The ecological sustainability of tropical forest management: evaluation of the national forest management standards of Costa Rica and Nicaragua, with emphasis on the need for adaptive management

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Abstract

From a conceptual point of view, national forest management standards in Latin American countries have progressed significantly in recent years. Examples include the Costa Rican Standards and Procedures for Sustainable Forest Management and Certification, developed by the National Commission for Forest Certification and in Nicaragua, the National Institute of Forestry proposal of principles, criteria and indicators for sustainable forest management. In line with general approaches worldwide, these national standards primarily focus on the fulfillment of sound forest practice. There is comparatively little emphasis on the assessment of management outcomes or changes in key components of the eco- and social-systems that result from management impacts. Essentially, there is little emphasis on adaptive management, though arguments that management cannot be sustainable if it is not adaptive are persuasive. This study sought to contribute to the development of standards that include elements for adaptive management that define, communicate and evaluate sustainable forest management in Costa Rica and Nicaragua. Elements from the national standards and the CIFOR generic C&I template (predominantly focused on forest management outcomes) were used as a starting point. The basic research process consisted of three phases of evaluation (in-office, desk and field). The evaluations were carried out by multidisciplinary, international groups of experts in forest ecology, management and policy. This study demonstrated the value of forums and workshops that facilitate exchange between forest scientists and policymakers; the innovation and application of a practical, applicable and scientifically based methodology for developing national level C&I; and acceptance of this methodology by key players in the fields of forest management and policy. These experiences and the resulting proposals of C&I for the evaluation of ecologically sustainable forest management are expected to be used as points of reference for future development of forest policy in Costa Rica and Nicaragua, and to contribute to the overall understanding of C&I development processes in the region.
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Table 1
Three types of C&I, what they evaluate and their characteristics

C&I types	What is evaluated	Characteristics
Input	Objects or investments *e.g. management plan*	Define sound forest practice Easy to apply, measures and evaluate
Process	Intentions or actions *e.g. harvesting*	Do not measure impacts, outcomes
Outcome	State or response of the forest or social system to management impacts *e.g. biodiversity*	Identify forest management impacts Provide information for monitoring and adaptive management

Source: Prabhu et al. (1999).

1. Introduction

Global initiatives to increase the sustainability of forest management and the subsequent advances in the development of standards[2] to define, communicate and evaluate sustainable forest management (SFM) have progressed significantly in the past 10 years (Castañeda, 1999). Within this framework, Central American countries such as Guatemala, Nicaragua and Costa Rica are developing and implementing standards for forest management unit (FMU) level sustainability assessments in natural forest. Yet, in spite of the degree of ongoing activity, standards for forest management in Central America, as in many other parts of the neotropics, have not progressed much beyond the conceptual level. Once set out on paper, few national standards have been subjected to testing and validation, steps considered fundamental in establishing guidelines for forest practice and evaluation (Prabhu et al., 1996, 1999; Ghazali and Simula, 1998). Furthermore, the principal focus of these initiatives has been on evaluation of management inputs and processes, with little focus on the evaluation of management results or outcomes (Table 1). These standards, therefore, place little emphasis on adaptive management, even though the argument that forest management cannot be sustainable if it is not adaptive is

persuasive (Howard and Majid, 1996; Taylor, 1996; Raison and Flinn, 2000; Table 1, Fig. 1).

We strongly believe that an increased focus on the outcomes and adaptive nature of forest management is necessary in the development of criteria and indicators (C&I) and forest policy, especially in the area of ecological sustainability. This necessity has been evident for some time. For example, after CIFOR tested and evaluated C&I from five existing sets in four locations around the world (Germany, Indonesia, Cote d'Ivoire and Brazil), they noted a clear deficiency in local level C&I that evaluate ecological responses to forest management (Prabhu et al., 1996). A proposal of ecological principles, criteria, indicators and verifiers (PCI&V)[3] was subsequently developed (Stork et al., 1997) and incorporated into the CIFOR generic template (CIFOR C&I Team, 1999), though at the time of this study, the template had not been tested or validated in the field. Another important product of CIFOR's C&I testing was the development of a first-of-its-kind set of guidelines for developing, testing and selecting C&I for sustainable forest management (Prabhu et al., 1999). These guidelines were adapted for use in the present study (Table 2).

What is the status of forest policy on sustainability assessments and C&I development in Costa Rica and Nicaragua? In Costa Rica, initiatives to create a national forest management standard

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[2] Following Lammerts van Beuren and Blom (1997) we define 'standard' as a set of principles, criteria, indicators and verifiers (PCI&V) or at least some combinations of these hierarchical levels, that serves as a tool to promote sustainable forest management, as a basis for monitoring and reporting or as a reference for assessment of actual forest management.

[3] The letters of this acronym (PCI&V) will also be used individually in the text or in different combinations, such as C&I—criteria and indicators— or I&V—indicators and verifiers.
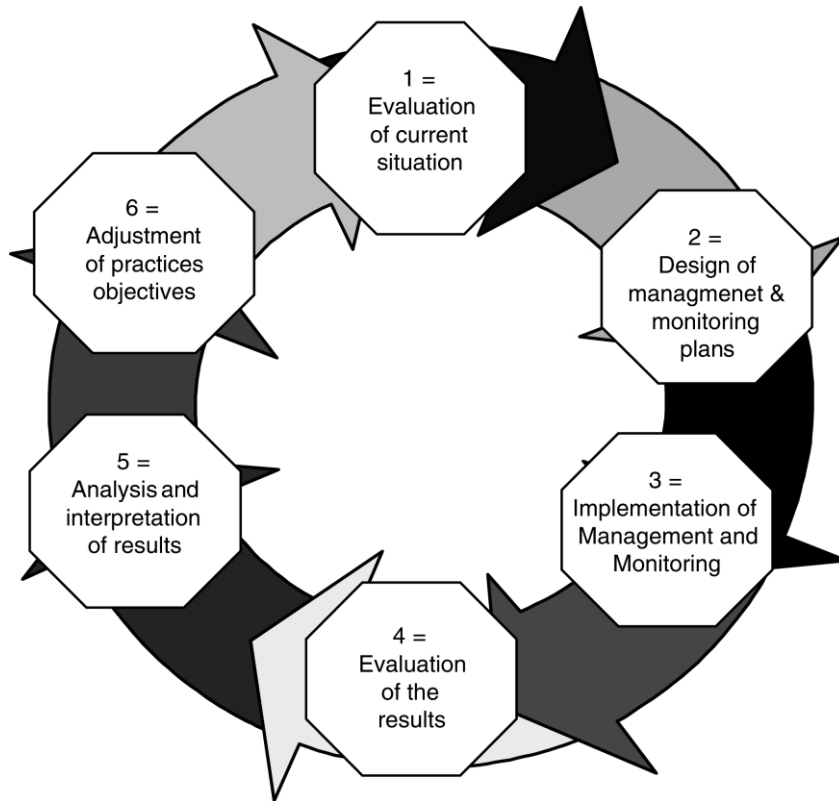
Fig. 1. Six steps of adaptive management (*Source:* Taylor, 1996).

began in 1994 with the objective of establishing an accepted and applicable mechanism for evaluation and certification of forest management at the FMU level (Campos and Müller, 1999). The national set of PC&I was developed with cooperation from the public and private sectors and is based on the Forest Stewardship Council (1999) P&C for sustainable forest management (CNCF, 1999). In Nicaragua, efforts to create a national standard for evaluating forest management have resulted in the establishment of a national set of technical norms, (INAFOR, 2000a) and a proposal of PC&I for sustainable forest management in the country (INAFOR, 2000b).

In line with the preceding comments, the principal focus of the Costa Rican PC&I, the Nicaraguan technical norms and the Nicaraguan PC&I is the evaluation of forest practice and the fulfillment of predefined standards (or best practices) for reducing management impacts. They contain little emphasis on the outcomes of forest management and neither the Costa Rican National Commission for Forest Certification (CNCF) nor the Nicaraguan National Institute of Forestry (INAFOR) PC&I had been subjected to testing or validation at the time of this study.

The present study was carried out on the premise that the integration of existing elements from the Costa Rican or Nicaraguan national standards, and elements for monitoring the ecological impacts of forest management from the CIFOR generic template, would provide the means to determine good practice as well as determine the ecological outcomes of forest management within an adaptive framework. Integration of different elements, such as C&I that evaluate forest management inputs, processes, and outcomes, from multiple sets of C&I (i.e. national standards, CIFOR C&I generic

Table 2
Important C&I attributes and their descriptions

Attributes	Description
Relevance Closely and unambiguously related logically to the assessment goal	C&I should be 'relevant' to the issues that define SFM Each I must be directly related to a C, each C must be directly related to a P, all P have SFM as their goal. PC&I fit into a hierarchical framework with horizontal and vertical consistency
Precisely defined Diagnostically specific	Simple and unambiguous wording in the definition of C&I I should provide information that allows direct interpretation
Easy to detect, record and interpret	I should be selected in such a way as to result in minimal additional costs and contribute to cost-effectiveness
Reliability	Techniques for measuring C&I should be reliable and replicable
Adequate response range to changes in levels of stress on FM, eco- or social-systems	C&I should be defined so that provide meaningful gradual change in response to system changes. A useful indicator will provide meaningful information over a wide range of changes in the system.
Provide a summary or integrative measure over space &/or time	When possible, a single I will relate a quantity of information in relation to the system and tend towards cost-effectiveness
Appealing to users	Those who apply C&I will accept them as important, practical, legitimate measures

Source: Prabhu et al. (1999).

template), is facilitated by methods for C&I development, such as those proposed by CIFOR (Prabhu et al., 1999) and Tropenbos (Lammerts van Beuren and Blom, 1997).

The overall objective of the study was to develop proposals for integrated, adaptive sets of PCI&V for the reliable and efficient evaluation of the ecological impacts of forest management in the Northern and Atlantic regions of Costa Rica and the Southern Atlantic region of Nicaragua. The forests in these areas represent valuable timber, non-timber, biodiversity, water, soil, recreational and other forest resources, yet, they are under continuous pressure from illegal harvesting practices and demands for land for settlement and agriculture (Campos and Müller, 1999). The study was designed to contribute to the development of tools for assessing the sustainability of forest management, and its impacts on forest production and the associated ecological and socioeconomic functions of the forest system. We believe that it represents one of the first neotropical initiatives to go beyond generic regional or national sets of PC&I and focus on the development of PCI&V for the forests of a defined region in a context of accessible and available scientific and technical

information. Results from this process are expected to contribute to advances in sustainable management practices in Costa Rica and Nicaragua, strengthen institutional capacity in the control and monitoring of forestry activities, encourage increased dialogue between forest researchers and policymakers and improve the understanding of, as well as advance the experience with, processes for developing national and local level PCI&V for sustainability evaluations of natural tropical forest management, using existing or generic C&I sets as a starting point.

2. Methods

2.1. General

The study was first carried out in Costa Rica, then in Nicaragua. It encompassed three phases of evaluation in both countries. The methodology was based on modifications of the CIFOR proposal for developing, testing and selecting criteria and indicators for sustainable forest management (Prabhu et al., 1999) and the Tropenbos hierarchical

framework (Lammerts van Beuren and Blom, 1997).[4]

2.2. Phase 1: initial evaluation

The study began with the selection of a multi-disciplinary group of national and international experts in forest ecology and management. An expert group carries out the evaluations and lends credibility to the results and final integrated, adaptive set of PCI&V in each country (Mendoza et al., 1999). According to Mendoza et al. (1999), the strength of the expert group evaluations depends on the experts' combined knowledge and experience in the field of study. Four experts in forest management and three in forest ecology were selected to participate in the Costa Rican study, and three experts in management and three in ecology participated in the expert group in Nicaragua.

Once selected, the expert groups were provided with the initial set of elements that would serve as the starting point for the development of the integrated, adaptive standard. In Costa Rica, the initial set of elements consisted of PC&I from the CNCF standard (CNCF, 1999) and CI&V from the CIFOR C&I Generic Template. In Nicaragua, the initial set consisted of PC&I from the INAFOR proposal (INAFOR, 2000b), elements from the national set of technical norms (INAFOR, 2000a) and CI&V from the CIFOR Template (CIFOR C&I Team, 1999). In office, the expert group members reviewed the initial set of elements, documentation on the research process, and a draft manual documenting the justification and scientific basis for the initial set of PCI&V (Delgado and Finegan, in preparation). Then, the expert evaluated each element from the initial set in respect to its relation to the assessment goal of ecologically sustainable forest management. The objective of this office evaluation was to facilitate the experts' familiarization with the initial set of elements before the second phase of evaluation. The results were used as an early indication of each element's strength in relation to the evaluation of ecological

sustainability, but were not used to eliminate any element from the initial set.

2.3. Phase 2: application and evaluation in the field

The second phase of evaluation consisted of a multidisciplinary application and evaluation of the initial set of elements in the field. Phase 2 initiated with the selection of a site representative of general FMU conditions in the region of study. Once selected, sampling plots proposed by CATIE (Delgado and Finegan, in preparation) for the application of the CIFOR I&V for monitoring forest management impacts were established at the field site in preparation for a 4-day workshop.

At the start of the workshop, the expert group members completed a desk evaluation in which all elements of the initial set were scored (scale 1, very low to 5, very high) according to four attributes, e.g. were they (i) related to the assessment goal, (ii) useful for the evaluation of ecological sustainability, (iii) defined precisely and (iv) understandable. The results of these evaluations were tabulated to determine the element's average score for each attribute, as well as determine its overall average score. These scores were then used to indicate which elements were better or less suited for the final set of PCI&V based on higher or lower overall average scores, respectively.

Elements which received mid-range overall scores were more closely examined. Those with higher scores for 'relation to the assessment goal' and 'useful for the evaluation of ecological sustainability', and lower scores for 'defined precisely' and 'understandable', were considered possibilities for the final set based on their potential for modification or improvement. On the other hand, elements receiving mid-range overall scores but lower scores for 'relation to the assessment goal' and 'useful for the evaluation of ecological sustainability' were considered inadequate for the final set due to their conceptual weakness. After discussing each element's score, the expert group decided to retain it for further evaluation or reject it based on the desk evaluation results. The Phase 2 desk evaluation served as the first filter of the initial set of elements.

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[4] See McGinley and Finegan (2001, 2002) for a more detailed description of the methodology.

Table 3
Important attributes for elements evaluated in the field and their descriptions

Attributes	Description
Informative	Provides information related to the assessment goal
Measurable	Provides quantifiable information
Available	Encompasses information easy to detect and record
Reliable	Provides replicable information
Efficient	The cost to collect the information is justified by its importance
Robust[*]	Reflects the changes in the eco- or social-system

[*] Applies only to elements that evaluate the outcomes of or responses to forest operations.

After the desk evaluation, the expert group was divided into task-oriented teams of 2–3 people, responsible for the evaluation of specific elements associated with their areas of expertise. The teams carried out desk and field exercises related to the application of the initial set of elements. In the field exercises, teams used the sampling protocols proposed by CATIE (Delgado and Finegan, in preparation) for the application of the CIFOR elements. Evaluation scores and final recommendations to accept (without need for modification), modify (and subsequently recommend for the final set) or reject the evaluated elements were based on their actual application, bibliographic references, interviews with key players (i.e. forest manager, forest workers, etc.), and team and group discussions.

The second evaluation only examined applicable elements (I, V and technical norms), scoring them on a scale of 1–5 for six attributes: informative, measurable, available, reliable, efficient and robust (Table 3). Results from these evaluations were tabulated to determine the overall average score for each element based on the attribute scores. The overall average scores, and the team observations and recommendations were then presented to the entire expert group. Following discussion, the group reached the final recommendation to accept, modify or reject each evaluated element. This evaluation resulted in the second filter for the I, V and technical norms from the initial set. Finally, there was a group discussion to accept or modify the higher level elements (P&C) which passed through the first filter (the Phase 2 desk evaluation). At the end of the Phase 2 workshop, the recommended elements served as the basis for the first draft of the integrated, adaptive set of PCI&V for evaluating ecological sustainability.

2.4. Phase 3: final workshop

At the beginning of the third and final phase of evaluation, the coordinating group analyzed and reviewed the recommended elements from the first two phases of evaluation in terms of redundancy, inconsistency, incoherence and gaps. When inconsistency was detected the elements were modified or reworded following the definitions for PCI&V established by Lammerts van Beuren and Blom (1997). Redundancies and incoherence were eliminated, and gaps were noted for discussion in the final workshop. The coordinating group then formulated a first draft integrated, adaptive set of PCI&V.

Subsequently, a final workshop and meeting of experts was held with members of the original expert group, as well as other experts in forest ecology, management and policy. The experts carried out a detailed bottom-up analysis (starting with lower level elements (I&V)) of the first draft of integrated PCI&V. The objective of this analysis was to improve weaker elements, to provide suggestions for filling gaps and to reach group consensus on the hierarchy and individual PCI&V. Results were incorporated into the first draft and a final, integrated, adaptive set of PCI&V was proposed.

3. Results and discussion

3.1. Costa Rica and Nicaragua evaluation results

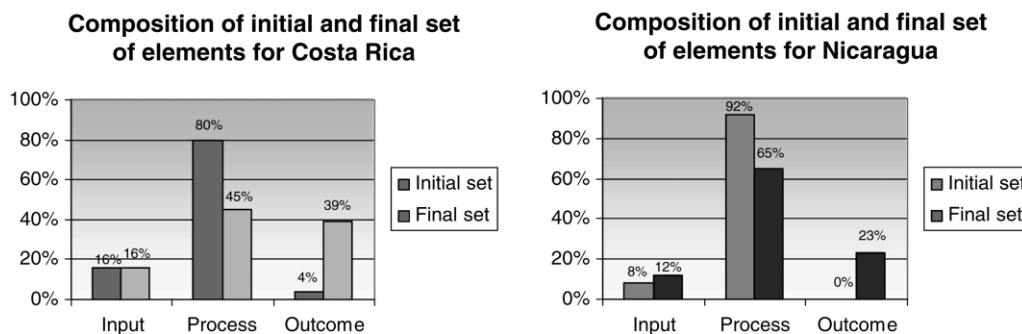Once the coordinating group classified the initial and final set of elements according to input,

Fig. 2. Composition of initial and final C&I sets for Costa Rica and Nicaragua according to the percentage of elements that evaluate forest management inputs, processes and outcomes.

process or outcome, their distribution was analyzed. It should be noted that this classification was found to be somewhat ambiguous in certain cases. Examples include CNCF indicator I8.1.4 regarding vegetative monitoring that does not indicate how the information should be used to determine management outcomes or how to apply it to adaptive management. For this study, CNCF I8.1.4 was classified as process. Another example is CNCF I6.3.11, which calls for minimal impacts on runoff, soil and water resources to be determined by predefined limits such as maximum gap area. Although these limits could be considered norms, for the purposes of this study the indicator was classified as outcome.

Of the initial C&I taken from the Costa Rican Standards and Procedures for Sustainable Forest Management and Certification (CNCF, 1999), 16% address the evaluation of management inputs, 80% are for evaluating processes and 4% are for the evaluation of management outcomes (Fig. 2). Of the initial elements taken from the INAFOR Proposal of PC&I for SFM (INAFOR, 2000b) and the technical norms and administrative dispositions for forest management (INAFOR, 2000a), 8% are for evaluating management inputs and 92% for processes. No elements existed for the evaluation of management outcomes in either INAFOR document. In the final integrated set of PCI&V for Costa Rica, 16% of the elements are for the evaluation of management inputs, 45% for processes and 39% for management outcomes. In Nicaragua, the final set of PCI&V consisted of

12% input type elements, 65% process and 23% outcome.

Almost half of the recommended Costa Rican I&V required modification for the final set. Only 7.5% of the initial I&V were accepted without need for modification, while 45% were rejected. Almost all of the accepted and modified I&V needed supplementary documentation (91%). Of the rejected I&V, one-third were recommended to be separated from the initially proposed set and incorporated into a Code of Forest Practice. The remaining I&V were rejected due to redundancy (17%), conceptual weakness (17%), poor precision in measurement (17%), and need for further research and development (17%).

In Nicaragua, 41% of the initial I, V and technical norms required modification before recommendation, and equal parts were accepted (without need for modification) and rejected for the final set (29.5%). In most cases, rejection of elements was due to redundancy (45%). Other reasons for rejection were conceptual or scientific weakness (21%), lack of applicability or relevance to the region (21%), application at the national level rather than that of the FMU (7%), incoherence (poor hierarchical placement) (3%) and inefficiency in application (3%).

3.2. General recommendations for the development and application of a national forest management standard

In discussions and observations during the evaluation process in Costa Rica and Nicaragua, the

expert group members stressed the need for instruction manuals for the application of the national forest management standards (such a manual has now been prepared by CATIE for Costa Rica, under contract to the CNCF) and Codes of Forest Practice. Considering the present status of forest management in the region and the lack of consistency in applied SFM, Codes of Forest Practice would serve as a guide for forest management operations, monitoring and control. These should be developed and used as a complementary document to the national standard for forest management.

The expert groups noted that the implementation of an integrated, adaptive standard would require additional information, such as up-to-date lists of threatened and endangered species. They also stressed the need to classify forest types, based on compositional criteria relevant to forest management, which would provide the information necessary to establish sustainable forest practices appropriate to local conditions, as well as reference data for monitoring. Managers and practitioners of research in forests of our study area should take note that these recommendations were made in spite of the large amount of information they have already generated.

The groups emphasized the need for considerable collaboration between key players in the forestry sector for the implementation and assessment of the integrated sets of PCI&V. They concurred that state regents (forestry professionals recognized and reporting to the State Forestry Administration and responsible for the sound and effective execution of approved forest management plans) should be primarily responsible for the collection, management and analysis of data related to C&I that evaluate management inputs and processes. The groups agreed that regarding C&I that evaluate forest management outcomes, regents would be primarily responsible for the collection and management of associated data, and that forest research institutions should play a significant role in the data analysis and assessment. The group also noted that other entities such as the State Forestry Administration (responsible for activities such as the approval of management plans, establishment of forest management guidelines, coordination of

the forestry sector); accredited certifiers; and forest managers, operators and owners would also play a role and provide support in relation to data collection, management and assessment.

Excerpts from the final proposals for integrated, adaptive sets of PCI&V for Costa Rica and Nicaragua are presented in Table 4. In both sets, means for evaluating sound management practices, primarily derived from the national sets, are complemented by methods for monitoring the changes and outcomes in the forest system through the recommended CIFOR I&V. The development of input and process elements was greatly facilitated by their predominance in the existing standards and familiarity with their application and assessment. The acceptance and integration of the less common outcome elements was greatly facilitated by their application in the field and familiarization during this study. The resulting sets of PCI&V are expected to work as tools through which conformity with best practice, as well as an element of adaptive forest management, and continuous learning can all be achieved. These integrated sets are proposed for the evaluation of ecological sustainability, and should be adapted and updated in association with changes in local environmental, social and political conditions. It should be noted that the proposal of the final Costa Rican set of PCI&V assumes the establishment of a Code of Forest Practice and the development of the recommended, supplementary documentation.

4. Conclusions and recommendations

The development of these local level C&I sets for the evaluation of forest management incorporated field and desk applications and evaluations, and involved multidisciplinary groups of experts. These methods created a medium for exchange between experts in different disciplines (e.g. researchers, policymakers, practitioners) and worked to build bridges for sharing and understanding new information and knowledge, all for the benefit of national forest policy.

Standards for assessing the sustainability of forest ecosystems are often based on predefined approaches to reduced-impact forest management, with little, if any regard for the sometimes unpre-

Table 4
Examples of elements from the integrated, adaptive sets of PCI&V proposed for the evaluation of ecological sustainability in the Northern and Atlantic regions of Costa Rica, and in the Southern Atlantic region of Nicaragua

	No.		Original source
Costa Rica			
P	P6	Management Impact: Forest management will promote the conservation of biological diversity and its associated water and soil resources, and by so doing, will maintain the ecological functions, integrity and environmental services of the forest	CNCF (1999)
C	6.2	Rare, threatened and endangered forest species and their habitats are protected. Hunting, capturing and collecting of plant and animal species are controlled	CNCF (1999)
I	6.2.1	Measures exist for the protection of rare, threatened, and endangered tree species, as well as those whose harvesting is restricted or prohibited, and for the protection of the characteristics of their habitats. Their location in the field and their identifying numbers correspond with the map of tree location	CNCF (1999)
I	6.2.2	Measures exist to control hunting, capture and collection of plant and animal species	CNCF (1999)
P	P8	Monitoring and Evaluation: Forest condition, forest product yield, chain of custody and the social and environmental impacts of management activities will be monitored and evaluated in ways appropriate to the scale of forest management	CNCF (1999)
C	8.1	The management plan includes a monitoring plan that allows the determination of the impact of management operations, and this plan is executed	CNCF (1999)
I	8.1.4	Changes in the diversity of selected groups are monitored to determine their direction, magnitude and importance, and the need to take corrective measures	CIFOR C&I Team (1999)
V	8.1.4.1	The diversity of selected indicator groups of butterflies	CIFOR C&I Team (1999)
V	8.1.4.2	The diversity and species composition of select indicator species of the dung beetle guild (Scarabaeinae)	Aguilar-Amuchastegui et al. (2000)
Nicaragua			
P	P1	Sound forest management is compatible with the long-term conservation, protection and productivity of the ecosystem	INAFOR (2000a) INAFOR (2000b)
C	1.1	Sound planning of forest management and operations exist	INAFOR (2000a) INAFOR (2000b)
I	1.1.10	Stratification of the managed forest is carried out with the objective of determining areas for production, protection and conservation	INAFOR (2000a) INAFOR (2000b)
I	1.1.13	All inventoried forest species are classified according to their forest use: commercial, potentially commercial, no commercial value, protected, endangered, threatened and scarce	INAFOR (2000a) INAFOR (2000b)
C	1.4	Changes produced in the ecosystem by forest management operations are evaluated	INAFOR (2000a) INAFOR (2000b)
I	1.4.2	Changes in the diversity of habitats as a result of human interventions are monitored to determine their direction, magnitude and importance, and the necessity to take corrective actions	CIFOR C&I Team (1999)
V	1.4.2.1	The vertical structure of the forest	CIFOR C&I Team (1999)
V	1.4.2.2	Class size distribution	CIFOR C&I Team (1999)
I	1.4.7	Results from monitoring and evaluation are used to improve the management system	INAFOR (2000a) INAFOR (2000b)

dictable responses of ecosystem components. While predefined standards for reduced impact are essential, many recognize that reducing negative impacts does not necessarily guarantee sustainability. And although CI&V that evaluate system responses to forest management operations often involve an increased investment of time, training, costs and multi-institutional participation, they are essential in assessing and monitoring sustainability. If forest management standards are to be useful in providing important information about the sustainability of forest management and indicate where adaptations or improvements can be made, they should move towards an evaluation of the outcomes of forest management, in addition to the inputs and processes. C&I sets that evaluate the state of the eco- or social-system, the stresses that act upon them, and the system responses will provide a valuable overall understanding of the sustainability of forest management operations. An encouraging result of the present study was the acceptance and recommendation of outcome and response elements, indicating that key players in forest policy development and implementation in Costa Rica and Nicaragua are supportive of the concept of adaptive forest management.

The integrated, adaptive sets of PCI&V that resulted from this study are expected to be used at least as points of reference in the future development forest policy in Costa Rica and Nicaragua. What's more, implementation of the research presented here has also contributed to regional experience in C&I development processes.

Acknowledgments

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