999)
Poor data management	Caughlan and Oakly (2001)
Loss of integrity of the long-term data record	Strayer et al. (1986)
Lack of funding	Caughlan and Oakly (2001)
Loss of key personnel	Kendeigh (1982)
Unexpected major event	Laurance and Luizão (2007)

2.3 Characteristics of effective monitoring programs

From our extensive assessment of the very large literature on monitoring, we believe that it is possible to identify some key features of effective or successful monitoring programs (Table 3). It is important to identify such factors to improve public perspectives of monitoring and provide policy-makers with reasons to continue funding investments in monitoring programs.

Table 3 Critical components for maintaining effective monitoring programs (Modified from Likens (2007).

Plots and study sites should be permanently marked and identified. Detailed descriptions of study areas and field protocols filed in more than one location with sufficient detail provided so that other investigators can find sites, reproduce calculations and methods at some later date
Appropriate and adequate reference and/or control sites established at the beginning of the study
Availability of appropriate field equipment
Long-term security of research sites and field equipment
Reliable access to field sites, including availability of safe and reliable vehicles, such as trucks, boats, snowmobiles
Careful attention to field and laboratory protocols. Methods and procedures standardized to the extent possible, and inter-calibrated with other organizations or individuals doing similar studies. Calibration of analytical results by comparison against standardized samples. Analytical methods or collection procedures should not be changed without testing fully the effect of the new procedure on the long-term record
Match the scale of monitoring to the spatial and temporal dimensions of the question being addressed. Duration of measurements at least as long as the phenomenon being evaluated, or scaled to the frequency of the event or the life history of the organism being studied
Methods or procedures developed for one location or study should not be adopted for another area or study without careful testing and justification
Strict database management and data storage, including the agility to adapt with changes in technology. Dataset storage in at least two separate locations to avoid accidental loss. Long-term storage of samples is highly desired
Stability and competence of staff
Resolution of intellectual property issues at the onset of a project
Significant time in the field by senior and junior scientists working together
Constant updating and reviewing of data sets (including scrutinization for errors)
Use long-term data sets to answer questions
Maintenance of a stream of publications to develop project credibility and outreach
Maintenance of scientific independence and integrity of the project by avoiding conflicts of interests
Partnerships among scientists, policy-makers and staff from resource management agencies to ensure that long-term work passes the test of management relevance
Availability of adequate, sustained and reliable funding
Ongoing development and evolution of questions that can use the information from the monitoring program as a frame or operate parallel to it

2.4 Establishing Monitoring Goals and Objectives

The overall purpose of natural resource monitoring is to develop scientifically sound information on the current status and long term trends in the composition, structure, and function of ecosystems, and to determine how well current management practices are sustaining those ecosystems. Use of monitoring information will increase confidence in manager's decisions and improve their ability to manage resources, and will allow managers to confront and mitigate threats and operate more effectively in legal and political arenas. To be effective, the monitoring program must be relevant to current management issues as well as anticipate future issues based on current and potential threats to the resources. The program must be scientifically credible, produce data of known quality that are accessible to managers and researchers in a timely manner, and be linked explicitly to management decision-making processes.

The need to clearly articulate the goals and objectives of a monitoring program is emphasized in just about every guide that has ever been written about natural resource monitoring, and yet good examples of specific, measurable objectives are hard to find.

A **goal** is a concise, general statement of the overall purpose of a program. It is often expressed in non-technical, qualitative terms, such as "conserve biodiversity" or "reduce threats." An **objective** is a more specific statement that provides additional focus about the purpose or desired outcome of the program. An effective set of monitoring objectives should meet the test of being realistic, specific, and measurable. Unclear or ambivalent goals and objectives can lead to "the wrong variables being measured in the wrong place at the wrong time with poor precision or reliability" (Noss and Cooperrider, 1994).

The development of a good set of monitoring objectives is especially important for monitoring protocols, which are detailed study plans that describe how data are to be collected, managed, analyzed, and reported. The set of monitoring objectives for a protocol should specify what the protocol will do, and the objectives should meet the test of being realistic, specific, and measurable.

Monitoring objectives provide additional detail about what the monitoring program or sampling protocol will do. For purposes of a sampling protocol, however, we are looking for a set of specific, measurable objectives that meet the test of being realistic, specific, and measurable. After reading only a brief justification statement and the set of monitoring objectives, the reader should be able to anticipate what the resulting data set will look like, and should have a good sense of what measures will be included or not included. The monitoring objectives explain 'what the protocol will do', and they often put boundaries or limits on what will be included in the monitoring by specifying particular study areas, species, or measures. The following checklist of questions should be applied to the set of monitoring objectives to see if they meet the test:

- Are each of the objectives measurable?
- Are they achievable?
- Is the location or spatial bounds of the monitoring specified?
- Is the species or attribute being monitored specified?
- Will the reader be able to anticipate what the data will look like?

While there is much variation in the individual goals and objectives targeted by different monitoring and evaluation practices, it is possible to identify a general set of common universal objectives that apply to monitoring and evaluation, as follows:

- To measure attributes of environmental conditions and biological resources in the system of interest within relevant temporal and spatial scales.
- To conduct ecological research at landscape scales and to better understands the distribution and abundance of ecological variables at those scales.
- To improve the integration, coordination, and sharing of monitoring efforts across organizations, geographic scales, and relevant elements of the ecosystem.
- To ensure that management decisions are based on the best and most current information.
- To predict future conditions and suggest hypotheses for subsequent scientific testing.

2.5 Monitoring protocol development

To be certain that changes detected by monitoring are actually occurring in nature and not simply a result of measurements taken by different people or in slightly different ways, detailed and standardized monitoring protocols should be developed and implemented as part of all long-term monitoring programs (Geoghegan et al. 1990, Shampine 1993, Geoghegan 1996, Beard et al. 1999). Monitoring protocols are 1) a key component of quality assurance for monitoring programs to ensure that data meet defined standards of quality with a known level of confidence, 2) necessary for the monitoring program to be credible so that data stand up to external review, 3) necessary to detect changes over time and with changes in personnel, and 4) necessary to allow comparisons of data among places and agencies.

Any successful long-term monitoring program must survive turnovers in personnel (as people change jobs or retire) and technology. In almost all cases measurements over time will be taken by different people. Several important conclusions follow from these facts: (1) sampling protocols must be fully documented, with great enough detail that different people can take measurements in exactly the same way; (2) protocols must include quality control/quality assurance measures, so that it can be demonstrated that any changes in measurements are actually occurring in nature, and not simply a result of measurements being taken by different people or in slightly different ways; and (3) protocols should not rely on the latest instrumentation or technology that may change in a few years, such that measurements cannot be repeated. An effective monitoring protocol will provide more than a detailed description of field methodology. Careful documentation of the questions being asked; the sampling framework and survey design; step-by step procedures for collecting, managing, and analyzing the data; and expectations on how the data will be presented and used are all part of "getting it right the first time." A good monitoring protocol will include extensive testing and evaluation of the effectiveness of the procedures before they are accepted for long-term monitoring. Peer review of protocols and revisions are essential for their credibility. The documentation should include reviewers' comments and authors' responses.

No matter how much advanced planning goes into protocol development, some changes and improvements in such things as field methodology and approaches to data analysis and reporting are to be expected. To accommodate and plan for periodic review and revision, we propose a modular protocol organization consisting of a protocol narrative, a series of Standard Operating Procedures (SOPs), and a supplementary section of supporting materials. In this way, changes to specific protocol components are more easily documented and tracked through time. A modular organization also facilitates export and adaptation of protocols across ecological regions or agencies. Oakley et al. 2003 recommend that a monitoring protocol include the following three sections:

1. Narrative. The Protocol Narrative provides the rationale for why a particular resource or resource issue was selected for monitoring, gives background information concerning the resource or resource issue of interest, describes how monitoring results will inform management decisions, and discusses the linkages between this and other monitoring projects. The narrative gives an overview of the various components of the protocol, including measurable objectives, sampling design, field methodology, data analysis and reporting, personnel requirements, training procedures, and operational requirements. The narrative also summarizes testing and evaluating procedures involved in protocol design, and documents the history of decision-making that accompanied protocol development. This may be accomplished directly in the protocol narrative or by referencing related reports. Providing a history of protocol development and refinement will help ensure that periodic review and revision result in continued protocol improvement, rather than mere repetition of previous trials and comparisons. The recommended content of the protocol narrative is outlined below.

1. Background and objectives

- a. Background and history; describe resource issue being addressed
- b. Rationale for selecting this resource to monitor
- c. Measurable objectives

2. Sampling design

- a. Rationale for selecting this sampling design over others
- b. Site selection
  - i. Criteria for site selection; define the boundaries or "population" being sampled
  - ii. Procedures for selecting sampling locations; stratification, spatial design
- c. Sampling frequency and replication
- d. Recommended number and location of sampling sites
- e. Recommended frequency and timing of sampling
- f. Level of change that can be detected for the amount/type of sampling being instituted.

3. Field methods

a. Field season preparations and equipment setup (including permitting and compliance procedures)

b. Sequence of events during field season

c. Details of taking measurements, with example field forms

d. Post-collection processing of samples (e.g., lab analysis, preparing voucher specimens)

e. End-of-season procedures

4. Data handling, analysis, and reporting

a. Metadata procedures

b. Overview of database design

c. Data entry, verification, and editing

d. Recommendations for routine data summaries and statistical analyses to detect change

e. Recommended reporting schedule

f. Recommended report format with examples of summary tables and figures

g. Recommended methods for long-term trend analysis (e.g., every 5 or 10 years)

h. Data archival procedures

5. Personnel requirements and training

a. Roles and responsibilities

b. Qualifications

c. Training procedures

6. Operational requirements

a. Annual workload and field schedule

b. Facility and equipment needs

c. Startup costs and budget considerations

7. References

2. Standard Operating Procedures. A series of SOPs present the details on how all aspects of the components described in the narrative will be carried out. The SOPs are likely to be updated more often than the protocol narrative. The SOPs should be written in the form of instructions, with step-by step details of how to carry out each procedure (Wieringa at al. 1998). One of the SOPs should explain the procedure for making revisions to the protocol, and each protocol should include a log of its revision history and archives of previous versions. The revision procedure should also specify the need for and appropriate duration of an overlap period before new methods are adopted (Newell and Morrison 1993). Data sets should indicate which version of the protocol was being used when the data were collected, perhaps by including a field in the database to describe protocol version number.

3. Supplementary Materials. Supplementary Materials include example databases, supporting data and reports (e.g., digital maps of soil strata, guild assignments of bird species), custom data management, data analysis or decision support tools (e.g., link to software programs), as well as materials that cannot easily be formatted and included as part of the digital protocol document (e.g., paper maps, photographs, binders of peer reviewers' comments and authors' responses).

Section 3 Fundamentals of environmental and socio-economic indicators

In many important areas, most decision-makers do not have the data and the analytical tools that would allow them to say whether current patterns of change to the natural environment are sustainable, or whether certain development initiatives would help alleviate environment, social, or economic standards. This is effectively driving a train with neither a definite known origin nor a specific desired destination.

To be sure of where we are and where we are heading, improving our view of the road ahead by enhancing the information database is a very high priority. Our intended destination is a sustainable pattern of development, but it is not always clear which direction we need to take to get there.

As this illustration makes clear, we often do not have the information to assist actions we want to take. We need data and understanding - and acquiring them may be expensive and time consuming. In some cases, we may have lots of data, but of variable quality, or not well related to the areas, timeframes or issues we are interested in.

This section introduces the idea of indicators and demonstrates their effectiveness as tools in guiding and facilitating decision-making, improving the quality of information and simplifying its interpretation and management as well as assessing environment and development trends overtime and in relation to goals and targets.

3.1 Definitions and use of indicators

Indicators are direct or indirect measures of the quality of environment and development conditions within a society, and are used to assess the status and trends of these conditions (Turnhout et al., 2007). These trends may refer to causes, pressures, or stresses resulting from human or natural processes that are affecting environment and development, the state or condition of resources, and societal responses or efforts to mitigate these stresses. In other words, indicators are tools to facilitate effective decision-making. They are used to show the condition of a parameter according to a specific baseline and allow for observation of changing trends. Indicators summarize large amounts of complex information in a concise, easily understood scientific way to provide tools that measure progress toward achieving goals and milestones. Indicators could also express measures of physical, chemical, biological or socio-economic factors that best represent the key elements of complex ecosystems or environmental issues. They contribute to planning and management processes and are not just any piece of quantitative information. They can describe an environment or development factor at some moment, show trends, or track progress to a given goal.

3.2 Significance of Environment and Development Indicators

Indicators provide information to the decision makers and the general public as well as early warning information; they are of high significance in:

- Helping quantify the situation, highlight its significance and monitor progress and changing trends
- Helping simplify the data and present it in a form directly relevant to the problem being addressed
- Guiding decision-makers to the status of the current priorities
- Enabling decision-makers to evaluate and compare the implications of their policies and choices
- Facilitating external scrutiny of decisions and policies, thus ensuring transparency and accountability

A significant environmental indicator:

☑	Is scientific, measurable and based on quantitative data
☑	Represents an aspect of importance to society
☑	Provides a common base for information exchange among the different stakeholders
☑	Has a sound and practical measurement process
☑	Focuses information to assist decision-makers in their planning processes
☑	Is easily repeatable to allow for observing changing trends

The complex problem of sustainable development requires integrated or interlinked set of indicators, for that an indicator must be:

- Specific
- Measurable
- Relevant
- Simple
- Repeatable

Table 4 Characteristics of good monitoring variables (Adapted from Margoluis et al., 1998; Gibbs et al., 1999; Pawley, 2000; Bisbal, 2001)

Relevant to Management
• Relevant to program goals and objectives; can assess program performance • Relevant to adaptive management process • Appropriate spatial scale • Appropriate temporal scale
Scientifically Defensible
• Biologically pertinent, reflects status and dynamics of system under management • Sufficient scientific basis, supported by published scientific findings or conceptual models
Statistically Powerful and Interpretable
• Directly related to the ecosystem component it is intended to represent or is an acceptable surrogate • Sensitive to changes in the ecosystem component it represents • Indicates cause of change as well as existence of change • Timely, relevant to management timeframe • Anticipatory, serves as an early warning of change • Responsive across necessary range of stress, i.e., provides continuous assessment over wide range of stress (does not "level off") or complements other monitoring variables to achieve necessary range • Known statistical properties, with baseline data, reference or benchmark available
Measurable and Feasible
• Technically feasible; measurable using standard methodologies • Accurate and precise, with low observer variability and bias • Cost effective • Low impact to system being monitored • Low risk to field personnel
Coordinated with Existing Programs and Data Sets

• Compatible with already existing monitoring programs' data collection, or could be modified to be so • If data exist, they are obtainable, preferably as long-term data sets
Easily Understood
• Simple, direct • Communicable, easily interpreted and explained • Documented; methodology supported by complete standard operating procedures

3.3 Types of Indicators

Indicators are divided into three types (Figure 3): Pressure, State and Response indicators (Winograd et al., 1999): Human activities exert pressure on the environment and change its state in terms of its quality and its wealth of natural resources. Society responds to these changes through general environmental, economic, & sectoral policies, and through changes in behavior, thus affecting the pressure caused by human activities.

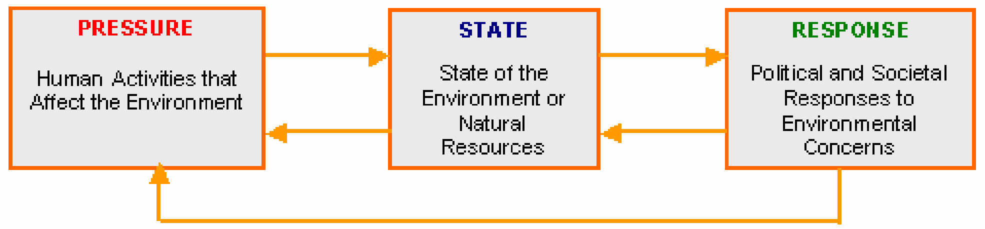
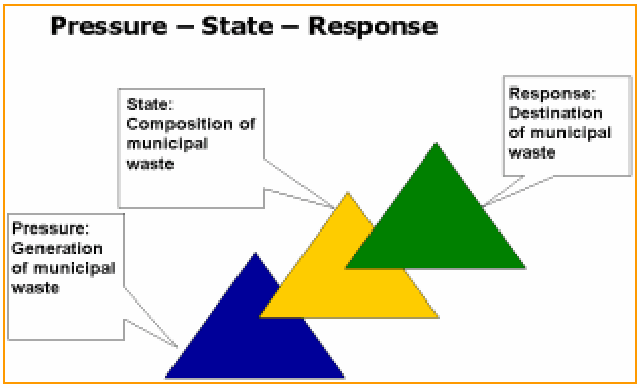


Figure 3 Types of indicators

- Pressure: human activities that exert stresses or pressures on the environment and change it (i.e. population growth, use of pesticides, industrial releases into water, etc.). The Pressure indicator describes the underlying cause of the problem. It can be an existing problem or it may be the result of a new project or investment.
- State: the quality and quantity of natural resources, and the quality of the environment (i.e. level of air pollution, burnt forest area, etc). The State indicator usually describes some physical, measurable characteristic of the environment that results from the pressure.
- Response: the actions adopted (environmental, economic, institutional or sectoral policies) in response to changes (i.e. regulatory action, legislation, environment or research expenditure, etc). The Response indicators are those policies, actions or investments that are introduced to solve the problem. As responses to environmental problems they can affect the state either directly or indirectly, by acting at the pressures at work.



Indicator types are interrelated, for example, under the waste theme, the indicator "Generation of municipal solid waste" that reveals how many kg of municipal solid waste are generated per inhabitant per year falls under the Pressure type.

It is of a State type, whenever we are dealing with the "Composition of municipal waste", i.e. percentage of organic, metals, glass, etc.

The Response type would be the "Destination of municipal waste" that represents the actions adopted to manage municipal solid waste through composting, incineration or land filling processes.

3.4 Selecting the monitoring indicators

Coastal dunes with *Juniperus* spp. priority habitat in Greece are facing various natural and man-induced stresses. Assessing the health condition of these habitats presents numerous challenges because of their vast diversity in structure, extent, composition, difficult access, and harsh environment associated with extreme summer temperatures, and our limited knowledge of how they collectively operate.

The environmental and socio-economic indicators for monitoring the coastal dunes with *Juniperus* spp. in Crete have been identified following a participatory process (see deliverables of action A6, Stakeholders' consultation) adopted for the identification of the: a) stakeholder and community perceptions of the habitat values, b) the habitat perceived status and trends, and c) the stakeholder and local community views regarding the main threats of the 2250* priority habitat in Crete.

One of the initial steps within this effort was the identification of the **main priority values** and **threats** related to each site. The second step was the establishment of relevant questions related to each of the values and threats. These questions were linked with societal values that have both social and biological relevance; and indicators were identified to evaluate the status and trends in the condition of each site. Input was sought from scientists, officers from various authorities and public interest groups. The main values of the sites as identified by the various stakeholders were natural and cultural heritage, recreation, and education. Whereas, wood cutting, fire risk, rubbish disposal, lack of public awareness, overgrazing, tourism and restricted natural regeneration of the juniper trees have been identified as the main threats affecting the sustainability of all the sites (identical threats were identified at the time/level of the project proposal) . This approach is illustrated below using a conceptual framework that links the indicators to the monitoring questions (Figure 4). Figure 4 represents the indicator framework which demonstrates how ecosystem processes are linked by using indicators to address monitoring questions important to society.

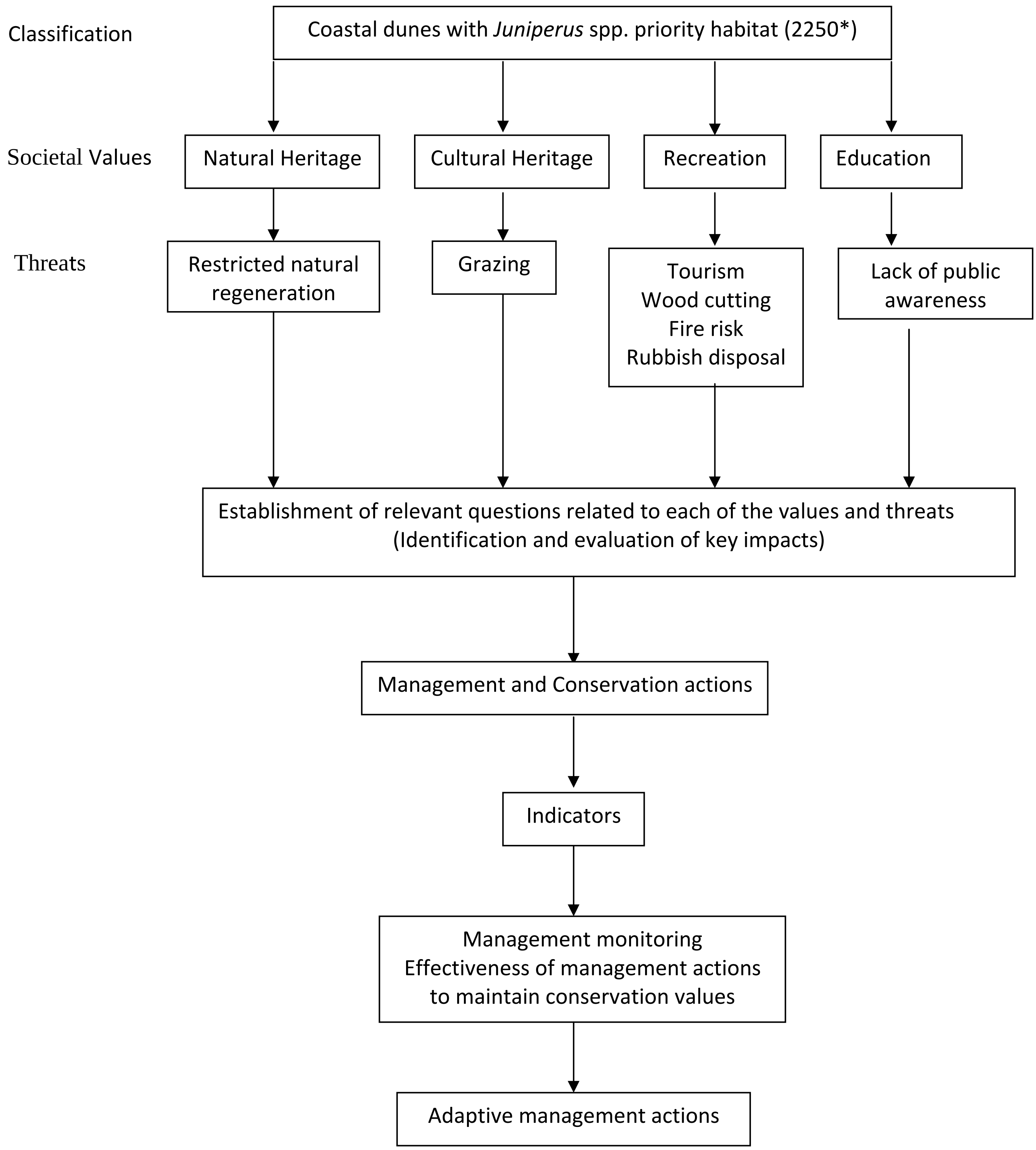


Figure 4 Conceptual framework linking the indicators to the monitoring questions

Selection criteria were developed so that relationships could be assessed at different spatial scales using ground and aerial measurements. Parameters including responsiveness and sensitivity to change, quality assurance and control, temporal and spatial variability, cost-effectiveness and statistical design played an important role in determining how indicators were selected.

Section 4 Proposed indicators and long-term monitoring protocols

This document proposes a methodology for implementing a system of monitoring designed to provide quality information on the status of coastal dunes with *Juniperus* spp. resources across Crete. While the protocol itself should serve as the primary tool with which to assess structural and functional changes in these habitats, available environmental datasets on potentially important abiotic factors (e.g., elevation, precipitation, soil properties) can help to elucidate underlying mechanisms of change and, subsequently, guide the adaptive management of the resource.

The protocols' feasibility, the indicators suitability (the actual relevance of proposed indicators to be monitored) and the statistical reliability has been validated through the preliminary monitoring results from the first phase of the project (preparatory actions). During this period it became evident which features had been improperly approached, either by using an unsuitable spatial scale or by using inappropriate sampling methods.

The concrete conservation and dissemination actions of the project, the goals of each action and the proposed measurements indicators to evaluate the success/effectiveness of the action are listed in table 5.

4.1 Background and objectives

4.1.1 Background and history

Coastal dunes with *Juniperus* spp. is a priority habitat (code: 2250*) of the Habitats Directive. The distribution of these habitats in Greece is mainly confined to South of the country and covers an area of 12 km^2. This habitat type consists primarily of *Juniperus oxycedrus* ssp. *macrocarpa* stands and secondarily of *Juniperus phoenicea* stands. The formations of this habitat are very representative on the Islands of the southern coast of Crete (Gavdos and Chrysi Islands), in the Cyclades and on the western coast of Peloponnisos. Gavdos island has the largest cover of this type of habitat in Greece (102 ha). The habitat in Chrysi Islet is one of the very few sites where the rare maquis with *Juniperus oxycedrus* spp. *macrocarpa* is found on sand dunes. Also, the mixed forest of *Juniperus oxycedrus* spp. *macrocarpa* and *Juniperus phoenicea* which is found on Chrysi Island is not very common in Greece.

Coastal dunes with *Juniperus* spp. are the product of both cultural and natural influences. The independent and interactive effects of human history and the coastal environment have resulted in a unique mosaic of habitat types, each with the potential to follow a different trajectory of change. Monitoring and understanding this change has become a major concern in the sustainable management of those habitats.

JUNICOAST (Actions for the conservation of coastal dunes with Juniperus spp. in Crete and the South Aegean (Greece) is a four-year LIFE + project funded by the EC. The project started in January 2009 and will end in December 2012. One of the main preparatory actions of this project (action A.7) aims at the elaboration of this long term monitoring protocols which will enable the evaluation of the effectiveness of the concrete conservation and dissemination actions as compared to the initial situation, objectives and expected results.

4.1.2 Rationale for monitoring coastal dunes with *Juniperus* spp. in Greece

Currently in Greece there is no documented evidence that active conservation measures have been implemented for the protection and restoration of this threatened habitat. At present, the junipers appear in isolated stands of different extension. Populations still survive in natural or semi-natural conditions, but others have no legal protection. In the past, this habitat type was covering more extensive areas on shady substrata. However, at present, the habitat is in danger of more severe reduction of its area due to various natural and anthropogenic threats summarized in decreasing order of importance below:

Restricted natural regeneration: studies have shown that natural regeneration of *Juniperus oxycedrus* spp. *macrocarpa* and other taxa in this genus is restricted due to several factors. These factors include slow growth, low seed viability and/or difficulty in germinating as well as the imbalance in the female/male ratio of the stands.

Tourism: coastal dunes with *Juniperus* spp. habitats in Greece are greatly affected by the negative impacts of tourism, Crete is no exception. Visitors amongst other things, cause habitat degradation through, trampling and camping, pose a risk of fire, and pollution (littering). The damage to the habitat and in particular to the *Juniperus* species is evident as visitors, due to lack of awareness, often consider parts of the trees dead, thus, cutting wood for fires or unintentionally damaging the root systems.

Lack of public awareness: coastal dunes with *Juniperus* spp. habitats in Crete are highly valued for their beauty and recreation potential. Their users however, lack awareness of the habitats conservation value as well as the negative impact their actions may be causing on the habitat itself. Lack of awareness is resulting in unsustainable activities such as camping, fires, woodcutting, trampling and general habitat damage. Lack of awareness exists also amongst stakeholders responsible for the management (local authority officials) and the activities (tourism operators) taking place at the sites. This is underpinned by the lack of documented and communicated information on appropriate conservation and management techniques for this priority habitat.

Solid waste disposal: coastal dunes with *Juniperus* spp. habitats in Crete are threatened by uncontrolled solid waste disposal, which is occurring through illegal fly-tipping as well as by visitor littering. This is a serious threat to the habitats as the material disposed is in many cases not biodegradable and may even incorporate chemical and toxic substances. Pollution as a result of fly-tipping is a serious issue as leaching can occur into the soil and water subsequently affecting the health of the habitat.

Fire: fire is a major threat to all terrestrial ecosystems in Greece. The coastal dune with *Juniperus* spp. habitats in Greece are no exception. In Crete, the use of fire is a common practice for rangeland improvement which in many cases cause extended damages in neighboring areas. Additionally, fire can be caused by uncontrolled camping fires. The sites that are under great risk are those where junipers are next to or in mixed stands with pines.

Wood cutting: woodcutting of the *Juniperus* species is a serious threat to the coastal dunes with *Juniperus* spp. habitats in Crete. Woodcutting, mainly dry branches of individual trees, is a common activity undertaken by most campers on the sites for lighting camping fires. This phenomenon is mainly due to the lack of awareness of visitors which consider the dry looking branches of the *Juniperus* trees as dead.

Grazing: freely grazing is the most common grazing practice in Crete and in the Aegean islands. The target habitat in many sites is bordering phryganic rangelands. Although the target habitat is not producing enough foliage there is much evidence of animal grazing where sheep flock and goat herd densities are notably high. Grazing and browsing activity influences vegetation distribution patterns significantly, which consequently have a bearing on dunes characteristics, dynamics and stability. The main grazing impact on the target habitat is the serious reduction in the regeneration of *Juniperus* spp. and very often leads to accelerated wind erosion of the dune system.

4.1.3 Measurable objectives

4.1.3.1 Management objective

Currently in Greece there is no documented evidence that active management and conservation measures/actions have been implemented for the protection and restoration of this threatened habitat. The management objective of the JUNICOAST project is the design and the implementation of concrete conservation and public awareness actions for the protection and long term restoration of the coastal dunes with *Juniperus* spp. habitat in Greece. It is expected that various combinations of concrete conservation and dissemination actions will mitigate the threats that this priority habitat is facing.

4.1.3.2 Monitoring objective

The main monitoring objective is to determine if the goals of the concrete conservation and dissemination actions have been attained, by establishing the magnitude of physical, biological, and/or management benefits from each particular restoration strategy. Moreover, we also wish to examine the spatial and temporal components of changes of the monitored features.

Table 5 The conservation and dissemination actions of Junicoast, their goals and the proposed measurements indicators

Action	Goals	Approach	Measurements Indicators	Baseline data
C1 On site habitat demarcation	Reveal/expose the area of the priority habitat to the public	Questionnaire based	-Level of environmental awareness	Available A.5 and A.6
C2 Waste removal	Increase level of environmental awareness Increase the aesthetic value of the site Minimize habitat degradation from pollution	Direct on-site measurement Questionnaire based	-Amount/distribution/composition of litter within the habitat, -Level of environmental awareness, -Visitors' opinion about level of cleanliness	Available A.5 and A.6
C3 Enhancement of juniper regeneration	Increase in the number and the survival of *Juniperus* seedlings	Direct on-site measurement	-*Juniperus* regeneration (number of *Juniperus* seedlings)	Available A.3 and A.5
C4 Restoration of target habitat floristic composition and structure	Enhance/Restore the floristic composition of the habitat	Direct on-site measurement	-Vegetation cover of keystone sp., -Sex ratio of *J. macrocarpa,* -Presence of invasive sp.	Available A.2 and A.3
C6 Visitor management	Reduce visitors negative impacts	Direct on-site measurement	-Number of broken branches, -Amount/distribution/composition of litter, -Ground vegetation cover (%), -Cover of root exposure (%), -Total number of plant species	Available A.5
C7 Design and installation of Signs	Increase level of environmental awareness Reduce visitors' negative impacts	Questionnaire based Direct on-site measurement	-Level of environmental awareness, -Number of broken branches, -Amount/distribution/composition of litter, -Ground vegetation cover (%), -Cover of root exposure (%), -Total number of plant species	Available A.5 and A.6
C8 Ex situ conservation of keystone species	Supply plant genetic material for a potential reintroduction	Direct measurement	-Amount of stored plant genetic material	N/A
D1 Communication strategy	Increase public awareness	Questionnaire based	-Level of environmental awareness	Available A.5 and A.6

Action	Goals	Approach	Measurements Indicators	Baseline data
D2 Website development	Improve interactions and communications between various stakeholders Increase public awareness	Direct measurement Questionnaire based	-Number of website visits, -Level of public awareness	Available A.5 and A.6
D3 Environmental education campaign	Increase public awareness	Questionnaire based	-Level of public awareness	Available A.5 and A.6
D4 Training for habitat protection and restoration	Improve capacity building Transfer of know-how	Direct measurement	-Number of training workshops -Number of trainees	N/A
D5 Habitat protection and restoration guidelines	Improve capacity building Transfer of know-how	Direct measurement	-Number of trainees	N/A
D6 Dissemination of findings and Layman's report	Consolidation of knowledge base Promote future best practices	Direct measurement	-Number of scientific publications	N/A

4.2 Proposed indicators

Indicator 1: Amount, distribution and composition of litter within the 2250* habitat

Sampling design

Litter surveys will be conducted at regular sampling points (point spacing 30-50 m) generated by the ArcGIS software. The sampling design for each site is shown in figure 5. The relocation between the sampling points will be done with the help of a GPS. The amount, the distribution and the composition of debris will be recorded in 10 m radius area around each sampling point. This sampling design was applied in action A.5 "visitors' impact assessment" and proved to be very practical and cost-effective. Litter surveys will be conducted at all Cretan study areas. The re-sampling will be done before the end of the project. Base line data is available (see Deliverable A.5.1 "Visitors' impact assessment").

Field methods

The following section provides an overview of the field operations in order to conduct the litter surveys. These procedures are described as "*Standard Operating Procedures*" (SPOs).

SOP#1: Preparations and equipment setup prior to field season

The field crew is advised to complete the following activities to prepare the field work for the litter survey:

1. Review the entire protocol
2. Get familiar with the practical use of GPS
3. Retrieve and review prior data for reference
4. Visit actual study areas to become familiar with each site
5. Consult maps and boundaries of the sites
6. Inspect equipment and compile the items listed below

Equipment List

- Hardcopy map of the study site with the sampling points on the map
- Hard support with sampling form
- Field notebooks
- GPS unit with site coordinates
- Digital camera
- First-Aid kit
- Pens

SOP#2: Using the global positioning system (GPS)

General use

Keep the GPS unit dry at all times. Do not leave the unit "on" for long periods of time between uses as the batteries will drain quickly. Satellite reception may vary substantially depending upon interference from trees, topography, structures, weather, and satellite configurations. The unit should be held face up (i.e., the display screen facing upward).

SOP#3: Conducting the litter survey

The litter survey should be done by a field crew (at least 2 people) trained on how to navigate with a GPS. The relocation between the sampling points will be done with the help of the GPS using the *"go to"* or the *"find point"* functions. One person will be handling the GPS and relocating between the sampling points and another person will be in charge of estimating and writing on the sampling form the amount, the distribution and the composition of debris in 10 m radius around the point. Once finishing a specific point, the field crew should move to the next point and so on until covering all points generated by the ArcGIS software.

SOP#4: Data management

Data management involves field data entry, daily backup, office data transfer, storage and archiving, and metadata documentation. Field data entry should be done on a Desktop computer equipped with Access-compatible software (Excel or Microsoft Access). The file should be labeled with the study area, theme, and person's initials. The data file should be located in a folder labeled with the study area. Data backup should be done at the end of data entry and backed up in two different places.

SOP#5: Reporting

After the fieldwork and data management are completed, a report that documents the field activities and describes the types and amount of litter that were collected should be produced. In addition, maps with the spatial distribution, type and amount of litter within each study site should be produced. Facility and equipment needed for the work are limited to a computer, ArcMap GIS software for mapping, statistical software for analysis, and word-processing software for reporting.

SOP#6: Preparations and equipment storage at the conclusion of field season

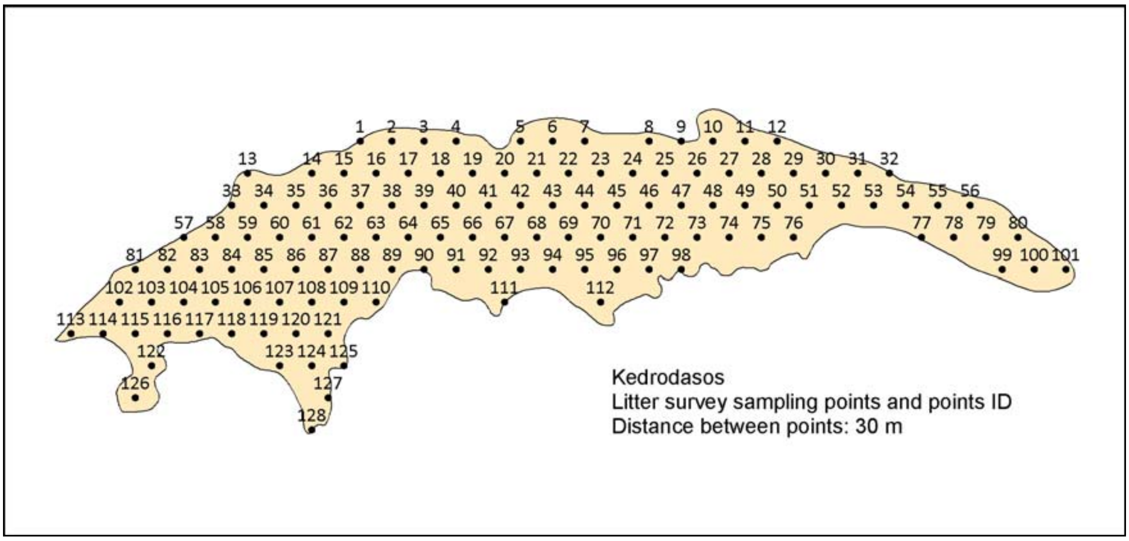
At the end of the field season, it is imperative that all equipment be inventoried, repaired (or replaced) if necessary, and stored in its proper location. The data and resulting products (e.g., reports) should also be organized and archived. To accomplish this, the field crew should follow these steps:

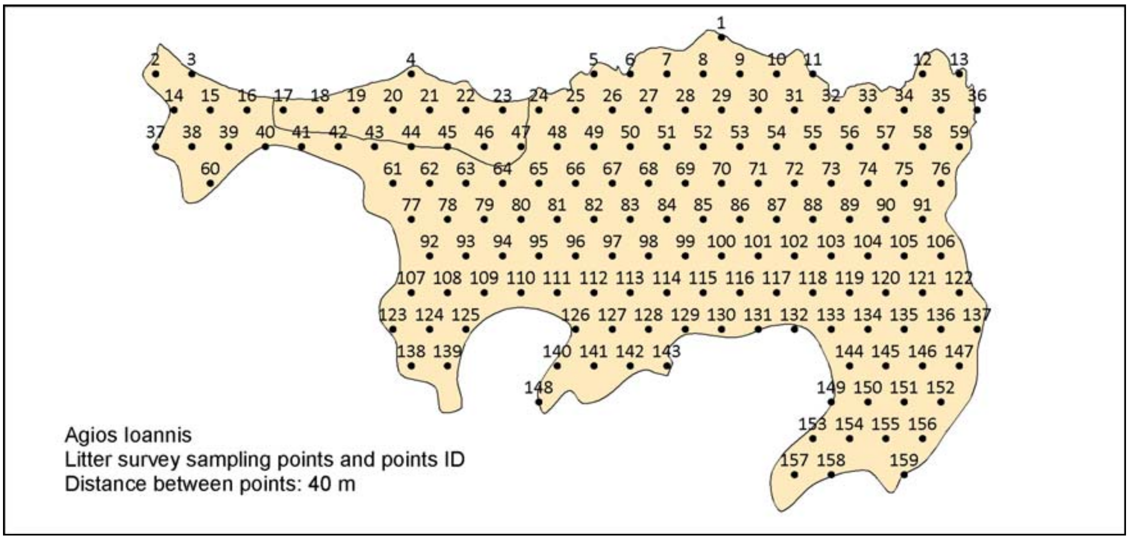
1. Compile, clean, and return all equipment to its proper storage place
2. Organize and photocopy all field datasheets and notes. Give all data to the project manager for safekeeping
3. Make sure all data has been entered into the electronic database and saved in the proper folder
4. Complete end-of-season report

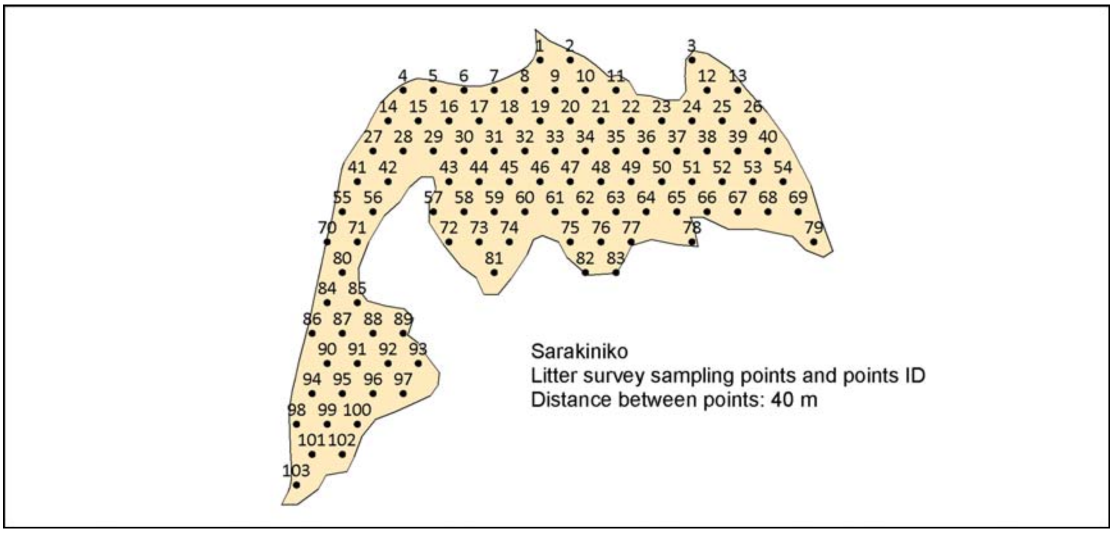
Data sampling form

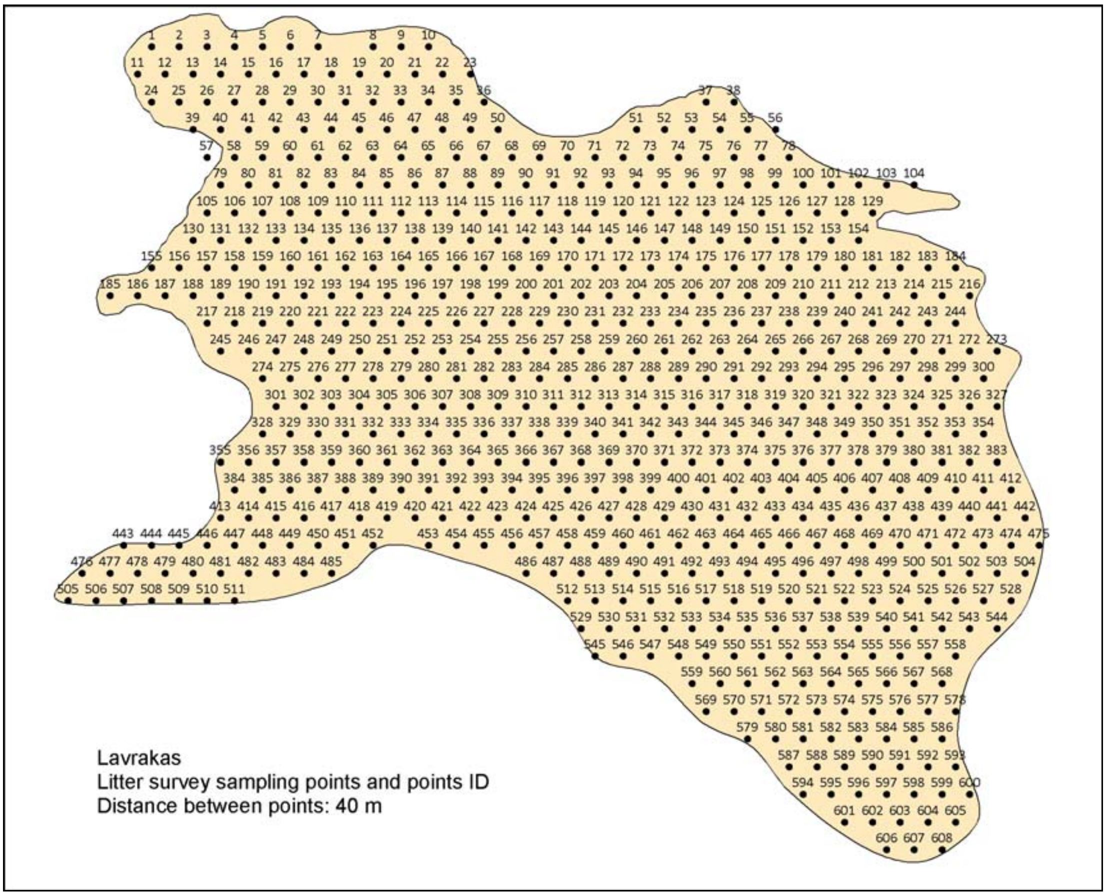
SITE:	OPERATORS:
DATE:	

POINT ID	Plastic bottles (No)	Plastic bags(No)	Glasses (No)	Cans (No)	Papers (No)	Toilet (yes/no)	Metals (No)	Fire (No)	Others
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									


Kedrodasos
Litter survey sampling points and points ID
Distance between points: 30 m


Agios Ioannis
Litter survey sampling points and points ID
Distance between points: 40 m


Sarakiniko
Litter survey sampling points and points ID
Distance between points: 40 m


Lavrakas
Litter survey sampling points and points ID
Distance between points: 40 m

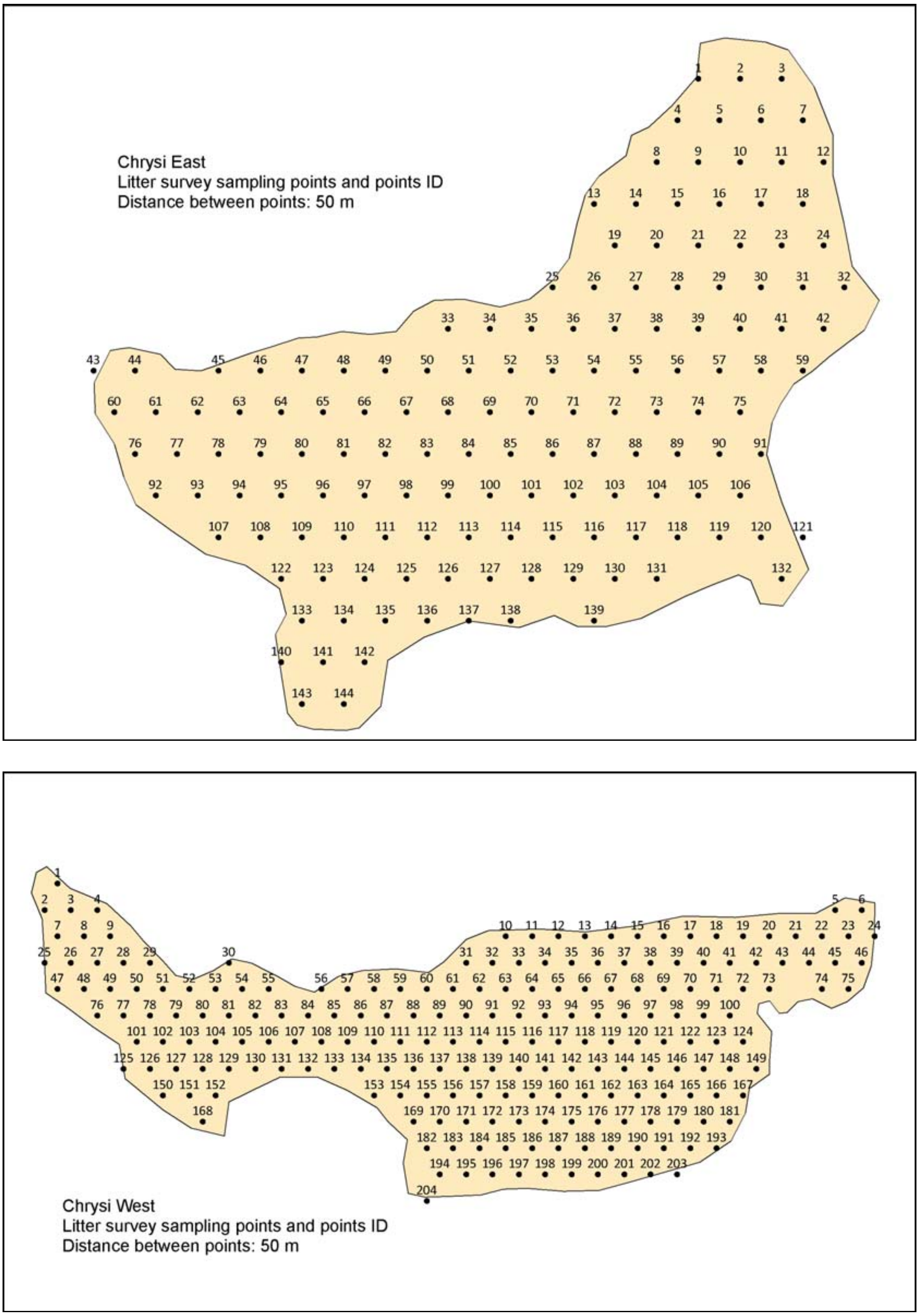


Figure 5 sampling design for the litter surveys in Kedrodasos, Agios Ioannis, Sarakiniko, Lavrakas, Chrysi east and Chrysi west.

Indicator(s) 2: Number of broken branches, cover of root exposure (%), ground vegetation cover (%), and total number of plant species

Sampling design

The damage on *Juniperus* trees (number of broken branches), the cover of root exposure (%), the ground vegetation cover (%) and the total number of plant species will be measured in 10x10m permanent plots already established in all study sites. At each site a number of 10x10m permanent plots (6 in Kedrodasos, 4 in Sarakiniko-Gavdos, 6 in Agios Ioannis-Gavdos, 8 in Lavrakas-Gavdos, 10 in Chrysi and 2 in Falasarna) were established (Figures 6, 7, 8, 9, 10 and 11). All 10x10m plots include trees (*Juniperus*) and their locations were geo-referenced using global positioning system. 10x10m plots were divided into 2 groups: "used" and "unused" plots depending on whether the plot was considered a recreation plot (camping site) or not. At each 10x10 m plot the number of broken branches of each Juniper tree, the cover of root exposure (%), the ground vegetation cover (%) and the total number of plant species will be measured/estimated. The ratio of broken branches per tree will be calculated. The square root transformation of the ratio of broken branches, the arcsine square root transformation of the percentage cover of root exposure and of ground vegetation cover will be used as independent variable for the statistical analysis. A t-Test (independent samples, confidence interval = 95%) will be used to measure the total number of plant species between the used and the unused plots. The re-sampling will be done during spring of 2012. Base line data is available (see Deliverable A.5.1 "Visitors' impact assessment").

Field methods

The following section provides an overview of the field operations in order to measure the damage on the *Juniperus* trees (number of broken branches), the cover of root exposure (%), the ground vegetation cover (%), and the total number of plant species. These procedures are described as "*Standard Operating Procedures*" (SPOs).

SOP#1: Preparations and equipment setup prior to field season

The field crew is advised to complete the following activities to prepare the field work to measure the damage on the *Juniperus* trees (number of broken branches), the cover of root exposure (%), the ground vegetation cover (%), and the total number of plant species:

1. Review the entire protocol
2. Get familiar with the identification of the habitat flora
3. Retrieve and review prior data for reference
4. Visit actual study areas to become familiar with each site
5. Consult maps, the locations of the 10x10m plots and the boundaries of the sites
6. Inspect equipment and compile the items listed below

<u>Equipment List</u>

- Hardcopy map of the study site with the position of the 10x10m plots on the map
- Hard support with sampling form
- Field notebooks
- List of species previously found in plots
- Plant identification materials (field guides, digital images, etc.)
- GPS unit with plot coordinates
- 50x50m or 30x30m tapes
- Rope on a spool to delineate plot boundaries
- Hammer
- Iron sticks
- Compass
- Digital camera
- First-Aid kit
- Pens

SOP#2: Personnel requirements and training

The field work should be done by a field crew with knowledge of vegetation and a small amount of training to set up the plots and to collect the routine data measurements.

Identification of plant taxa

Before the field work, the team leader should take the field crew out to the actual sites or similar habitats and review as many different taxa as possible. It is also advisable for the field crews to sit down with a list of species they are likely to encounter and study characteristics, images, or actual samples available from a herbarium.

Establishing plots and collecting data

The team leader will go over the procedure of setting up a plot and going through the data collection procedure. Ideally, this practice session would be conducted at an actual site so that useable data can be collected. During this training period, the crew will receive instruction on how to find the corners of each plot (see SOP#3).

SOP#3: Establishing and marking the 10x10m plots

Site and plot information

The coordinates and the locations of the 10x10m plots per site should be printed out on the map of the site. Moreover photographs of each plot should be available.

Establishing the plots

With the help of a GPS find the 4 corners of the plot and mark them. Then use field tapes to adjust and delineate the boundaries of each plot. Photographs of each plot will help adjust the exact boundaries of each plot since the crew will see which trees are in or out of specific plots.

SOP#4: Conducting the plot survey

Number of broken branches

Count the number of Juniper trees inside the plot and assign a number for each tree. For some trees, multiple stems may protrude from the ground and are all part of the same individual tree. Count every stem as though it were a separate individual since each has the potential to grow into the over-story and function more or less as an individual tree. Then, count the number of broken branches per Juniper tree.

Cover of root exposure (%)

The percentage cover of root exposure of the trees within the 10x10m plots will be estimated visually using the Braun-Blanquet 9-grade cover-abundance scale as the following:

R: very rare, 1-2 individuals (average cover: 0.02%),

+: rare, few individuals (average cover: 0.1%),

1: many individuals <5% (average cover: 2.5%),

2m: cover 5% (average cover: 5%),

2a: cover 5-12% (average cover: 8.75%),

2b: cover 12-25% (average cover: 18.75%),

3: cover 25-50% (average cover: 37.5%),

4: cover 50-75% (average cover: 62.5%),

5: cover >75% (average cover: 87.5%)

Ground vegetation cover (%)

The percentage cover of each type of ground vegetation (shrubs, phrygana and forbs) will be estimated visually using the same Braun-Blanquet 9-grade cover-abundance scale. The total ground vegetation cover in percentage will be calculated as the total cover of shrubs, phrygana and forbs.

Total number of plant species

All plant species within the 10x10m plots will be identified and their total number will be counted.

Identifying unknown species

In the event that a species cannot be identified in the field, a voucher sample should be collected. Specimens should be taken outside the plot area. Flowers or fruit, even if they are last year's growth, are very helpful in identification. In general, the specimens should appear "typical" and healthy, based on leaf shape, color, etc. In the case of small plants, roots or underground stems are also used in identifying specimens. Samples can be stored in a refrigerator on a short-term basis (i.e. ~1 week) or air-dried and pressed flat between 2 pieces of cardboard for long-term storage. If no specimens can be found outside the plots, a small amount of material (i.e., a branch, or portion of the stem with a few leaves) should be harvested in a way that will not compromise the survival of the plant. If this is not possible or there is reason to suspect that the species may be rare, a digital photograph can be taken instead. There are several different tools available for identification. The simplest way is rely on the expertise of the field worker. Color photography, identification guides, taxonomic keys, and the herbarium of MAICh are other sources of information. As a last resort, if the specimen still cannot be identified, the plant should be listed as "unidentified <growth form>" in the database (e.g., unidentified tree/shrub/graminoid etc.).

SOP#5: Data management

Data management involves field data entry, daily backup, office data transfer, storage and archiving, and metadata documentation. Field data entry should be done on a Desktop computer equipped with Access-compatible software (Excel or Microsoft Access). The file should be labeled with the study area, theme, and person's initials. The data file should be located in a folder labeled with the study area. Data backup should be done at the end of data entry and backed up in two different places.

SOP#6: Reporting

After the fieldwork and data management are completed, a report that documents field activities and describes the types and amount of data that were collected should be produced. In addition, an Appendix Table should be created listing Plot ID, Date, observers, location coordinates, and some other variables of particular interest to provide a hard copy listing of general plot information. Results of hypothesis testing to evaluate the significance of changes among years should be also provided. Facility and equipment needed for the work are limited to a computer, statistical software for analysis and word-processing software for reporting.

SOP#7: Preparations and equipment storage at the conclusion of field season

At the end of the field season, it is imperative that all equipment be inventoried, repaired (or replaced) if necessary, and stored in its proper location. The data and resulting products (e.g., reports) should also be organized and archived. To accomplish this, the field crew should follow these steps:

1. Compile, clean, and return all equipment to its proper storage place
2. Organize and photocopy all field datasheets and notes. Give all data to the project manager for safekeeping
3. Make sure all data has been entered into the electronic database and saved in the proper folder
4. Complete end-of-season report

Data sampling form

Project	JUNICOAST		
Date			
Releve N°		New	
Releve Size (m^2)			
Releve centre X:			
Releve centre Y:			
Altitude (m)			
Aspect			
Slope (%)			
Tree Cover (%)			
Shrub Cover (%)			
Phrygana Cover (%)			
Forb Cover (%)			
Bare Ground Cover (%)			
Rubish cover (%)			
Exposed roots cover (%)			
Moss cover (%)			
Browsed branches 0-1.5m (%)			
Browsed branches >1.5m (%)			

Site-Area			
Plot N°		Size	
Plot Coordinates: X		Y	
C			
1			
2			
3			
4			
Fire evidence			
No of Juniperus seedlings			

Braun-Blanquet **cover-abundance** scale		Avg. Cover %	Releve Size m^2		
			100	25	400
r	Very rare, 1-2 indiv.	0.02			
+	Rare, few individuals	0.10			
1	Many individuals <5%	2.50	2.50	0.63	10.00
2m	cover 5%	5.00	5.00	1.25	20.00
2a	cover 5-12%	8.75	8.75	2.19	35.00
2b	cover 12-25%	18.75	18.75	4.69	75.00
3	cover 25-50%	37.50	37.50	9.38	150.00
4	cover 50-75%	62.50	62.50	15.63	250.00
5	cover >75%	87.50	87.50	21.88	350.00

No	Species	Cover	Height
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

Stems	M/F	DBH	BB
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

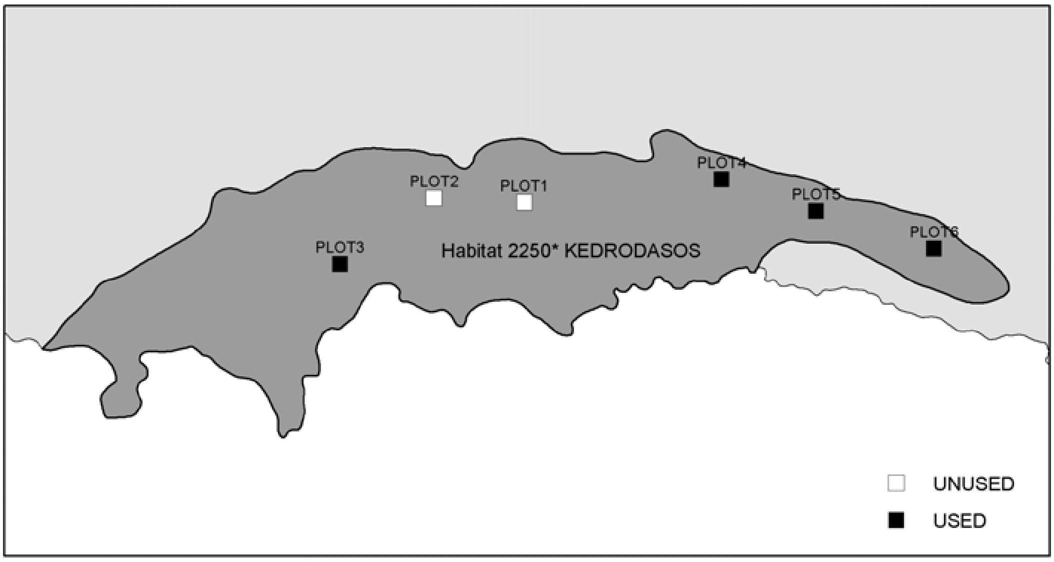


Figure 6 Distribution of the "used" and "unused" 10x10m plots in Kedrodasos

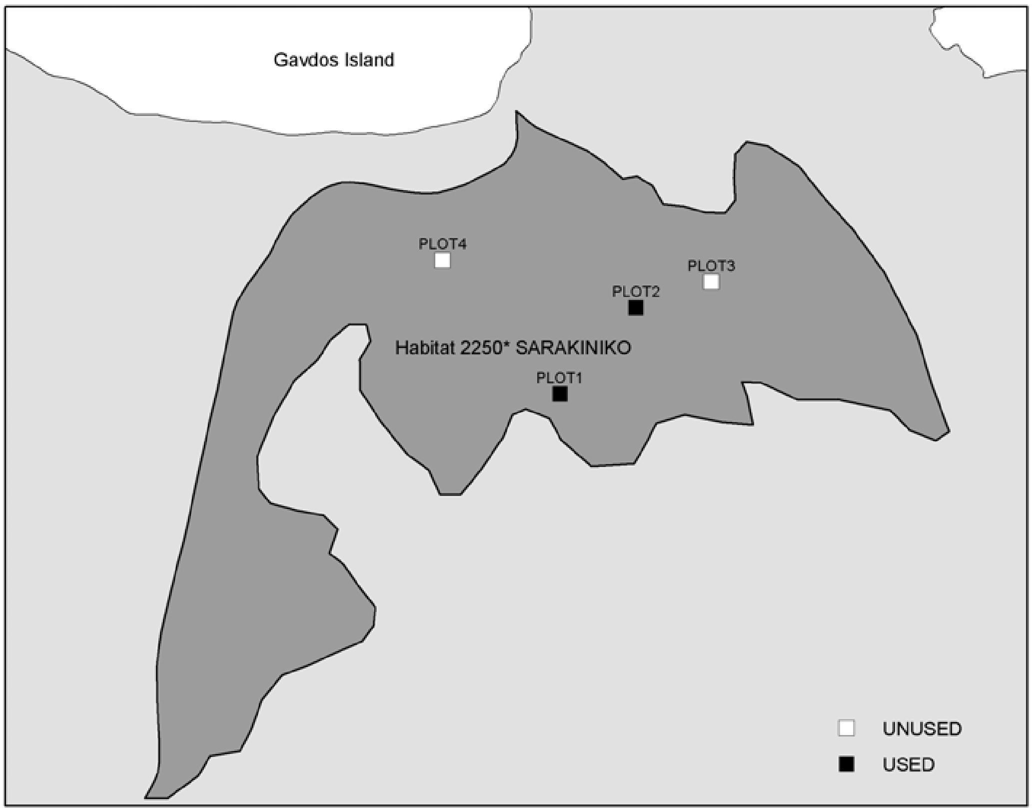


Figure 7 Distribution of the "used" and "unused" 10x10m plots in Sarakiniko-Gavdos

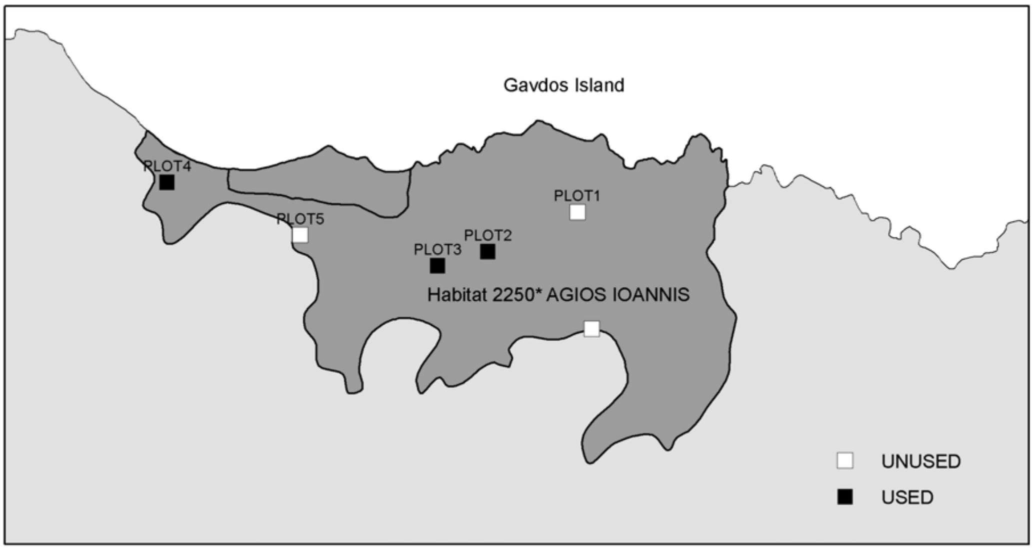


Figure 8 Distribution of the "used" and "unused" 10x10m plots in Agios Ioannis-Gavdos

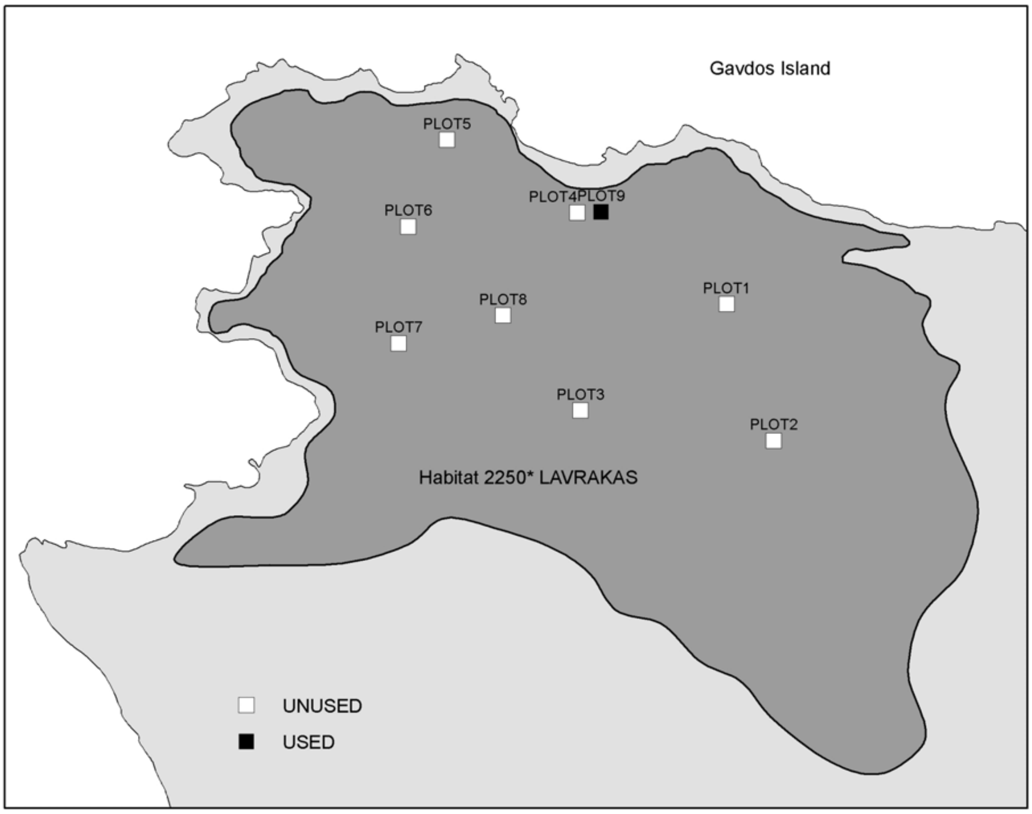


Figure 9 Distribution of the "used" and "unused" 10x10m plots in Lavrakas-Gavdos

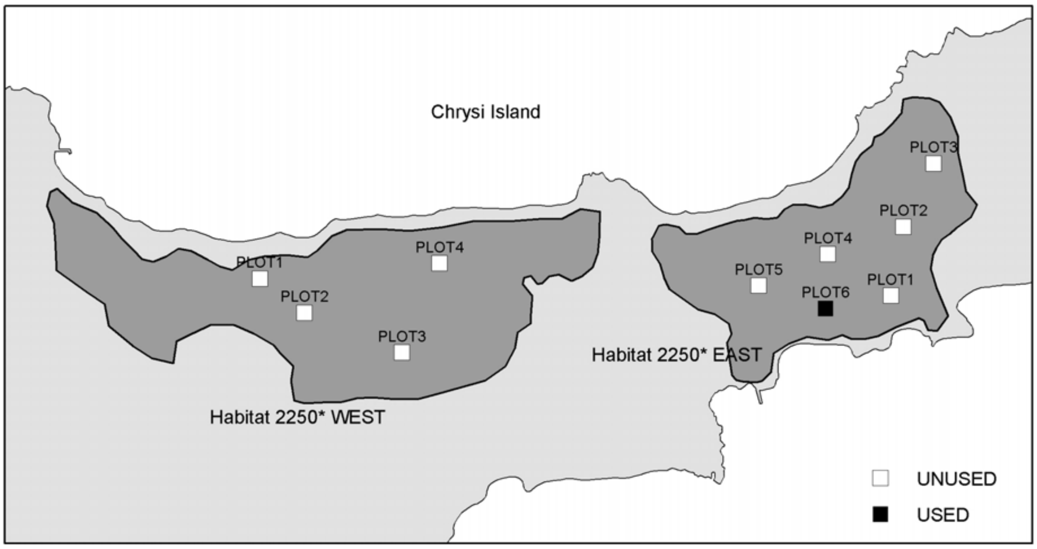


Figure 10 Distribution of the “used” and “unused” 10x10m plots in Chrysi

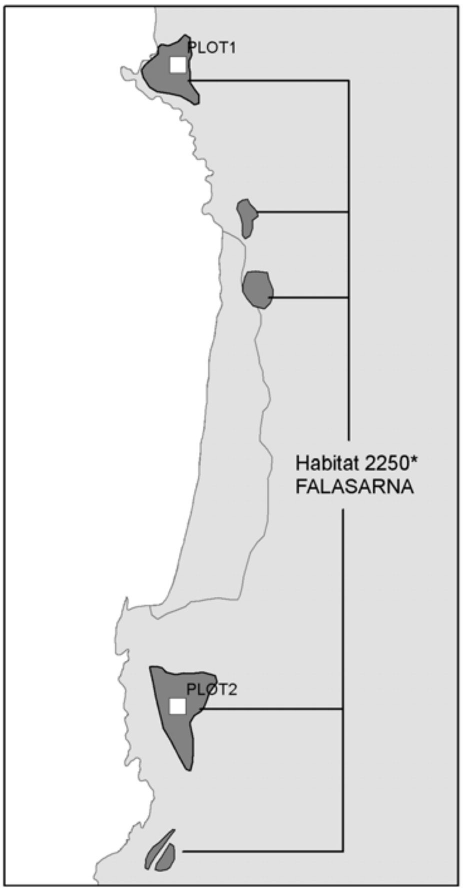


Figure 11 Distribution of the “used” and “unused” 10x10m plots in Falasarna

Indicator 3: *Juniperus* regeneration within the 2250* habitat

Sampling design

The number of *Juniperus macrocarpa* seedlings and juveniles as well as their condition (good or poor) will be assessed at specific sampling points. Seedlings and juveniles will be considered to be in poor condition if a significant part of them is dried, grazed or trod down. The sampling points for the study areas in Chrysi Islet (east and west parts) as well Gavdos Island (Sarakiniko, Agios Ioannis, Lavrakas) will be those used in Action A.3. New samplings points are set for the study areas of Kedrodasos and Falasarna which were investigated throughout their entire range in Action A.3. The sampling design for each site is shown in Figure 12. The relocation between the sampling points will be done with the help of a GPS. The total number of seedlings and juveniles and their condition will be recorded within the borders of the sampling areas that were designated around each sampling point in the study areas of Chrysi and Gavdos and in a 12 m distance around each sampling point in Kedrodasos and Falasarna. This sampling design, applied partly in action A.3 proved to be practical and representative of each *Juniperus* subpopulation. Regeneration monitoring surveys will be conducted in all 7 Cretan study areas. Field measurements will be carried out before the end of the project (Spring 2012). Baseline data for the number of juveniles are already available (see Deliverable A.3.1 "Composition and structure of *Juniperus* subpopulations").

Field methods

The following section provides an overview of the field operations in order to conduct the regeneration monitoring surveys. These procedures are described as "*Standard Operating Procedures*" (SPOs).

SOP#1: Preparations and equipment setup prior to field season

The field crew is advised to complete the following activities in order to set up the field work for the regeneration monitoring survey:

1. Consult photographic and literature data of *Juniperus* phenology.
2. Review the entire protocol.
3. Get familiar with the practical use of GPS.
4. Retrieve and review prior data for reference.
5. Consult maps and boundaries of the sites.
6. Inspect equipment and compile the items listed below.

Equipment List

- Hardcopy map of the study site with sampling points clearly shown on the map
- Sampling forms mounted on a hard support.
- Hardcopies of photographic material on *Juniperus* phenology.
- Field notebooks.
- GPS unit with site coordinates.
- Digital camera.
- First-Aid kit.
- Pens.

SOP#2: Using the global positioning system (GPS)

General use

Keep the GPS unit dry at all times. Do not leave the unit "on" for long periods of time between uses as the batteries will drain quickly. Satellite reception may vary substantially depending upon interference from trees, topography, structures, weather, and satellite configurations. The unit should be held face up (i.e., the display screen facing upward).

SOP#3: Conducting the regeneration monitoring survey

The regeneration monitoring survey should be done by a field crew (at least 2 people) trained on how to navigate with a GPS. Moving around and among sampling points will be done with the help of the GPS *"go to"* or *"find point"* functions.

One person will be handling the GPS and relocating between the sampling points and another one (person in charge) will be filling in the sampling form, while both will be responsible for the assessment of the number of *Juniperus macrocarpa* seedlings and juveniles as well as their condition within the sampling areas. Once having finished a specific point, the field crew should move to the next point and so on until covering all sampling points. Moreover, one person of the crew should take representative photos of *Juniperus* seedlings and juveniles in each study area.

SOP#4: Data management

Data management involves field and photographic data entry, daily backup, office data transfer, storage and archiving, and metadata documentation. Field data entry should be done on a computer equipped with Access-compatible software (Excel or Microsoft Access). The file should be labeled properly with indications of study area, theme, and person's initials. The data file should be located in a folder named after the study area. Data backup should be done at the end of data entry and backed up in two different places.

SOP#5: Reporting

After the fieldwork and data management have been completed, a report that documents all field activities and includes the regeneration monitoring data should be produced. In addition, digital maps with the spatial distribution and number of *Juniperus* seedlings and juveniles at the sampling points within each study site should be produced. Facilities and equipment needed for the work are limited to a computer, ArcMap GIS software for mapping, statistical software for analysis, and word-processing software for reporting.

SOP#6: Preparations and equipment storage at the conclusion of field season

At the end of the field season, it is imperative that all equipment be inventoried, repaired (or replaced) if necessary, and stored in their proper location. The data and resulting products (e.g. reports) should be well organized and archived. To accomplish this, the field crew should follow these steps:

1. Compile, clean, and return all equipment to their proper storage place.
2. Organize and photocopy all field datasheets and notes. Give all data to the project manager for safekeeping.
3. Make sure all data has been entered into the electronic database and saved in the proper folder.
4. Complete the end-of-season report.

Data sampling form

SITE:		OPERATORS:			
DATE:					
POINT ID	**Seedlings in good condition (No)**	**Seedlings in poor condition (No)**	**Juveniles in good condition (No)**	**Juveniles in poor condition (No)**	**Comments**
1					
2					
3					
4					
5					
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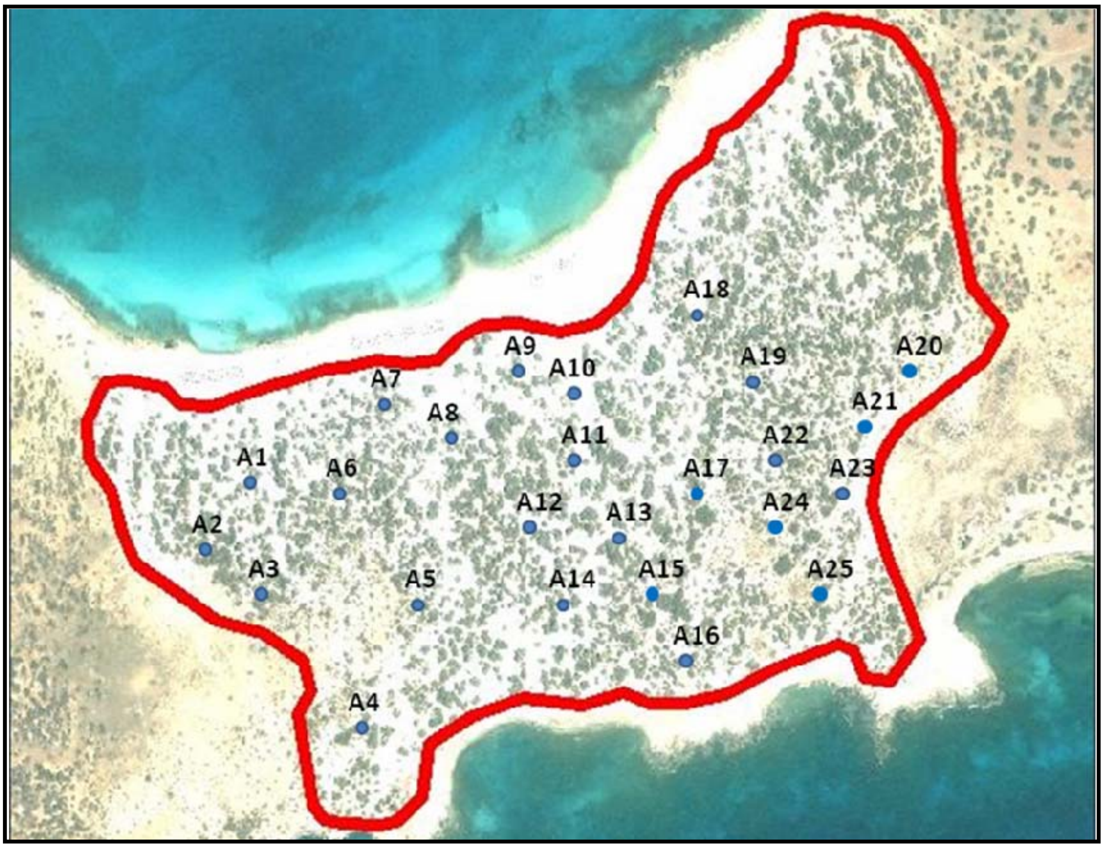
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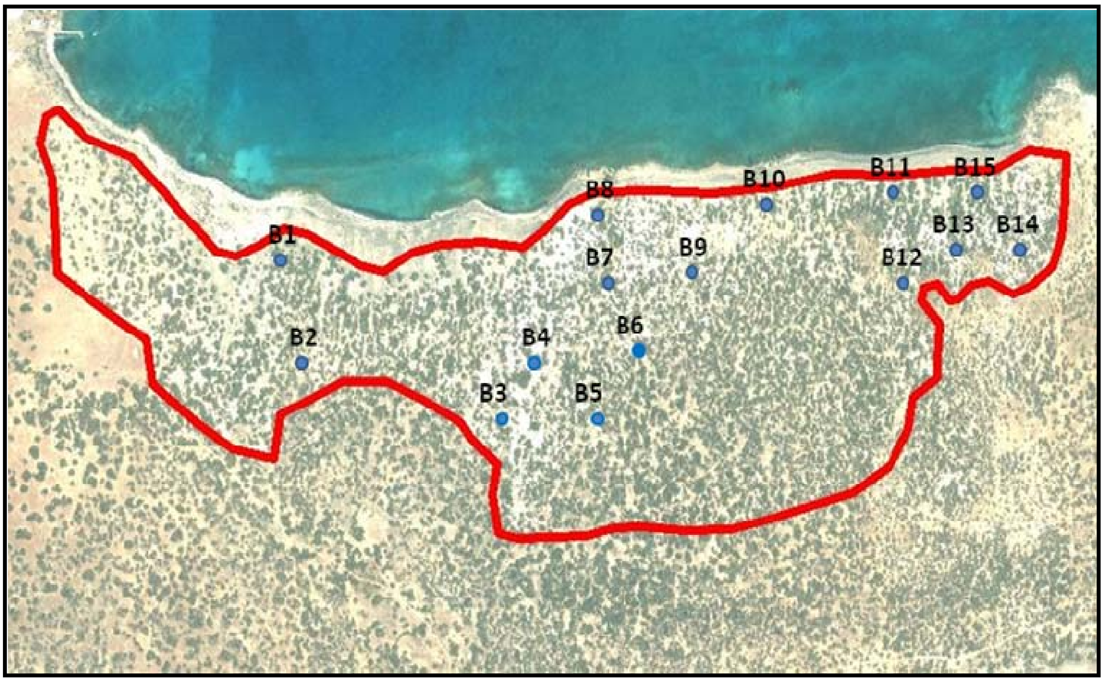
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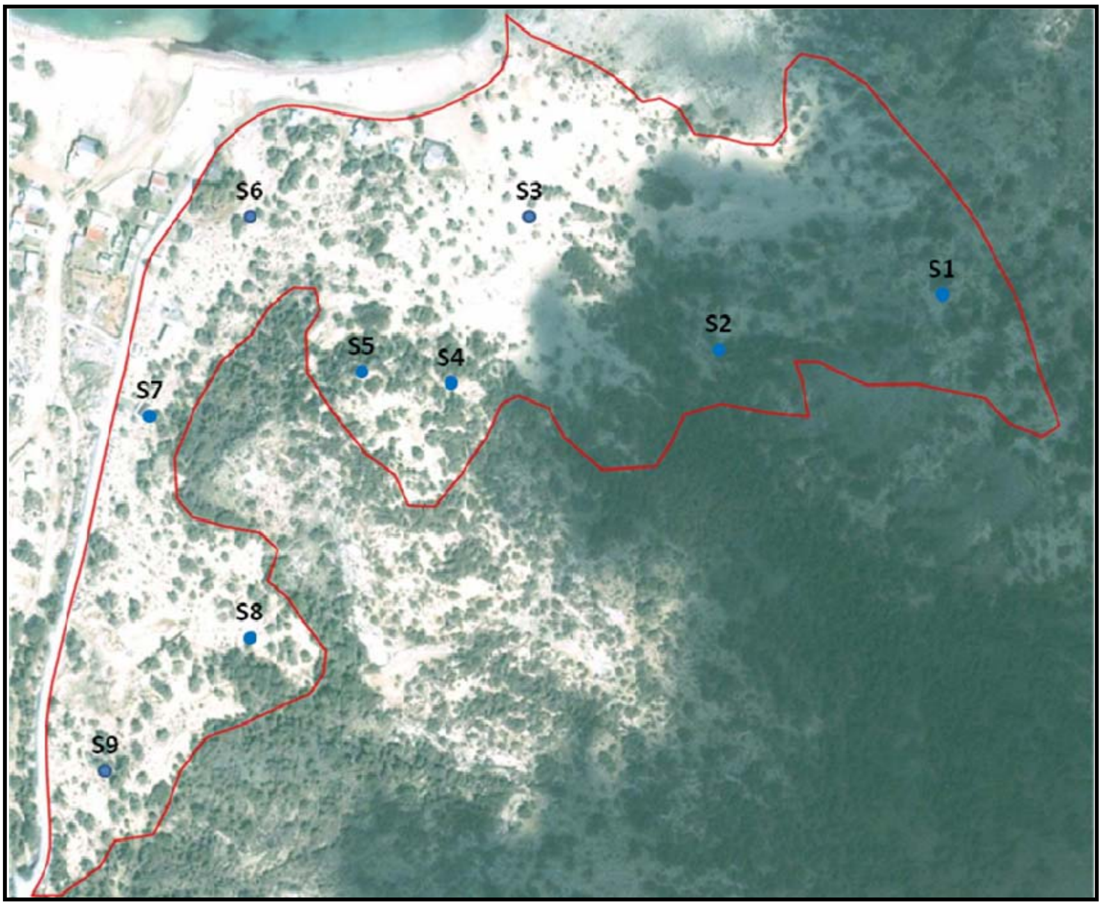
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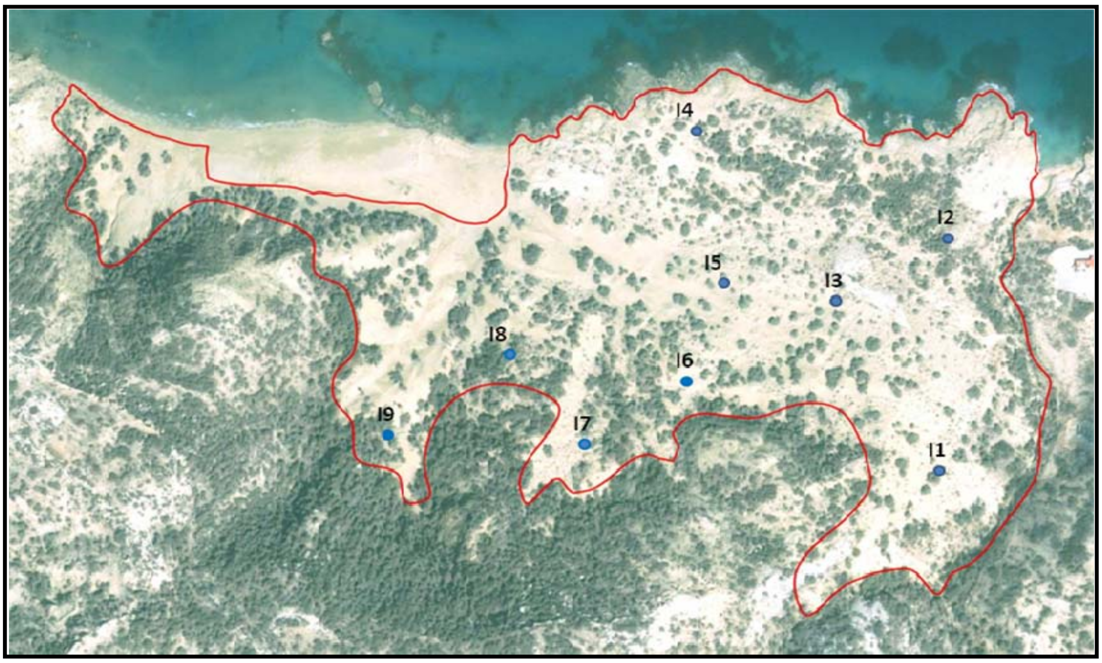
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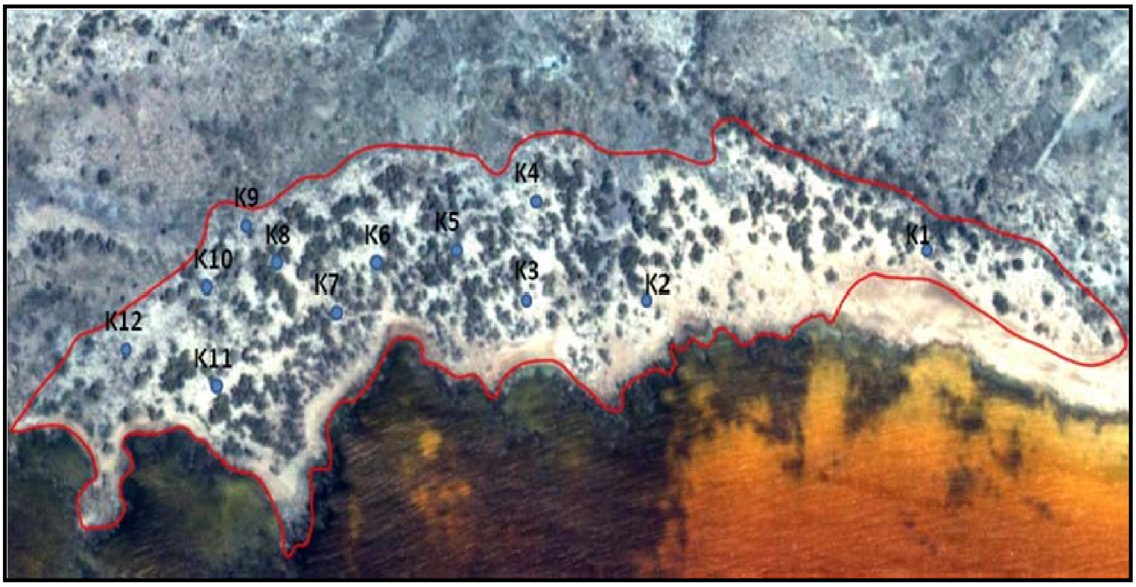
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Figure 12 Sampling design for the regeneration surveys in Chrysi-East, Chrysi-West, Sarakiniko, Agios Ioannis, Lavrakas, Kedrodasos and Falasarna, from top to bottom, respectively.

Indicator(s) 4: vegetation cover of keystone species, sex ratio of *J. macrocarpa* and presence of invasive species

Sampling design

Restoration of 2250* habitat floristic composition and structure will be assessed with the use of three indicators: vegetation cover from keystone species (number of individuals from keystone species), sex ratio and presence of invasive species. Depending on the specific features and diverse conservation status of 2250* habitat in each study area, one or more of these indicators will be estimated at specific sampling points. On the study areas of Chrysi Islet (east and west parts) and Gavdos Island (Sarakiniko, Agios Ioannis, Lavrakas) the sampling points will be selected among those used in Action A.3. New samplings points are set for the study areas of Kedrodasos and Falasarna which were studied in their entirety in the previous Action A.3. The sampling design for each site is shown in figure 1.

Moving around the sampling points and the borders of sampling areas will be achieved with the help of a GPS. The vegetation cover from keystone species and sex ratio will be recorded within the borders of the sampling areas that were designated around each sampling point in the study areas of Chrysi and Gavdos and within a 12 m radius circle around each sampling point in Kedrodasos and Falasarna. This sampling design, applied partly in action A.3 proved to be practical and representative for the study of the 2250* habitat. The presence of invasive species (mainly *Pinus brutia,* as well as *Carpobrotus edulis* in Chrysi and possibly others) will be recorded in a 15 m wide band around specific localities where the invasion is particularly dense.

Restoration monitoring surveys will be conducted in all 7 Cretan study areas. The re-sampling will be carried out before the end of the project (spring 2012). Some baseline data for the vegetation cover from keystone species, sex ratio and presence of invasive species are already available (see Deliverable A.3.1 "Composition and structure of *Juniperus* subpopulations").

Field methods

The following section provides an overview of the field operations in order to conduct the restoration monitoring surveys. These procedures are described as "*Standard Operating Procedures*" (SPOs).

SOP#1: Preparations and equipment setup prior to field season

The field crew is advised to complete the following activities in order to set up the field work for the restoration monitoring survey:

1. Consult photographic and literature data of keystone and invasive species phenology.
2. Review the entire protocol.
3. Get familiar with the practical use of GPS.
4. Retrieve and review prior data for reference.
5. Consult maps and boundaries of the sites.
6. Inspect equipment and compile the items listed below.

Equipment List

- Hardcopy map of the study site with the sampling points clearly marked on the map.
- Sampling forms with a hard support.
- Hardcopies of photographic material on keystone and invasive species phenology.
- Field notebooks.
- GPS unit with site coordinates.
- Digital camera.
- First-Aid kit.
- Pens.

SOP#2: Using the global positioning system (GPS)

General use

Keep the GPS unit dry at all times. Do not leave the unit "on" for long periods of time between uses as the batteries will drain quickly. Satellite reception may vary substantially depending upon interference from trees, topography, structures, weather, and satellite configurations. The unit should be held face up (i.e., the display screen facing upward).

SOP#3: Conducting the restoration monitoring survey

The restoration monitoring survey should be done by a field crew (of at least 2 people) well trained on how to navigate with a GPS. Moving around between the sampling points will be done with the help of the GPS *"go to"* or *"find point"* functions.

One person will be handling the GPS and walking around between the sampling points and another person will be in charge, filling in field data into the sampling form, while both will be responsible for the assessment of the number of keystone species, sex ratio and presence of invasive species at the sampling points. Once having finished a specific point, the field crew should move to the next point and so on until covering all sampling points.

SOP#4: Data management

Data management involves field and photographic data entry, daily backup, office data transfer, storage and archiving, and metadata documentation. Field data entry should be done on a computer equipped with Access-compatible software (Excel or Microsoft Access). The file should be labeled after the study area, theme, and person's initials. The data file should be inserted in a folder named after the study area. Data backup should be done at the end of data entry and backed up in two different places.

SOP#5: Reporting

After the fieldwork and data management have been completed, a report that documents all field activities and includes the restoration monitoring data should be produced. In addition, maps with the spatial distribution and number of keystone and invasive species at the sampling points within each study site should be produced. Facilities and equipment needed for the work are limited to a computer, ArcMap GIS software for mapping, statistical software for analysis, and word-processing software for reporting.

SOP#6: Preparations and equipment storage at the conclusion of field season

At the end of the field season, it is imperative that all equipment be inventoried, repaired or replaced as necessary, and stored in their proper location. The data and resulting products (e.g. reports) should also be organized and archived. To accomplish this, the field crew should follow these steps:

5. Compile, clean, and return all equipment to their proper storage place.
6. Organize and photocopy all field datasheets and notes. Give all data to the project manager for safekeeping.
7. Make sure all data has been entered into the electronic database and saved in the proper folder.
8. Complete end-of-season report.

Data sampling form

SITE:	OPERATORS:
DATE:	

POINT ID	Cover from keystone species (No of indiv.)	Sex ratio (No of male indiv./no of female indiv.)	Presence of invasive species (No of indiv.)	Comments
1				
2				
3				
4				
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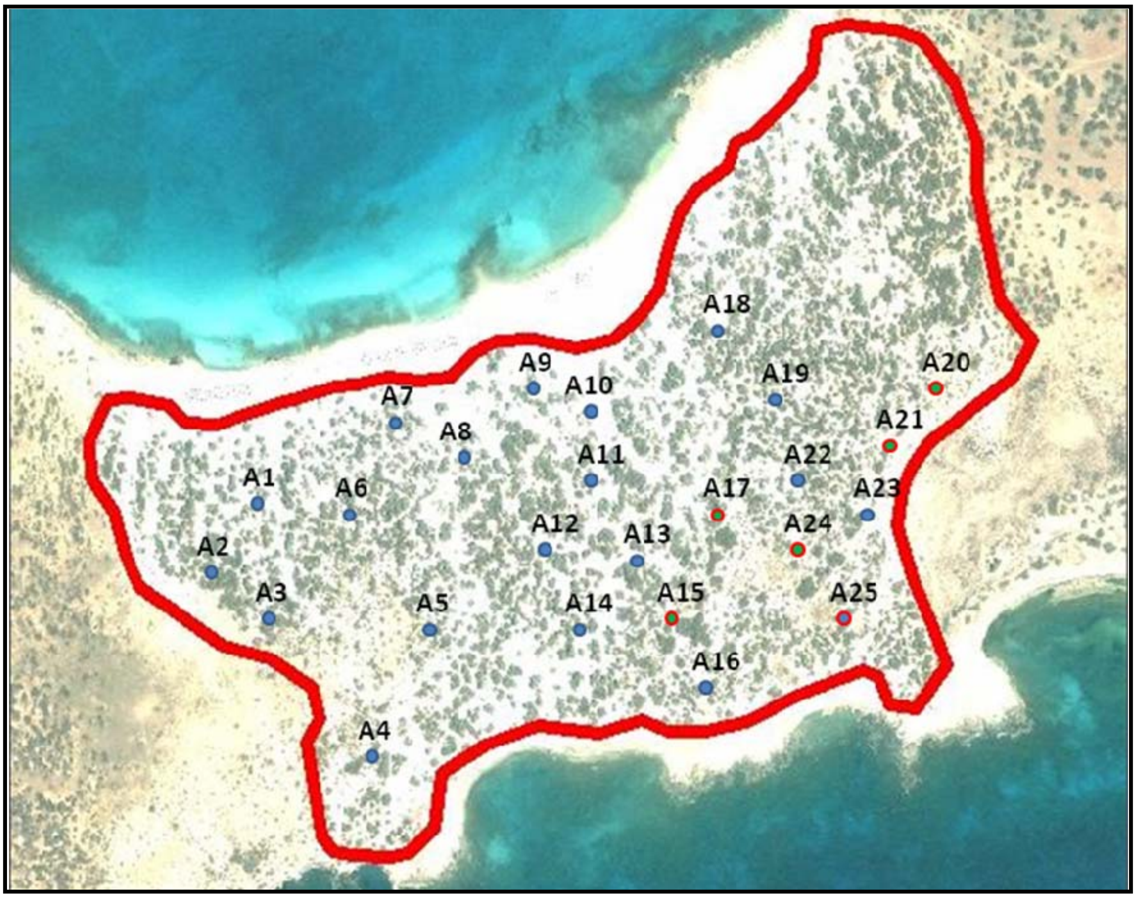
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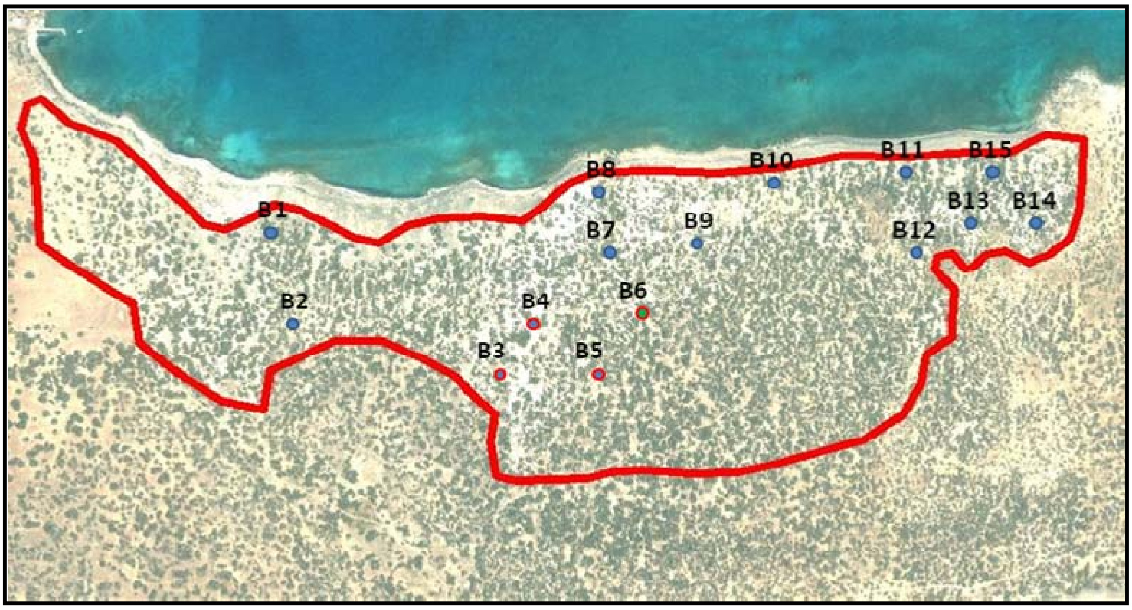
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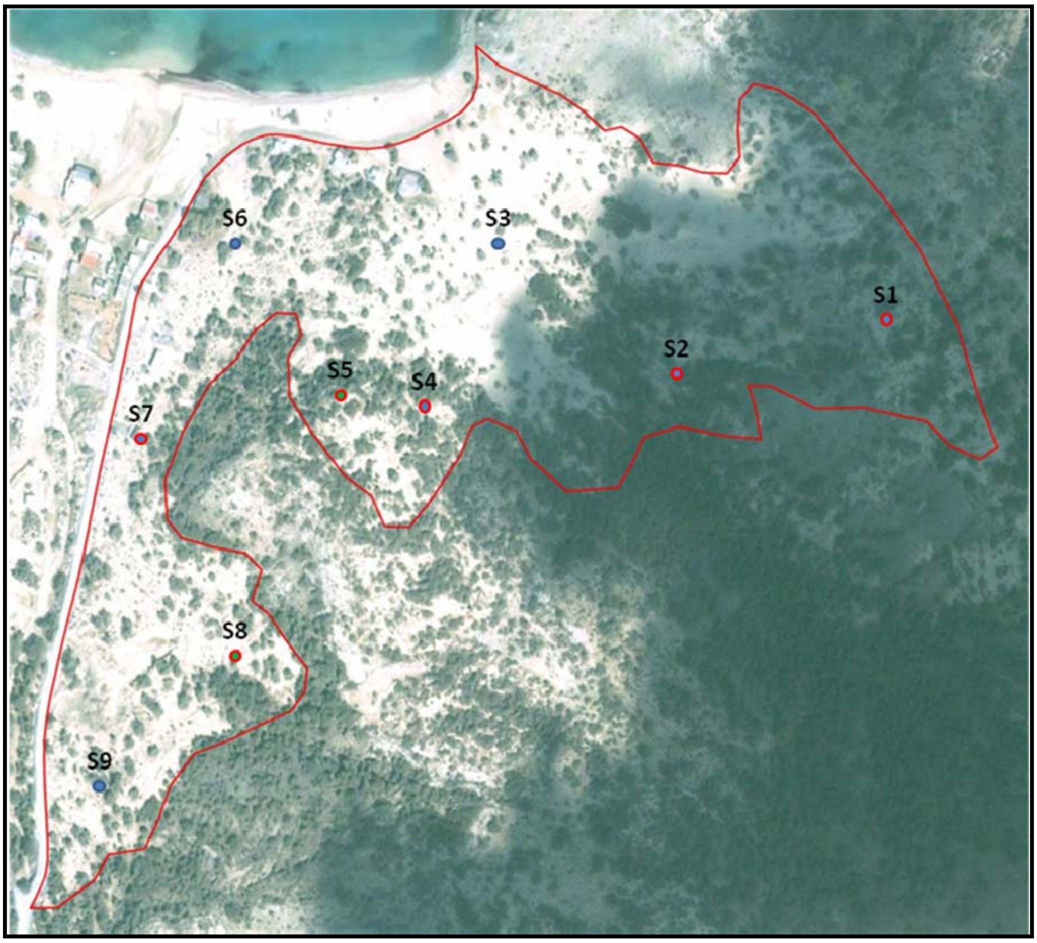
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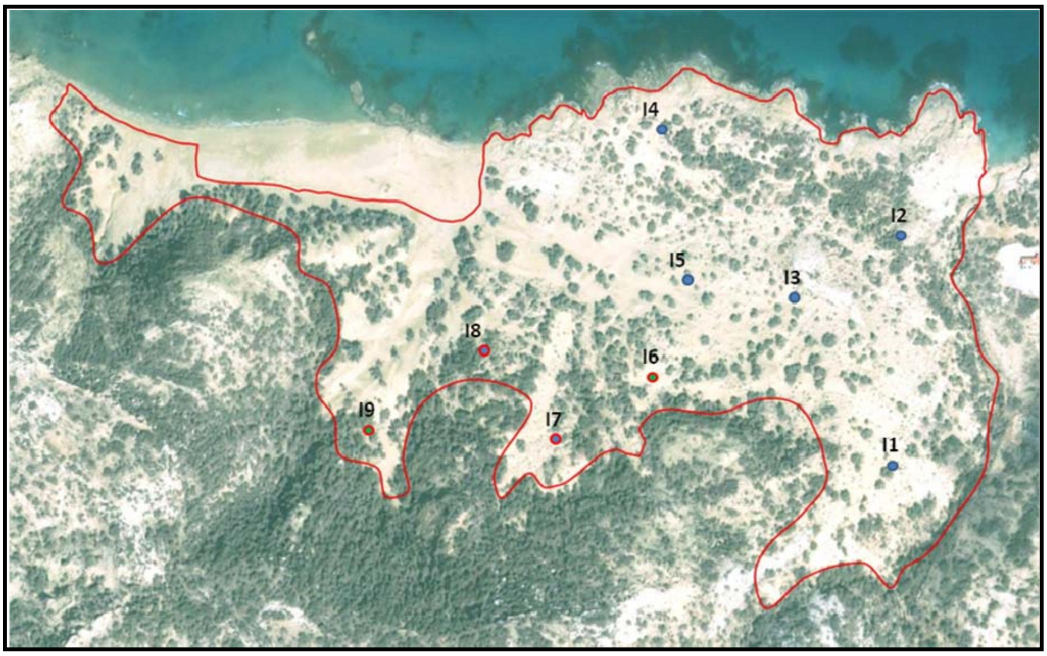
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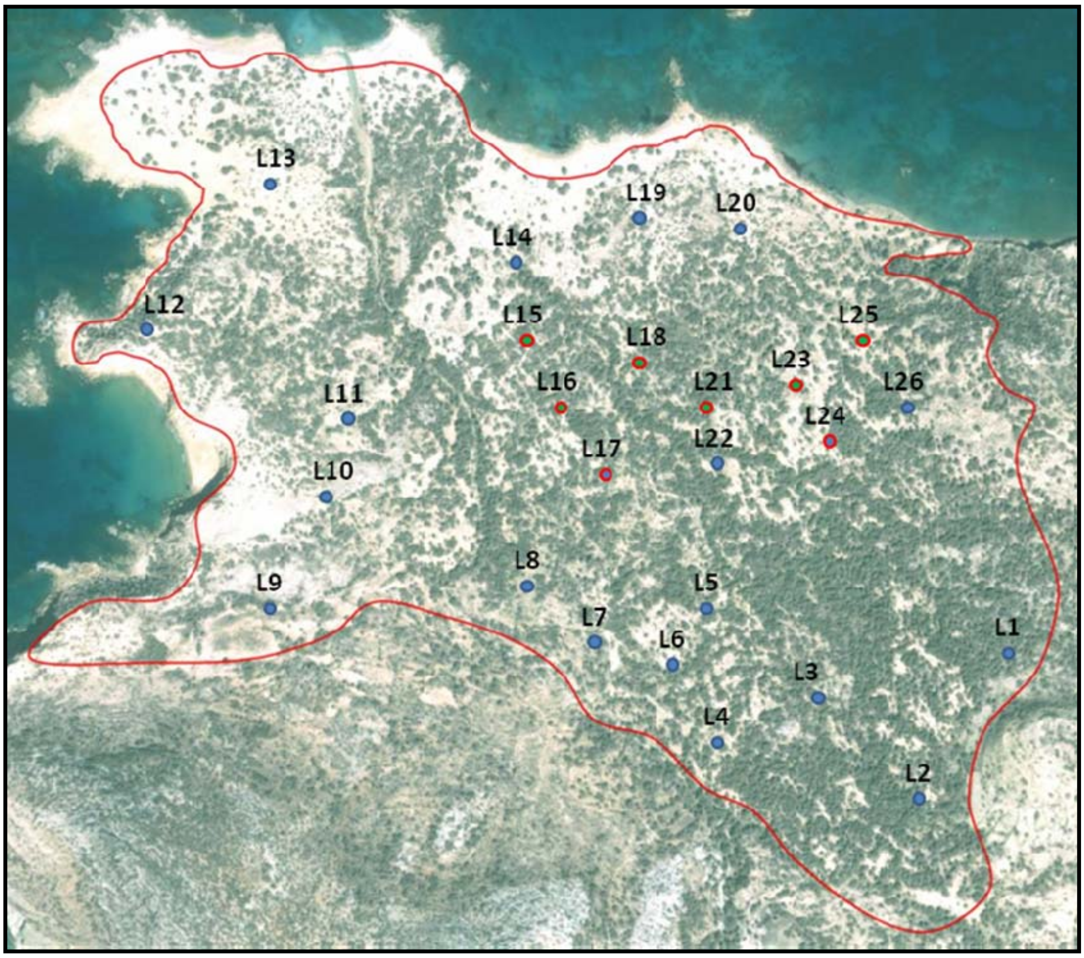
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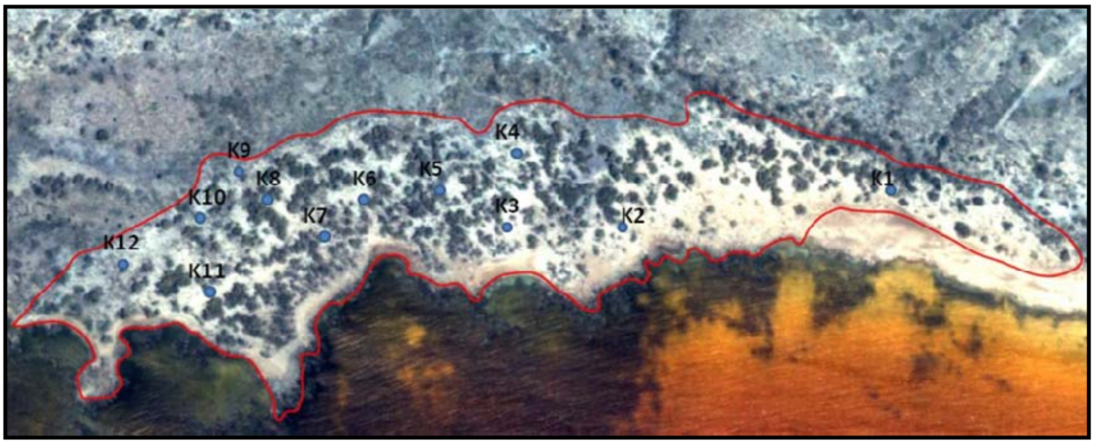
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Figure 13 Sampling design for the restoration surveys in Chrysi-East, Chrysi-West, Sarakiniko, Agios Ioannis, Lavrakas, Kedrodasos and Falasarna, from top to bottom, respectively. Points filled with blue color are sampling points for the indicators 'cover from keystone species' and/or 'sex ratio', while points with red outline are sampling points for the indicator 'presence of invasive species'.

Indicator 5: Level of public/environmental awareness

Sampling design

The level of public/environmental awareness will be estimated by conducting a social survey i.e. interviews with visitors at each site. Questionnaires will be used in order to establish the visitors' level of environmental awareness regarding the habitat sensitivity. Questionnaires will be conducted in English or Greek, depending on the native language of the interview subject (visitors). Visitors will receive a verbal introduction of the aims of the survey and a copy of the questionnaire to help them choose their answers. Interviews will be transcribed and content analysis will be performed for qualitative responses (Sarantakos 1993). Social surveys will be conducted at all Cretan study areas namely Gavdos (Sarakiniko, Agios Ioannis and Lavrakas), Chrysi (East and West sites), and Kedrodasos. Base line data is available (see Deliverable A.5.1 "Visitors' impact assessment"). The time of re-sampling will be summer 2012.

Field methods

The following section provides an overview of the field operations in order to conduct the social survey. These procedures are described as "*Standard Operating Procedures*" (SPOs).

SOP#1: Preparations and equipment setup prior to field season

The field crew is advised to complete the following activities to prepare the field work in order to establish the visitors' level of environmental awareness regarding the habitat sensitivity.

1. Review the entire protocol
2. Get familiar with the questionnaire
3. Retrieve and review prior data for reference
4. Visit actual study areas to become familiar with each site
5. Inspect equipment and compile the items listed below

Equipment List

- Hardcopy map of the study site
- Hard supports
- Questionnaires
- Digital camera
- First-Aid kit
- Pens

SOP#2: Conducting the questionnaires

Visitors will receive a verbal introduction of the aims of the survey and a copy of the questionnaire to fill up their answers.

SOP#3: Data management

Data management involves field data entry, daily backup, office data transfer, storage and archiving, and metadata documentation. Field data entry should be done on a Desktop computer equipped with Access-compatible software (Excel or Microsoft Access). The file should be labeled with the study area, theme, and person's initials. The data file should be located in a folder labeled with the study area. Data backup should be done at the end of data entry and backed up in two different places.

SOP#4: Reporting

After the fieldwork and data management are completed, a report that documents field activities and describes the types and amount of data that were collected should be produced. In addition, an Appendix Table should be created listing Plot ID, Date, observers. Visitors' perception about the main threats, the protection status of the sites and the reasons why the sites are protected should be provided.

Facility and equipment needed for the work are limited to a computer, statistical software for analysis and word-processing software for reporting.

SOP#5: Preparations and equipment storage at the conclusion of field season

At the end of the field season, it is imperative that all questionnaires be inventoried. The data and resulting products (e.g., reports) should also be organized and archived. To accomplish this, the field crew should follow these steps:

1. Organize and photocopy all questionnaires and notes. Give all data to the project manager for safekeeping
2. Make sure all data has been entered into the electronic database and saved in the proper folder
3. Complete end-of-season report

Questionnaire templates (English and Greek versions)

Actions for the conservation of coastal dunes with *Juniperus* spp. in Crete and the South Aegean (Greece)

Junicoast

JUNICOAST "Actions for the conservation of coastal dunes with *Juniperus* spp. in Crete and the South Aegean (Greece)" is a four year (2009-2012) LIFE+ Nature and Biodiversity project funded under the first call for the EU LIFE+ programme (2007-2013). JUNICOAST aims to promote and enable the long term conservation of the coastal dunes with *Juniperus* spp. habitats in Greece. The project will describe the current situation in all Cretan sites (Chrysi, Gavdos, Kedrodasos-Elafonisi and Falasarna), will design and implement habitat restoration actions, visitor management interventions, and actions for public awareness and environmental education.

This survey is being carried in order establish the visitor's level of environmental awareness regarding the habitat sensitivity.

Date: **Gender:** **Country of origin:**
Name: **Age:**

Please indicate whether you believe the following statements are TRUE or FALSE: *Please circle your response*

The site is protected because of the presence of:	***TRUE***	***FALSE***	***Don't Know***
… the *carretta carretta* turtle			
… the sea shells			
… the antiquities - ancient monuments			
… the sand dunes with juniper trees habitat			
Other reason? (please specify)			
The site is a National park			
The site is a NATURA 2000 site			
The site is a designated Site of Community Interest			
The site has a designated Special Protection Area for birds			
The site is **NOT** protected			

Please indicate your level of agreement or disagreement with the following statements: *Please circle your response*

	Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
The site with Juniper trees and sand dunes is well managed	*1*	*2*	*3*	*4*	*5*
Visitors should be restricted from certain parts of the site in order to protect the Juniper trees and the sand dunes	*1*	*2*	*3*	*4*	*5*
The site with juniper trees and sand dunes does not require further protection	*1*	*2*	*3*	*4*	*5*
Visitors should be required to carry their personal rubbish back from the site	*1*	*2*	*3*	*4*	*5*

Your education

- No formal education ☐
- Primary education ☐
- Secondary education ☐
- Post-secondary (non-tertiary) education ☐
- Tertiary education (university) ☐

Thank you for completing this questionnaire – Please put it in the box on board of the boat

To find out more about the JUNICOAST, please visit www.junicoast.gr

Δράσεις για την προστασία των παράκτιων αμμοθινών με είδη Juniperus στην Κρήτη και στο Νότιο Αιγαίο (Ελλάδα).

Junicoast

Το πρόγραμμα JUNICOAST "Δράσεις για την προστασία των παράκτιων αμμοθινών με είδη *Juniperus* στην Κρήτη και στο Νότιο Αιγαίο (Ελλάδα)" είναι ένα 4ετές πρόγραμμα (2009-2012) που υλοποιείται στα πλάισια του LIFE+ για τη Φύση και τη Βιοποικιλότητα. Σκοπός του προγράμματος είναι να διασφαλίσει την μακροχρόνια διατήρηση του οικοτόπου στην Ελλάδα, στοχεύοντας στην διεύρυνση και διάδοση της γνώσης, στην αποκατάσταση των λειτουργιών του οικοτόπου και στην ελαχιστοποίηση των φυσικών ή ανθρωπογενών επιπτώσεων. Το πρόγραμμα θα καταγράψει τη σημερινή κατάσταση στη Κρητη ( ) και στη συνέχεια θα εφαρμόσει δράσεις όπως, αποκατάσταση του συστήματος των αμμοθινών, κατασκευή ήπιων υποδομών διαχείρισης- διευκόλυνσης των επισκεπτών και δράσεις ενημέρωσης-ευαισθητοποίησης του κοινού και περιβαλλοντικής εκπαίδευσης.

This survey is being carried in order establish the visitor's level of environmental awareness regarding the habitat sensitivity.

Date: **Gender:** **Country of origin:**
Name: **Age:**

Ποιες από τις <u>παρακάτω προτάσεις πιστεύετε πως είναι</u> <u>ΣΩΣΤΕΣ</u> και ποιες <u>ΛΑΘΟΣ:</u> Παρακαλώ κυκλώστε την απάντηση

Η Χρυση προστατεύεται λόγω της παρουσίας:	***ΣΩΣΤΟ***	***ΛΑΘΟΣ***	***ΔΕΝ ΞΕΡΩ***
... της χελώνας caretta caretta			
... των δέντρων (λεγόμενοι κέδροι)			
... των κοχυλιών			
... των αρχαιοτήτων			
... του οικοσυστήματος αμμολόφων με κέδρους			
Άλλος λόγος (προσδιορίστε)			
Η Χρυση είναι Εθνικός Δρυμός;			
Η Χρυση ανήκει στο δίκτυο NATURA2000;			
Η Χρυση έχει χαρακτηρισθεί ως Περιοχή Κοινοτικού Ενδιαφέροντος (SCI)			
Στην Χρυση έχουν ορισθεί Ζώνες Ειδικής Προστασίας			
Η Χρυση **ΔΕΝ** προστατεύεται			

Παρακαλώ υποδείξατε κατά ποσό <u>συμφωνείτε</u> ή <u>διαφωνείτε</u> με τις ακόλουθες προτάσεις: Παρακαλώ κυκλώστε την απάντηση

	Διαφωνώ απόλυτα	**Διαφωνώ**	**Ούτε διαφωνώ/ Ούτε συμφωνώ**	**Συμφωνώ**	**Συμφωνώ απόλυτα**
Η κατασκήνωση υποβαθμίζει το οικοσύστημα των αμμολόφων με τους κέδρους	*1*	*2*	*3*	*4*	*5*
Η υφιστάμενη διαχείριση της Χρυσης είναι επαρκής.	*1*	*2*	*3*	*4*	*5*
Σε μερικές περιοχές στην Χρυση πρέπει να απαγορευτεί η πρόσβαση στους επισκέπτες ώστε να προστατευτούν οι αμμόλοφοι με τους κέδρους	*1*	*2*	*3*	*4*	*5*
Η Χρυση **δεν** χρειάζεται περαιτέρω μέτρα για την προστασία του	*1*	*2*	*3*	*4*	*5*
Οι επισκέπτες θα έπρεπε να είναι υποχρεωμένοι να παίρνουν μαζί τα απορρίμματα τους κατά την επιστροφή τους από το νησί	*1*	*2*	*3*	*4*	*5*

Section 5 A complementary, practical and cost-effective approach to evaluating conservation projects - Threat Reduction Assessment (TRA)

There is a growing trend among conservation practitioners to design conservation projects by identifying threats to biodiversity at a project site and then developing interventions that explicitly address these threats (Nature conservancy 1997, Bryant et. al 1998, Margoluis and Salafsky 1998). Moreover, there are few if any standardized and cost-effective methods for defining and measuring conservation success so that different projects can be assessed over time or compared to other projects in different ecological and socioeconomic contexts (Salafsky and Margoluis 1999). To address this problem, Salafsky and Margoluis 1999 developed an approach which they called the **"threat reduction assessment" (TRA)** that measures project outcome and proposed to calculate what they called a **"threat reduction index" (TRI)**.

5.1 Definition and assumptions

The TRA approach to measuring project success seeks to identify threats not only in order to design projects, but to monitor them as well. In other words, instead of merely monitoring the target condition, the TRA approach monitors the threats themselves as a proxy measurement of conservation success. Assessment of the progress in reducing threats pro- vides a framework for measuring conservation success.

The core principle behind TRA is that if a project team can identify the threats to the biodiversity of a region, then the team can assess its progress in achieving conservation by measuring the degree to which these threats are reduced (Margoluis & Salafsky 1998). The TRA approach to measuring project success is based on three key assumptions. First, all biodiversity destruction is human-induced. Loss of species or habitats due to natural processes such as fires or hurricanes is not considered a threat to biodiversity. Human-induced increases in the magnitude or frequency of catastrophic events, however, can be considered threats. Second, all threats to biodiversity at a given site can be identified, distinguished from one another, and ranked in terms of their scale and intensity of impact and their urgency. At any given point in time, project teams can determine all the direct threats to biodiversity that exist at the project site. The teams can also separate the effects of different threats and can rank them in terms of their magnitude, degree of impact, and timing. Third, changes in all threats can be measured or at least estimated.

The TR index is designed to identify threats, rank them according to their relative importance, assess progress in meeting each of them, and then pool the information to obtain an estimation of actual threat reduction as a percentage of total potential threat reduction so that meaningful comparisons can be made across different projects.

The TRA approach to measuring conservation success is not without its limitations. In particular, it is not a completely direct and precise measurement of the state of the biodiversity at a project site. It is, however, a practical and cost-effective method for getting a sense of whether or not a project is meeting its conservation goals. In particular, the TRA approach can overcome many of the constraints that are currently keeping project teams from doing any monitoring of the success of their efforts. The TRA also has the potential to make the data from this monitoring available to the people who are making decisions about conservation at the site-the project teams and community members.

5.2 Implementing the TRA approach

The procedure involves seven steps (Table 5). The TRA is best used as a pre-test/post-test non-experimental design, so steps 1-4 should ideally be done at the start of the project to create a baseline data set. If necessary, however, these steps can be done retrospectively during the assessment period as a "historical prospective study" (Mausner & Bahn 1974). In this case, the key is to think back in time to the start of the assessment period and complete these steps based only on knowledge that was available to the team at that time.

(1) Define the project area spatially and temporally. In conjunction with the project team, determine the exact area in which the project will take place and the start and end dates for the assessment period. In particular, it is important to define the specific biodiversity that the project is targeting for conservation. The biodiversity should be defined in terms of habitat, species and/or communities.

(2) Develop a list of all direct threats to the biodiversity at the project site present at the start date. Direct threats (Table 5, column 1) are those that immediately affect the biodiversity of the site. Indirect threats (e.g., poverty) are those that cause direct threats (e.g., logging) and should not be included in the list. For each threat identified, it is also necessary to define what completely (100%) meeting this threat will entail (outlined in the footnotes of Table 5).

(3) Rank each threat based on three criteria: area, intensity, and urgency. Area refers to the percentage of the habitat(s) in the site that the threat will affect: will it affect all of the habitat(s) at the site or just a small part? Intensity refers to the impact of the threat on a smaller scale: within the overall area, will the threat completely destroy the habitat(s) or will it cause only minor changes? Urgency refers to the immediacy of the threat: will the threat occur tomorrow or in 25 years? Count the total number of threats and assign this number (n) to the highest-ranking threat in each category (Table 5, columns 2-4). For example, if there are five threats and "subsistence hunting" is the most serious threat, then its rank is five. Assign the next highest-ranked threat in each category the score n - 1. Continue ranking the threats until you get to 1, which is assigned to the lowest ranked threat. It is often helpful to write all the threats on separate slips of paper, which can then be moved up or down relative to one another to create the rankings.

(4) Add up the score across the three criteria Add the three rankings for each threat together to get the total ranking (Table 5, column 5).

(5) Determine the degree to which each threat has been met. At the end date of the assessment period, work with the project team to determine the degree to which each threat has been met, based on definition of 100% threat reduction devised in step 2. These assessments can be made either quantitatively (e.g., area of forest that has not been clearcut by logging firms or reduction in numbers of animals hunted) or qualitatively (e.g., ranking of intensity of clearing for agriculture on a scale of 1-5 or assessing local expert opinion on the level of hunting), depending on the type of threat and the data available. In either case, the reduction in threat should be expressed as the percent change in the original threat identified at the start of the project (Table 5, column 6).

(6) Calculate the raw score for each threat. Multiply the total ranking by the percentage calculated in step 5 to get the raw score for each threat (Table 5, column 7).

(7) Calculate the final threat reduction index score. Add up the raw scores for all threats, divide by the sum of the total rankings (e.g., 45 in Table 5), and multiply by 100 to get the final threat reduction assessment index for the project (Table 5, last column).

The two most difficult parts of this procedure lie in identifying all the threats to biodiversity at the site and in evaluating the extent to which each threat has been addressed. Identifying the threats can best be accomplished during the project design phase (Margoluis & Salafsky 1998). The key is to identify all the important threats but not try to include every conceivable threat no matter how remote. As an absurd case, we point out to teams we work with that a project can inflate its TRA index by declaring "invasions by Martians" as the most critical threat and then claiming success in meeting this threat when no Martians have appeared by the end of the evaluation period. This "index padding" will not help the project achieve its conservation goals.

5.3 Example of the TRA approach

The Research and Conservation Foundation has been working with the Wildlife Conservation Society to implement research tourism and handicraft enterprises with the communities of Crater Mountain Wildlife Management Area (CMWMA) in the highlands of Papua New Guinea (Biodiversity Conservation Network 1996, 1997a, 1997b). Calculation of the TRA index for one site from this project showed that there was a 30% reduction in total threats, primarily by reducing the threats posed by corporate logging and commercial mining (Table 5). A key lesson learned from this analysis is that it is generally fairly easy to define and assess success in meeting external threats such as corporate logging or mining because either the firms are operating in the CMWMA or they are not. It is much harder, however, to define and assess success in meeting internal threats such as over- hunting of animal populations or expansion of subsistence food gardens, especially if the information for evaluating the threat comes only from local people.

Table 6 Sample calculation of threat reduction assessment (TRA) index based on data drawn from an interview with field staff about the Haia site (1994-1997 assessment period) at the Crater Mountain Wildlife Management Area Project in Papua New Guinea.[a]

Direct threat[b]	Area ranking	Intensity ranking	Urgency ranking	Total ranking	Threat met (%)	Raw score	TRA index
Hunting (subsistence)	5	3	4	12	15	1.08	
Logging (corporate)	2	5	1	8	50	4.0	
Expansion of gardens	4	1	5	10	5	0.5	
Hunting (market)	3	2	3	8	0	0.0	
Mining (commercial)	1	4	2	7	100	7.0	
Total	15	15	15	45		13.3	30%

- [a] See text for an explanation of column headings.
- [b] **Hunting (subsistence),** harvesting of birds and mammals by local people for their own consumption (100% reduction involves harvesting animals on a sustainable basis through setting up and implementing hunting regulations);
- **Logging (corporate),** timber harvesting conducted by large multinational firms (100% reduction involves eliminating logging and any plans for logging in the boundaries of the wildlife management area [WMA]);
- **Expansion of gardens,** cutting primary forest to make subsistence agricultural plots (100% reduction involves eliminating expansion of gardens into areas of primary forest);
- **Hunting (market),** harvesting of selected bird and mammal species that are commercial commodities (100% reduction involves harvesting animals on a sustainable basis through setting up and implementing hunting regulations);
- **Mining (commercial),** mineral extraction conducted by large, multinational firms (100% reduction involves eliminating mining and any plans for mining in the boundaries of the WMA).

5.4 Comparing TRA and biological approaches to measuring project success

A comparison of TRA and biological approaches to measuring project success is presented in Table 6.

Table 7 Comparison between TRA and biological approaches to measuring project success*

	Criterion	TRA approach	Biological approach
Theoretical	Directness of measurements	**(-)** a proxy measurement of biodiversity	**(+)** a more direct measurement of biodiversity
	Consistency and unambiguity	**(-)** qualitative measurements can be biased (although quantifiable ones are less so)	**(+)** less subjective and thus less likely to be biased
	Sensitivity to temporal and spatial changes	**(+)** sensitive to changes in shorter (1-5 year) time periods	**(-)** difficult to measure change over short time frames, especially given natural variation
	Sensitivity to spatial changes	**(+)** sensitive to changes in entire project site	**(-)** vulnerable to bias based on choice of sampling sites
	Analytical uses	**(+)** allows direct comparisons between different types of projects	**(-)** difficult to create standardized indices across different types of projects
Practical	Ease and cost of data collection	**(+)** based on data obtained through simple biological and social techniques; Can be done by most project teams **(+)** data can be collected as part of routine project activities	**(-)** based on data collected through complex biological techniques; difficult for many project teams **(-)** data often must be collected outside of project activities
	Ease in interpreting data	**(+)** readily interpreted by project staff	**(-)** can be difficult to interpret, especially by project staff
	Retrofitability	**(-)** not directly linked to biodiversity per se **(+)** can be done in retrospect	**(+)** directly linked to biodiversity **(-)** requires baseline data

*Minus and plus signs indicate overall disadvantages (-) and advantages (+).

Despite the arguments in favor of the TRA approach, we are not advocating complete abandonment of the traditional biological approach to measuring project success. Instead, the TRA should be viewed as a complement to the biological approach. Wherever possible, project teams should attempt to use both approaches.

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