Landscape Ecol Eng (2005) 1: 221–228
DOI 10.1007/s11355-005-0018-9

REPORT

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A guideline for ecological risk management procedures

Received: 8 July 2005 / Accepted: 11 July 2005 / Published online: 28 October 2005

Abstract A practical guideline for community-level ecological risk management is proposed, with particular emphasis on the mutual interdependencies of the scientific analysis, public consensus building, and an adaptive management. The procedure we recommend spans the screening of potential ecological risks, the involvement of related stakeholders, the conceptual development from the "undesired event" over assessment endpoints to measures of effect and stress factors, the risk assessment for the no-action case, the planning phase from the public decision to become active and the setting of goals over a specification of monitoring and control methods to an assessment of feasibility and a public approval of the management plan and finally the adaptive management from initiation over continued monitoring to revisions of the plan, if required. The procedure contains several checkpoints, alternative routes, and possibilities to correct previous decisions.

Introduction

The Millennium Ecosystem Assessment (2005) stresses the importance of involving local citizens and stakeholders in ecosystem management with the goal of environmental sustainability. Many have pointed this out before—just recall the slogan "Think globally, act locally!", which has often been used in the context of environmental issues. But technical, organizational, and political barriers can stand in the way of local involvement; in particular if future developments, without intervention or in reaction to conceivable measures, are inherently unclear, i.e., if the management involves ecological risks and has to deal with scientific and public uncertainties.

To develop a framework of ecological and biological risk management, the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) selected Yokohama National University for a twenty-first century Center of Excellence (COE) Program with intensive support for a 5-year program during the fiscal years 2002–2006. Our COE program "Environmental Risk Management for Bio/Eco-Systems" is designed to collect and evaluate environmental risk information by focusing on East Asia, including Japan. As part of this work, we had intense discussions about the theory and methodology of ecological risk management with all faculties, fellows, students, and colleagues of our COE program.

In this article, we synthesize theoretical considerations and practical experiences with local ecological risk-management projects in which we participated, to a general framework. We pay particular attention to those aspects that may be unclear to researchers interested in initializing and leading local ecological risk-management projects, not least to encourage more active involvement of the scientific community. In the form of a practical guideline this work describes step-by-step how a project can be led from the observation of a problem to a successful solution involving the local community.

The Ecological Society of Japan (ESJ) published a "Guideline for nature restoration projects" (Matsuda et al. 2005), which also addressed the problem of general ecosystem management. The idea of risk management, however, was not fully included in this guideline, despite the principal acknowledgment of uncertainties. The guideline presented in this paper corresponds well with the guideline of the ESJ.

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The methodology to deal with the inherent difficulties of ecological risk management has many points in common with ecosystem management (Christensen et al. 1996). Briefly, it can be described like this (see Fig. 1): Before the *decision about the necessity and purpose of a management* (step 8), a *risk assessment for the no-action case* (step 7) should be undertaken. However, for a meaningful risk assessment a *description of the ''undesired event''* (step 4), an *enumeration of measures of effect* (step 5), and an *analysis of stress factors by modeling* (step 6) are indispensable. Even when a management has been enacted, its success is not certain. Therefore an *assessment of the feasibility of goals* (step 12) has to be done. Steps 9–12 constitute a risk assessment for the management case. Furthermore, a scientific proposal for the measures and goals of management has to be developed; and they have to obtain the consent of the community.

Anyhow, the flow chart displayed in Fig. 1 is only a basic outline. In practice, the plan and its execution have to be adjusted flexibly to the actual circumstances. But it is clear that at least four tasks have to be distinguished: first, getting the relevant stake holders involved, then attaining a basic scientific understanding of the problem, reaching agreement on a risk management plan, and finally implementing the plan, which may, depending on monitoring results, require adjusting targets and methods. As the following, detailed description shows, these tasks are connected by a system of feed-back loops and decision points.

Initial steps

The public or scientists become aware of a risk or actual damage (steps 0–1)

This is our starting point: awareness of a potential risk has risen to a degree that it becomes an issue. There are many ways a problem can be brought up. Public claims or scientific findings might have drawn attention to the problem.

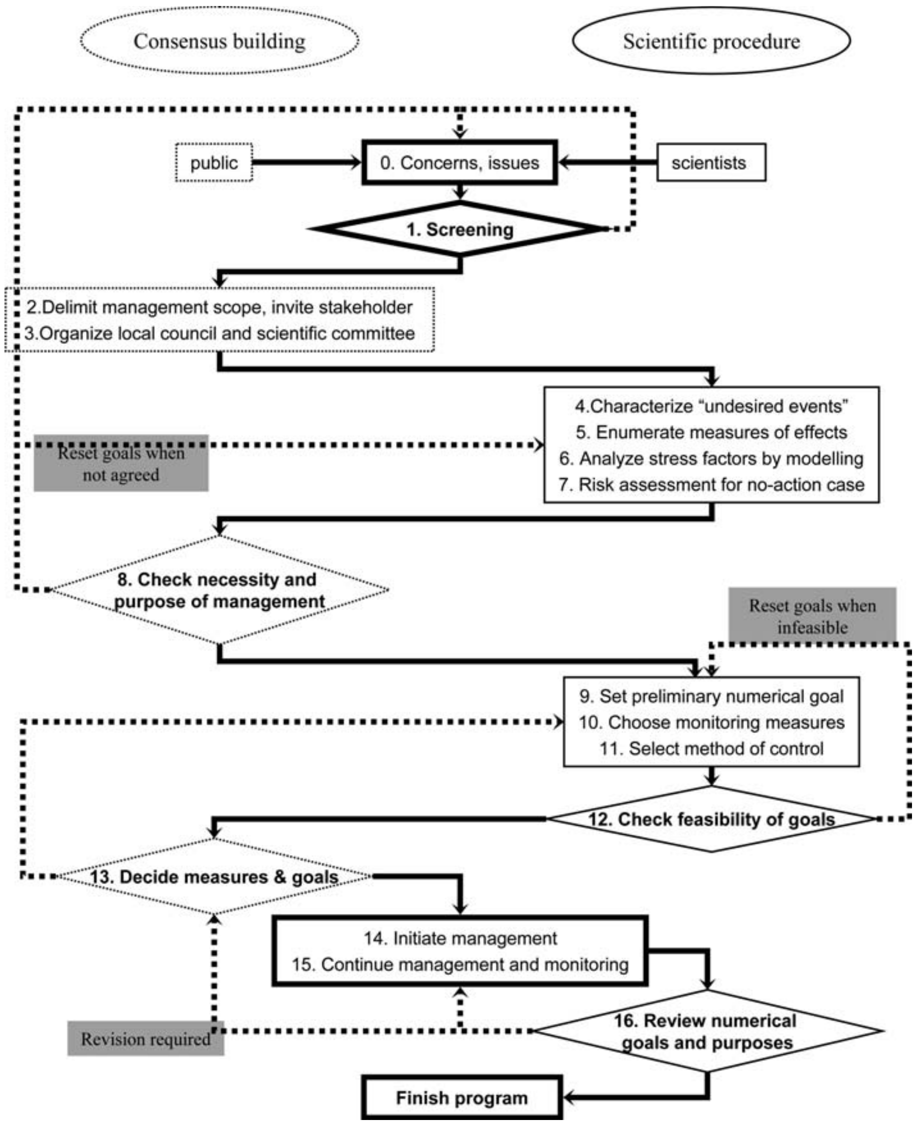

Fig. 1 Flow diagram for ecological risk management

For example, the risk posed by growing populations of sika deer *Cervus nippon* to forestry and agriculture in Hokkaido, Japan (Matsuda et al. 2002), has been noticed by the stakeholders themselves, but the detrimental effects that DDT and other chlorinated hydrocarbon pesticides had on songbird populations throughout the United States became a public issue only after it had been pointed out by a scientist (Carson 1962).

Often, the occurrence of a large accident—or a small accident pointing to the possibility of a larger one—can become an occasion to start thinking about counter-measures. In any case, the power of the public media is very important here. But not all issues discussed in public will become the target of risk management. Sometimes it turns out after a preliminary risk assessment that no particular counter-measures are required. This is called *screening*.

Delineation of management scope and invitation of stakeholders (step 2)

In order to determine who are the relevant stakeholders related to the risk, the next step is to decide the scope of the management. Knowledge of environmental interactions and an understanding of the inherent openness of environmental systems is important here. The inclusion of all stakeholders relevant for building a consensus should be attempted. Seeing the full range of stakeholders involved now is crucial. Inclusion of other stakeholders later can become difficult if they oppose decisions already agreed upon. However, the wider the scope, the more difficult a practical solution of the problem might become.

To make sure that all parties have a chance to participate, it is important to disperse information regarding planned activities as early as possible. Being careful at this point is important in order to avoid having to reiterate the consensus building process and to develop trust-based relationships (Levin 1999). Only if there is no reason to expect a major conflict of interests between stakeholders, might it not be necessary to handle the decision process as careful as we recommend here.

Formation of management council and scientific committee (step 3)

As the next step, an assembly of public representatives of the stakeholders (hereafter *management council*) should constitute itself and a scientific advisory committee (hereafter *scientific committee*) approved by the management council should be formed (Ministry of the Environment of Japan 2005).

When inviting participation at the first meeting of the management council, the purpose of the management project should be specified. Stakeholders, related administrative organs, knowledgeable individuals, environmental groups, etc. should be invited, in order to guarantee a fair chance for everybody to participate (e.g., Ministry of the Environment of Japan 2005).

The duties of the management council include drafting the management plan, accepting or rejecting it, verifying its success, amending it if required, and answering to outsiders for its decisions. The decisions of the management council should follow the Unanimity Principle. The council should have written rules of internal procedure, e.g., guaranteeing the freedom of speech for all council members, specifying the conditions for approval of important decisions, or the right to have reservations recorded in the minutes. The minutes of the management council and the scientific committee must be made public, and important data and documents generally as well. By using the Internet or other media, it becomes easier for interested persons to follow the procedures. It is important to use these possibilities of information disclosure and open discussion to guarantee the transparency of the process. All these measures have the purpose of paving the road to smooth enactment of a management plan.

Basic scientific understanding and risk assessment

Description of the undesired event (step 4)

To give an appropriate scientific definition of a risk, we have to describe an underlying undesired event first. In the simplest case, the undesired event itself is sharply specified and it can be the basis for the scientific description and analysis of risk and risk management. It is then identical with the *assessment endpoint*. But often the situation is more complex.

Conservation of biodiversity and ecosystem integrity is generally one of the purposes of ecosystem management. The goal of biodiversity conservation was codified in the Convention of Biological Diversity (CBD) of 1992. Undesired events thus include extinction of species or some regional population, or a decline in primary production or other indicators of ecosystem functions. Resilience of ecosystem processes is another important aspect of ecosystem integrity. However, ecological risk management is not a single task but a balance between multiple purposes, e.g., a balance between nature conservation and economical cost (Oka et al. 2001), between marine reserves and sustainable fisheries (Makino and Matsuda 2005), or between the safety of residents and the persistence of endangered bears (Mano 1998, 2003). Other characteristics of biodiversity and ecosystem integrity should also be considered.

Thus, the undesired event is not simply given by the issues that have been raised in the public. For example, when deer populations increase and start to eat the crops from the fields or to tear off the bark of trees in the forest, this damage becomes a problem for farming and agriculture. However, deer are a part of the ecosystem and the simple measure of killing all deer is not acceptable. Synthetic solutions have to be sought which take the perspectives of both science and the general public into account.

In the case of nature conservation, it is sometimes unclear whether the undesired event has occurred or not. This may be, for example, simply because "loss of biodiversity" is an ambiguous concept. It is therefore better to consider the extinction of a local population of a threatened species as an assessment endpoint. The assessment endpoint is then an event representative for the less specific undesired event.

The description of the undesired event will form the basis for the management council's decision on the necessity of a management plan and also for a judgement of the plan's ultimate success. In the presence of probabilistic risks, it is therefore necessary to find a definition which allows an empirical verification.

The choice of the assessment endpoints might influence the structure of the corresponding management plan. Various combinations of endpoints should therefore be taken into consideration.

Enumeration of measures of effect (step 5)

For a systematic analysis of the risk-management problem, objective, quantitative characterizations of the degree to which the assessment endpoint is reached have to be introduced. These characterizations are called *measures of effect*. In order to allow a comparison between the theoretical analysis and empirical observations, preference should be given to measures of effect that are directly observable, i.e., for which a well specified sampling or measurement procedure exists. Measures of effect are used for modeling the problem and for the characterization of risks (Risk assessment for no-action case (step 7)); and their continuous measurement (*monitoring*) forms the basis for the verification and possible adjustment of the management plan in the future.

Analysis of stress factors by modelling (step 6)

There are several factors that can lead to the undesired event. Such factors are called *stress factors*. For example, illegal exploitation and habitat loss caused by land development are stress factors for species extinction. Other examples are overfishing, bycatch, environmental pollution, or exotic species.

In order to be able to predict how stress factors affect the measures of effect, it is necessary to develop deterministic or stochastic models of these interactions. Very simple models are often sufficient for quantitative descriptions of the main effects (e.g., Matsuda et al. 2002; F. Koike, unpublished; Amemiya et al. 2005; Morino and Koike 2005). Such models can also be used to obtain quantitative measures for the uncertainties of predictions, including stochastic effects and the sensitivity to poorly known parameters. General methods to handle complex systems should also be taken into consideration.

Among the stress factors, there may be some that cannot be controlled by the management. For these factors, plausible *scenarios* should be developed. The scenarios should be made explicit in the interpretation of model results.

Risk assessment for no-action case (step 7)

Using the model, a risk assessment for the no-action case (i.e., no management plan is enacted) can be performed. That is, the risk for damages by the undesired event is estimated.

Some authors have defined risk as the probability of the occurrence of an undesired event (Nakanishi 1996). We call this a *probabilistic risk*. If, for example, the assessment endpoint is the extinction of the Steller's sea-eagle (*Haliaeetus pelagicus*) population, the risk for the eagle's extinction could then be calculated from a stochastic model by determining from simulations the probability that the population goes to zero. However, in practice such simulations depend on too many uncertain assumptions and the results would often not be reliable.

One therefore introduces the notion of the *possibility* of the event characterizing the assessment endpoint, which either describes a quantitative probability as above, or some rank or order in terms of measures of effect. The categories of threatened species defined by the World Conservation Union (IUCN 2001; shown in Table 1) are a good example for such descriptions of possibility. The IUCN redlist categories are based on five criteria. Only criterion E is related to the extinction probability. In this criterion, the extinction risk is described by the probability that a species goes extinct within a specific time-period. However, few species are classified according to criterion E, because many data is needed to assess the extinction probability (Matsuda 2003). The other criteria of the IUCN redlist categories are not directly related to the extinction probability. It is easily understood that a faster population decline (Criterion A), a smaller habitat area (B), a smaller population size (D), and their combination (B) increase the possibility of extinction.

For the risk assessment, not only established methods have to be used. The method can be freely chosen, depending on the nature of the undesired event, the measures of effect, and the stress factors. But, if possible, the scientific validity of the assessment method should be verified in the future and the result of this verification should be published and be approved by the scientific committee and outside reviewers.

In ecological risk management, the undesired events are often severe and irreversible. Therefore the precautionary principle should be applied, as is codified, for example, in Principle 15 of the Rio declaration (UNCED 1992). For the risk assessment, this means that one should be careful in keeping the limitations of model simulations in mind and rely on the more conservative assumptions when in doubt.

Table 1 IUCN redlist criteria (revised 2001)

Criterion	Critical	Endangered	Vulnerable
A1 The rate of population reduction	> 90%/10 years or 3 generations	> 70%/10 years or 3 generations	> 50%/10 years or 3 generations
A2–A4 The rate of population reduction	> 80%/10 years or 3 generations	> 50%/10 years or 3 generations	> 30%/10 years or 3 generations
B1 The area of occupancy	< 10 km^2	< 500 km^2	< 2,000 km^2
B2 The extent of occurrence	< 100 km^2	< 50,00 km^2	< 20,000 km^2
C The size of decreasing population	< 250 (25% reduction/3 years or 1 generation)	< 2,500 (20% reduction/3 years or 1 generation)	< 10,000 (10% reduction/3 years or 1 generation)
D1 The size of population	< 50	< 250	< 1,000
D2 The area of occupancy	Not defined	Not defined	< 10% of a related taxon
E The risk of extinction	> 50% within 10 years or 3 generations and 100 years	> 20% within 20 years or 5 generations and 100 years	> 10% within 100 years

Since the possibility that an undesired event occurs can rarely be eliminated completely, the magnitude of the damage in the case of the occurrence of the undesired event, the *hazard*, has to be considered, too. The complete characterization of the ecological risk of an undesired event is therefore given by the combination of: (1) the possibility of the occurrence of this event, (2) its hazard, and (3) the scenario that is used in the assessment of its possibility (Kaplan and Garrick 1981; Newman et al. 2001).

Decision on necessity and purpose of management plan (step 8)

When it has become clear that there is an actual risk which has to be managed, a consensus within the community about the necessity of risk management should be sought. This should be done before starting to search for concrete solutions of the problem. After a concrete management plan has been developed and the particular advantages and disadvantages it will bring to the stakeholders are made clear, the plan might be spoiled due to the particular interests of individual groups.

When deciding the necessity of the management plan, the purpose of the plan must be specified. This specification will typically paraphrase the scientific description of the undesired event (Description of the undesired event (step 4)), but in such a form that it becomes intelligible and agreeable to as many of the parties involved as possible.

The purpose might, for example, be expressed in an abstract form such as "conservation of biological diversity". If it becomes clear later that the actual management does not fulfill this purpose, the management plan has to be corrected. Coming back to a previous example, the purpose should not be formulated simply as preventing damage to agriculture and forestry by deer, but it should be phrased in a more synthetic form which points to a solution of the problem as a whole.

At the time of deciding a concrete management plan, a consensus must be obtained once again. But the original management purpose might then take a back seat due to chances for individual advantages that some groups become aware of. Therefore, a decision regarding the necessity of the management plan, when the plan is still an abstract idea, specifies the direction in which to proceed and provides orientation later. For a constructive discussion respecting a variety of views from different stakeholders, and in order to avoid direct confrontations, it is necessary to take an attitude which seeks a solution to which as many stakeholders as possible can agree.

Reaching agreement on risk management plan

A risk can be managed by eliminating the stress factors, reducing the hazards of the undesired event, or compensating the risk with some benefit. For the case of environmental impact assessments (EIS), these three measures are defined in the guideline for environmental impact assessment released by the Ministry of the Environment of Japan in 1997. Such measures are called *mitigation*.

Thus, there are usually various options for mitigation. As we will explain below, choosing between them often involves economic, political, and moral decisions.

Decision of preliminary numerical goal (step 9)

After the management purpose is specified, a numerical goal has to be set which defines the distinction between success or failure of the management plan. This includes also a specification of the item to be monitored and the implementation of the method of monitoring. The numerical goal should relate to a specific time-interval. For example, in a plan for the recovery of southern bluefin tuna (SBT; *Thunnus maccoyii*) developed at the end of the 1980s, the agreed numerical goal was "to achieve a recovery of the SBT population to the level of 1980 by the year 2020" (CCSBT 1998). This example also shows that the numerical goal does not always have to be an absolute number of some quantity. Because the total population is itself an uncertain quantity, the numerical goal was not specified as an absolute number of SBT (e.g., 3 million adults, based on assumed catch per unit effort and temporal trends), but in a form robust to corrections in the estimated number of SBT in 1980, which might become necessary when improved estimation methods become available later.

Choice of monitoring measures (step 10)

For an adaptive management (Walters 1986), monitoring is indispensable (see also Monitoring measures of effect (step 15) below). The items that have to be monitored are given by the method of the previous risk assessment, in particular the measures of effect.

However, not for all measures of effect may a continuous monitoring be practicable. Since the set of monitored quantities strongly affects the structure of a management plan, a judicious choice is required here.

Selection of control method (step 11)

Among the stress factors, some are controllable, others are not. For some factors, the management plan might be the first time that the local society plays with the idea of taking them under control. The control method selected must allow the numerical goal to be reached.

Assessment of feasibility (step 12)

Since the management plan contains uncertainties, it is not sure that the numerical goal can always be reached: it may actually be quite difficult. That is, prior to the enforcement of the management plan, the feasibility of the target has to be assessed. This assessment includes not only an assessment of the risk of not reaching the goal, but also the social, political, and budgetary limitations to enforcement of the management plan. Constructing an operating model for the process as a whole might be helpful here. If the plan is not feasible, the specific goal has to be revised or the plan has to be modified such as to make the goal achievable.

Decision about management measures and numerical goal (step 13)

The management method, including the management plan and the numerical goal, cannot be decided solely by scientists, but must attain social consent.

The risk management often involves trade-offs between different kinds of risks. For example, the sika deer *C. nippon* feeds on *Sasa senanensis*. Recently the population of sika deer increased dramatically in Japan, thus threatening such herbs. Another example of this kind is the culling of alien species, such as the raccoon *Procyon lotor* (F. Koike, unpublished) or largemouth bass *Micropterus salmoides*, which are controversial. There can also be a trade-off between ecological risks and human health risks. Endangered brown bears sometimes attack humans. In bear management, this risk that bears attack residents and visitors has to be taken into account (Mano 1998, 2003). Even though values such as human safety and biodiversity are often thought not to be comparable, such a comparison will sometimes be implied in decisions on risk management. Thus, the scientific committee should present alternative management plans to the management council and the adopted plan should be polished by the management council, the scientific committee, and the public in open discussion.

The scientific risk assessment itself should ideally not support any value judgments. The notion of an ''undesired event'' implies a value judgment of some kind; however, the risk assessment procedure only estimates the possibility of ''undesired events'' and the magnitude of their hazards under some interim assumptions. It does not come to any normative conclusion.

Rather then offering a value judgement, the key role of scientists in risk management is to provide scientifically sound informations and analysis, and therefore to enhance consensus building between stakeholders. For example, deer management in Eastern Hokkaido has a numerical goal of 50% reduction of population size within several years by game hunting and nuisance control. Animal rights groups oppose this management. Scientists do not judge whether hunting and control are good or not. However, scientists can investigate whether population reduction by hunting is feasible or not. In the case of Hokkaido, it was found that the population size of deer in eastern Hokkaido was underestimated and concluded that the goal of a reduction by 50% was difficult to achieve (Matsuda et al. 2002).

After having reached a consensus about the management purpose, goals, and measures between the management council and the scientific committee, and before enacting the management plan, the management plan should be disclosed to the public. Not only the stakeholders, but all citizens should be given the chance to state their views. Based on the decision of the management council, a general public consensus should be sought. Ideally, the public consensus is also reached in three steps: first about the management purpose, then about management goal, and then about the complete management plan. Building up a consensus in small steps is often easier and more efficient than asking for consent only for the final result. If a consensus is difficult to reach, it can be effective to repeat the process of consensus building in smaller steps. Finding a consensus in small steps helps to build trust and to archive a cooperative atmosphere. When proceeding without public consent, there is a large possibility that the discussion at the previous step will later heat up again (Axelrod and Cohen 1999).

If reaching a consensus is still difficult, a re-examination of the management plan, including the numerical goal, is necessary. This work has to be repeated until a solution is found that is scientifically sound, technically feasible, and socially accepted.

The time it takes to reach the management goal might vary from a few days to many decades. But it is necessary to verify the level of achievement and consider a modification of the management plan in regular intervals. The fact that it might be required to re-adjust the management plan on a yearly basis should be included in the original plan by implementing appropriate feedback loops. This kind of management is called ‘‘feedback control’’. But, in order to incorporate also effects which cannot be foreseen at the time of setting up the plan, an assessment of the plan including feedback loops is recommended after a longer period (e.g., several years). The original plan should be set up such as to make this long-term assessment later possible. Thus, the full risk management consists of a monitoring strategy, a risk assessment method, a numerical goal, and an adaptive management plan to achieve this goal.

Executing the management plan

Initial phase (step 14)

At the moment when the management plan is enacted, it is important to start verifying whether the uncertain assumptions that entered the risk assessment are supported by a continuous monitoring of the system, as described below. That is, the management process itself becomes an experiment to verify the assumptions on which it is based. Depending on the results, it might become necessary to react quickly and correct the risk assessment or even the management plan. It is the responsibility of those enacting the plan to explain this possibility clearly.

For example, the intrinsic rate of population increase for minke whales is clouded by controversy. However, monitoring will give a more accurate information on the rate of increase.

Monitoring measures of effect (step 15)

Ideally, the risk management, with the underlying assumptions verified, can now proceed without alterations. But certainty is a matter of degree. With longer experience, model assumptions can be increasingly better verified. Conditions might also change in a form not anticipated, invalidating previous assumptions.

Under conditions of large uncertainties, the risk will increase substantially if the management plan is enforced without observing the results of monitoring. The risk can be decreased by taking the monitoring results into account and adjusting the plan flexibly before a serious damage occurs. We can expect that generally an adaptive management reduces the risk (Matsuda 2003). But the management should also not be so strict as to disable natural regulatory feed-back loops. The monitoring process itself should also be subject to inspections at times. It is possible that the monitoring method itself has to be revised.

While the management is enacted, it has also to be verified whether the numerical goal can be reached and is still consistent with the original purpose of the management. Even when the numerical goal is reached, if the management does not achieve the purpose it was designed for, this cannot be called a success.

Reviewing the management plan (step 16)

If, as a result of management, the situation develops in a different form than expected in the management plan, the reason for this has to be investigated, and it has to be verified whether the discrepancy is due to conditions unforeseen in the plan or is rather the result of chance. It might be required to revise the management plan. But it is essential not to interrupt monitoring or management in such a situation.

In the case of larger revisions, just as for the first plan, public consent for the new plan generally has to be sought. When public opposition can be expected, it should be clarified beforehand for which alterations of the plan public consent needs to be re-obtained.

No management plan will be valid forever. Provisions should be taken to review the plan regularly at increasing intervals. If it turns out that the goal cannot be reached, management might be suspended. It is also conceivable that stakeholders may turn their attention to other problems. If, however, the goal has been reached, one might consider setting a new, more ambitious goal. The management might also simply become a part of the normal life of the stakeholders and be actively continued for a long time.

Concluding remarks

Above, we explained the sequence of actions to be taken for successful risk management. The procedure we outlined is necessary for being prepared sufficiently to confront uncertainties and to be able to settle conflicts between stakeholders in a rational way. By distinguishing the abstract purpose, a verifiable numerical goal, and a management plan to reach the goal, and achieving consensus about each of these in three steps, proceeding to the next step only when a consensus has been reached, the realization of the management plan can proceed smoothly. In the case of serious conflicts of interest between stakeholders, in particular including businesses, it often happens that the disputes continue after a decision has been made. It might also happen that among the stakeholders some intend to block the plan. However, at the time of specifying the abstract ‘‘purpose’’, opposition is often difficult to articulate. Stakeholders might disagree without making any effort to reach a consensus.

Such unconditional disagreement, however, is much less convincing to the public than breaking consensus after a deep controversy. But even in such a situation where there is an unreasonable opposition, the remaining stakeholders can still seek an agreement. In any case, the final decision lies with the general public. A party disturbing the process in an unreasonable form will draw the criticism of the public opinion, making such opposition unlikely in the early stage. When a party refuses to a agree to a target value or a management plan after agreeing to the overall purpose, there will be a strong political pressure to suggest at least a counter-proposal. Hence we can expect all stakeholders to participate in consensus building. Counter-proposals can be analyzed by the scientific committee for their feasibility or potential problems, and can then be discussed based on these results. If a plan that the scientific committee found problematic is enacted and then the weaknesses of the plan become obvious, this becomes the responsibility of those who supported the plan.

This procedure—reaching first agreement about the purpose without going into details such as regulations and standards or funding, and then finding a consensus regarding the specific enforcement methods, standards, and plans—was used also at occasions such as the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity. The approach is called *framework procedure*. In these international negotiations, purposes are defined by conventions and actions are specified by protocols.

In the present Japan, the disclosure of information to the public is guaranteed by the regulations about public comment enacted in 1998: citizens have to be given the opportunity to express their views directly to the institution in charge, by holding public hearings and by improving accountabilities and the transparency of administrative decision processes. New media such as the Internet make it easier to conduct a public exchange of opinions.

As we have argued, local ecological risk management involves moral judgements, and affects stakeholders and relies on their cooperation in such a way that democratic processes, balancing the interests of all participants, are essential for success. However, the complex nature of environmental systems, the difficulties of predicting their behavior, and the large number of little-known interactions make the involvement of scientists indispensable in this process. Only by combining both will an environmentally sound risk management be achieved.

Local governments and administrations often do not have the resources, the insight, the institutions, or the commitment to go through the process of developing and enacting a workable ecological risk management plan. In view of the urgency of many ecological problems, personal efforts can therefore make a big difference.

Acknowledgements We are grateful to Dr. Y. Natuhara for inviting this contribution and to The 21st Century COE Program "Environmental Risk Management for Bio/Eco-Systems" of the Ministry of Education, Culture, Sports, Science and Technology of Japan for financial support. We also thank the COE members for valuable comments.

References

Amemiya T, Enomoto T, Rossberg AG, Takamura N, Itoh K (2005) Lake restoration in terms of ecological resilience: a numerical study of biomanipulations under bistable conditions. Ecol Soc 10(2):3 http://www.ecologyandsociety.org/vol10/iss2/art3

Axelrod R, Cohen MD (1999) Harnessing complexity: organizational implications of a scientific frontier. Free Press, New York

Carson R (1962) Silent spring. Houghton Miffli, Boston

CCSBT (1998) CCSBT Scientific Committee meeting 3. Experimental fishing program, step 1, attachment F2. CCSBT, Tokyo

Christensen NL, Bartuska AM, Brown JH, Carpenter S, D'Antonio C, Francis R, Franklin J, MacMahon JA, Noss R, Parsons DJ, Peterson CH, Turner MG, Woodmansee RG (1996) The report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management. Ecol Appl 6:665–691

IUCN (2001) IUCN red list categories and criteria, ver. 3.1. IUCN Species Survival Commission (IUCN), Gland

Kaplan S, Garrick BJ (1981) On the quantitative definition of risk. Risk Anal 1:11–27

Levin S (1999) Fragile dominion: complexity and the commons. Perseus, Reading

Makino M, Matsuda H (2005) Co-management in Japanese coastal fishery: its institutional features and transaction cost. Mar Policy 29:441–450

Mano T (1998) Harvest history of brown bears in the Oshima Peninsula. Ursus 10:173–180

Mano T (2003) Hokkaido's challenges for brown bear management through the brown bear conservation and management plan in Oshima Peninsula (in Japanese). Honyurui Kagaku 3:11–15

Matsuda H (2003) Challenges posed by the precautionary principle and accountability in ecological risk assessment. Environmetrics 14:245–254

Matsuda H, Uno H, Kaji K, Tamada K, Saitoh T, Hirakawa H (2002) Harvest-based estimation of population size for sika deer on Hokkaido Island, Japan. Wildl Soc Bull 30:1160–1171

Matsuda H, Yahara T, Takemon Y, Hada Y, Hasegawa M, Hidaka K, Hotes S, Kadono Y, Kamada M, Kanda F, Kato M, Kunii H, Mukai H, Murakami O, Nakagoshi N, Nakamura F, Nakane K, Nishihiro MA, Nishihiro J, Sato T, Shimada M, Shiosaka H, Takamura N, Tamura N, Tatsukawa K, Tsubaki Y, Tsuda S, Washitani I (2005) Guideline for nature restoration projects(in Japanese with English abstract). Jpn J Conserv Ecol 10:63–75

Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: synthesis. Island Press, Washington, D.C.

Ministry of the Environment of Japan (2005) Basic policy for nature reproduction (in Japanese). http://www.env.go.jp/nature/saisei/law-saisei/hoshin.html

Morino M, Koike F (2005) A risk assessment of economic damage for crops caused by Japanese Macaque on Yakushima Island. Proc Annu Meet Ecol Soc Jpn 52:218

Nakanishi J (1996) Environmental risk theory (in Japanese). Iwanami, Tokyo

Newman MC, Roberts MH Jr, Hale RC (2001) Coastal and estuarine risk assessment. CRC Press, Washington, D.C.

Oka T, Matsuda H, Kadono Y (2001) Ecological risk-benefit analysis of a wetland development based on risk assessment using 'expected loss of biodiversity'. Risk Anal 21:1011–1023

UNCED (1992) Rio declaration on environment and development. http://www.unep.org/Documents/Default.asp?DocumentID = 78

Walters CJ (1986) Adaptive management of renewable resources. McMilllan, New York