Conserv Genet (2010) 11:349–354
DOI 10.1007/s10592-009-0037-4

COMMENTARY

Genetic diversity is overlooked in international conservation policy implementation

Linda Laikre

Received: 3 September 2009 / Accepted: 19 December 2009 / Published online: 10 February 2010

Abstract The importance of genetic variation for maintaining biological diversity and evolutionary processes has been recognized by researchers for decades. This realization has prompted agreements by world leaders to conserve genetic diversity, and this is an explicit goal of the Convention on Biological Diversity (CBD). Nevertheless, very limited action has been taken to protect genetic diversity on a global scale. International conservation efforts to halt biodiversity loss focus on habitats and species, whereas little or no attention is paid to gene level variation. By this year, 2010, world leaders have agreed that a significant reduction of the rate of biodiversity loss should have been achieved. However, gene level diversity is still not monitored, indicators that can help identify threats to genetic variation are missing, and there is no strategy for how genetic aspects can be included in biodiversity targets beyond 2010. Important findings and conclusions from decades of conservation genetic research are not translated into concrete conservation action in the arena of international policy development. There is an urgent need for conservation geneticists worldwide to become involved in policy and practical conservation work beyond the universities and research institutions.

Keywords Biological diversity · Conservation management · Genetic variation · CBD · National biodiversity strategy and action plan · 2010 Biodiversity target · GEF · GBIF

L. Laikre (✉)
Department of Zoology, Division of Population Genetics, Stockholm University, 10691 Stockholm, Sweden
e-mail: linda.laikre@popgen.su.se

Introduction

Population genetics has been one of the corner stones of conservation biology ever since it emerged as a science in its own right (Ehrenfeld 1970; Soulé and Wilcox 1980; Schonewald-Cox et al. 1983). Over the last three decades conservation genetics has become an increasingly topical research field; the importance of genetic variation as a basis for future biological evolution and to assure long term viability of populations are well establish scientific fundaments (Frankel 1970; Frankel and Soulé 1981; Avise 2008). However, outside academia, genetics is still largely overlooked and neglected in practical management as well as in national and international policies. Here, I review and exemplify how implementation of existing international biological diversity policy work is currently failing with respect to conservation and sustainable use of gene level biodiversity.

There are several examples of where the importance of conserving genetic variation and results from conservation genetics research has been implemented in management. This includes many zoological parks and gardens where genetic analyses form the basis for breeding plans with the aim to reduce loss of genetic variation and minimize inbreeding (Frankham et al. 2004). Many zoos worldwide are parts of the World Association of Zoos and Aquariums (www.waza.org) and similar regional organizations, and follow genetically based conservation breeding plans for individual threatened species (Bowkett 2009). Similarly, within fisheries management the importance of genetic criteria for maintaining biologically sustainable fisheries and stocking operations are well known (Ryman and Utter 1987), and at least on some national levels translated into genetically sound conservation management operations (cf. US National Oceanic and Atmospheric Administration's National Marine Fisheries Service: www.nmfs.noaa.gov).

In Denmark, concerns regarding the potential negative genetic effects of large-scale commercial releases of salmonids have resulted in a ban for all types of fish releases where the released individuals originate from anything but the same population as the native, local stock (i.e., only so-called supportive breeding; Ryman and Laikre 1991) is allowed (Nielsen and Hansen 2008).

The importance of genetic variation within plants of economic importance has resulted in seed banks aimed at storing genetic material for future need, such as the Svalbard Global Seed Vault managed by the Norwegian government, the Global Crop Diversity Trust, and the Nordic Genetic Resource Center. In e.g. the United States of America the recognition of below species diversity in the Endangered Species Act legislation provides the possibility of listing genetically distinct populations or population systems as threatened.

Overall, however, the recognition of conservation genetic concerns in practical management is largely lacking. For example, gene banks for plants other than those of agricultural and forest interest are missing (Swaminathan 2009), and systematic assessment and monitoring of genetic variation of most natural plant as well as wild animal populations are not carried out (Laikre et al. 2008a). Similarly, large scale genetic manipulation of natural populations through, for example, harvest and mass releases occur at increasing rates worldwide without any monitoring of possible effects (Allendorf et al. 2008; Laikre et al. 2006). The possibilities for change so that genetic variation is taken into account in conservation management appear distant as implementation of existing conservation policies currently fails to acknowledge genetic variation. Examples of such neglect are summarized in Table 1.

The CBD and genetic variation

With respect to international policy the aim of conserving and sustainably using biological diversity at the recognized levels of ecosystems, species, and genes are clearly stated in the United Nations Convention on Biological Diversity (CBD; www.cbd.int). Together with the United Nations Framework Convention on Climate Change (the "Climate Convention"; UNFCCC), the CBD represents key agreements adopted at the second Earth Summit held in Rio de Janeiro in 1992. The CBD is now the most important international political instrument for halting biodiversity loss. Currently, 193 nations are parties to the CBD, representing the entire world's nations except for Andorra, the Vatican City State, and the United States of America. Fundamental to the CBD are (outlined in Article 7 of the convention) the tasks of (i) "identify[ing] components of biological diversity", (ii) "monitor[ing], through sampling and other techniques, the components of biological diversity" in order to (iii) "identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects."

The CBD is not a legally binding instrument and implementation of the convention at the national level rests with individual countries. Member nations outline intentions of such implementation in their National Biodiversity Strategy and Action Plan (NBSAP). A review of 24 out of 156 (15%) available NBSAPs revealed that one-third of these strategies do not explicitly include genetic variation, and only 20% of the plans recognize the need for monitoring this level of diversity (Table 1; Laikre et al. 2010). Clearly, if genetic diversity is not even recognized in the NBSAP, much less will this diversity be acknowledged in practical management when the NBSAP is put into practice.

A number of international services have been created to assist countries in implementing the CBD. Currently, however, these services fail to provide adequate information or assistance with assessing and monitoring genetic diversity. For instance, the World Conservation Monitoring Center, which is run in collaboration with the United Nations Environment Programme, currently does not deal with gene level biodiversity (Table 1). Similarly, the Global Biodiversity Information Facility (GBIF), created to collect and provide free and open access to biodiversity data, is at this point not constructed to deal with information regarding gene level biodiversity.

The Global Environment Facility (GEF), the designated financial mechanism for a number of multilateral environmental agreements and conventions including the CBD, has funded only seven projects that explicitly deal with genetic diversity among a total of 930 biodiversity projects (http://www.gefweb.org/ accessed in September 2009). This represents 0.7% of the number of supported projects and only 0.6% of the funds awarded to biological diversity by GEF. The seven projects dealing with genetic diversity all concern exploited agricultural or forestry species, and none addresses genetic variation of wild animal or plant populations that are not of immediate economic value.

Genetics missing in assessing conservation status

The International Union for Conservation of Nature (IUCN) is the world's oldest and largest global environmental network. IUCN has a strong impact on international policy implementation as the organization works to "bring governments, NGOs, United Nations agencies, companies and local communities together to develop and implement policy, laws and best practice with respect to conserving the integrity and diversity of nature" (www.iucn.org). However,

Table 1 Examples of genetic diversity being neglected in international policy implementation (websites accessed in July–September 2009)

Institution/action/concept	Aim of institution/action	Observation	Source
National Biodiversity Strategies and Action Plans (NBSAPs)	Documents outlining national implementation of CBD.	>30% of 24 reviewed NBSAPs does not explicitly include genetic diversity. Only 20% recognize the need to monitor genetic diversity.	www.cbd.int/countries; Laikre et al. 2010
United Nations Environment Programme's World Conservation Monitoring Center (UNEP-WCMC)	Aims at being an international Centre of Excellence for the synthesis, analysis and dissemination of global biodiversity knowledge, and to put authoritative biodiversity knowledge at the centre of decision-making.	The center does not deal with genetic diversity.	www.unep-wcmc.org; personal email communication
International Union for Conservation of Nature (IUCN)	The world's oldest and largest global environmental network. Supports research, field projects and brings governments, NGOs, United Nations agencies, companies and local communities together to develop and implement policy, laws and best practice with respect to conserving the integrity and diversity of nature.	Does not have any specific programme, specialist group, or other initiative that deals specifically with genetic diversity.	www.iucn.org
IUCN Red List of Threatened Species	Assessing conservation status of species.	No direct genetic criteria exist for threat classification.	www.iucnredlist.org
Global Biodiversity Information Facility (GBIF)	International facility to collect and provide biodiversity data.	The facility is not constructed to deal with information on genetic diversity. Less than 20 of the thousands of datasets in the GBIF system explicitly concerns genetic variation. The majority of these datasets concerns data related to agriculture or forestry.	www.gbif.org; www.gbif.org/dataset; personal e-mail communication
Global Environmental Facility (GEF)	Global financial partnership incl. 178 countries addressing global environmental issues. Financial mechanism for several multilateral environmental agreements/conventions incl. CBD. Assists countries in meeting their obligations under these conventions.	Only seven out of 930 funded biodiversity projects focus explicitly on genetic diversity, representing less than 1% of funded projects on biodiversity.	www.gefweb.org
Global Biodiversity Indicators	CBD indicators to assess progress at the global level towards the 2010 target, and to effectively communicate trends in biodiversity related to the three objectives of the Convention.	Only one out of 22 indicators focus on genetic diversity. That indicator deals exclusively with genetic variation of economic importance (domestic animals, cultivated plants and fish of major socioeconomic importance).	www.cbd.int
2010 Biodiversity Indicators Partnership	Coordinates the delivery and communication of the suite of indicators measuring progress towards the 2010 Biodiversity Target.	Only one out of 17 indicators focus on genetic diversity, and that indicator only deals with ex situ crop collections and domestic animal breeds (number and status of breeds).	www.twentyten.net

Table 1 continued

Institution/action/concept	Aim of institution/action	Observation	Source
Streamlining European 2010 Biodiversity Indicators (SEBI2010)	Initiative that aims to develop a European set of biodiversity indicators to assess and inform about progress towards the European 2010 target. Collaboration between EEA (the European Environment Agency), DG Environment of the European Commission, ECNC (the European Centre for Nature Conservation), UNEP/PEBLDS Secretariat, and UNEP-WCMC (the World Conservation Monitoring Centre).	Only one out of 26 indicators focus on genetic diversity, and that indicator in practice deals only with number of livestock breeds.	EEA 2009
Thematic programmes and cross-cutting issues under the CBD	Programmes and issues identified as important for implementing the CBD.	None of the programmes or cross-cutting issues focuses on genetic diversity.	www.cbd.int
Favourable Conservation Status	Central concept in the biodiversity conservation legislation of the European Union (EU).	Conservation genetic aspects so far neglected in implementation of the concept.	Laikre et al. 2009

the organization only marginally focuses on the genetic level of this diversity (Table 1), as exemplified also by the fact that the IUCN Red List system for classifying threat status of species does not include any direct genetic criteria. This is in spite of inbreeding, genetic drift, and loss of genetic diversity being well recognized reasons for reduced viability and increased extinction risk of populations (Frankham 2005; O′Grady et al. 2006). Lack of genetic concerns in assessing species viability is reflected also within European Union (EU) legislation where the central concept with respect to biodiversity conservation—"Favourable Conservation Status"—currently is implemented without incorporation of genetic aspects (Table 1; Laikre et al. 2009).

The 2010 biodiversity target fails on genetics

In 2002, parties to the CBD committed themselves to significantly reduce the current rates of biodiversity loss at global, regional and national levels by 2010 as a "contribution to poverty alleviation and to the benefit of all life on Earth." This 2010-biodiversity target was subsequently endorsed by the World Summit on Sustainable Development and the United Nations General Assembly and incorporated as a new target under the UN Millennium Development Goals (http://www.un.org/millenniumgoals/).

To meet the 2010 biodiversity target, several efforts have been made to identify means for detecting changes in biological diversity. CBD has proposed 22 indicators to assess progress towards the 2010 target. These include threatened species listings, such as the IUCN Red List, coverage of protected areas and abundance of selected species. The 2010 Biodiversity Indicators Partnership is an international service that "brings together a host of international organizations working at the forefront of biodiversity indicator development to assess progress towards the 2010 target". It uses 17 "headline indicators". In Europe, the initiative Streamlining European 2010 Biodiversity Indicators (SEBI2010) aims to develop a European set of biodiversity indicators to assess and inform about progress towards the European 2010 targets. SEBI2010 currently uses 26 indicators. In each of these cases only one indicator deals with genetic diversity, and that one focuses exclusively on animals and/or plants of economic importance—primarily domestic stocks (Table 1). No indicators currently exist for safeguarding gene level biodiversity of natural populations.

Millennium ecosystem assessment notes lack of genetic considerations

The Millennium Ecosystem Assessment (MA) was called for by the United Nations Secretary-General Kofi Annan

and was initiated in 2001. The objective of the MA was to assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems. The reports from the MA note that loss of genetic diversity decreases the resilience of ecosystems, that genetic diversity has declined globally with respect to domestic species, and that there are few data on the actual changes in the magnitude and distribution of genetic diversity (Millennium Ecosystem Assessment 2005). Nevertheless, in the most recently published Global Diversity Outlook, the "flagship publication" from the CBD (Secretariat of the Convention on Biological Diversity 2006), the need for increased focus on genetic variation of wild species is not mentioned.

Obviously, the gene level of biological diversity, although recognized in international policy, lags dramatically behind with respect to practical implementation, conservation and sustainable use efforts. Important findings and conclusions from decades of conservation genetic research largely rest with the scientific community, and are not translated into concrete conservation action in the arena of international policy development. This needs to change if potentially disastrous prospects with hampered future evolution and adaptation of wild animal and plant resources are to be avoided.

Scientific input needed in CBD process

Overall, there is a lack of scientific involvement in the CBD processes in general, and particularly with respect to conservation genetics. The scientific board of the convention—the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA)—is increasingly being politicized, effectively halting scientific discussion and progress, thereby strongly limiting the quality of the recommendations to the decision taking biannual Conference of the Parties (Laikre et al. 2008b). Also, the SBSTTA leads a very anonymous existence, and few conservation biologists and geneticists are even aware of it. As an example, at the Trondheim Conservation Genetics Conference in May 2009 only one out of c. 150 conservation geneticists had ever heard of the SBSTTA. This is in striking contrast to the scientific panel of the Climate Convention IPCC (Intergovernmental Panel on Climate Change) which, together with Al Gore, received the Nobel Peace Prize in 2007.

The need for a stronger scientific platform for the CBD has resulted in discussions of creating a new body for scientific advice on biodiversity issues. Discussions in this context have included suggestions for an International Mechanism of Scientific Expertise on Biodiversity (IMoSEB), but presently the creation of something called IPBES (Intergovernmental Platform on Biological Diversity and Ecosystem Services) receives stronger support. However, few conservation genetics scientists are involved in these discussions, as exemplified again from the Trondheim Conference where only two of the c. 150 participants had heard of IPBES.

Perspectives for increased conservation genetic concerns in policy

Clearly, there is an urgent need for incorporation of conservation genetics in international policy. To achieve this, conservation geneticists worldwide need to get more actively involved in policy work and in their countries' implementation of the CBD. Also, policy makers currently pushing the idea of an IPBES or a similar forum need to recognize that if such a platform is to fill the requested need for stronger scientific input in the CBD process, then the scientists themselves must be involved in the creation of this body. Likewise, reasons for scientists to become involved must be created and put forward.

There are several ways in which the shortcomings exemplified in Table 1 can be reversed. One important step is to develop indicators that can aid in detecting trends of loss of genetic diversity. Currently, the only international indicator focusing on genetic variation refers to domestic breeds. It is vital that conservation geneticists are asked for advice in future discussions concerning modification of present indicators.

With respect to neglect of genetic diversity within various organizations that deal with conservation of biodiversity, it appears feasible to supplement them with genetic expertise/focus. For example, it should be possible to create a specialist group within the IUCN that focuses on genetic variation, or a cross-cutting issue within the CBD process that focuses on gene level of biodiversity. Such measures would highlight the need for addressing concerns regarding this level of diversity in all of the CBD programs of work. Similarly, such a cross-cutting issue would put increased pressure on parties to the convention to implement the CBD also with respect to the gene level diversity within their own countries. The GBIF could most likely be modified to include information on genetic diversity, as could the UNEP-WCMC.

During 2010 we celebrate the International Year of Biodiversity and evaluate progress towards the 2010 Biodiversity Target. During this year conservation geneticists and policy makers need to make sure that genetic diversity is not neglected in future efforts to halt the erosion of global biodiversity.

Acknowledgments I thank Lena Larsson, Nils Ryman and two anonymous reviewers for valuable comments on the manuscript. Financial support was provided by Formas (the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning), the Swedish Research Council, Carl Tryggers Stiftelse. Parts of the work were conducted within the framework of the BaltGene project funded by BONUS Baltic Organisations' Network for Funding Science EEIG. Support from the ESF Science Networking Programme ConGen is also greatly appreciated. This work benefitted from discussions and collaborations within the Working Group on Genetic Monitoring supported by the National Evolutionary Synthesis Center (NSF #EF-0423641) and the National Center for Ecological Analysis and Synthesis (NSF #DEB-0553768) and chaired by Drs. Fred W. Allendorf and Michael K. Schwartz.

References

Allendorf FW, England PR, Luikart G, Ritchie PA, Ryman N (2008) Genetic effects of harvest on wild animal populations. TREE 23:327–337

Avise JC (2008) The history, purview, and future of conservation genetics. In: Carroll SP, Fox C (eds) Conservation biology: evolution in action. Oxford University Press, New York, pp 5–15

Bowkett AE (2009) Recent captive-breeding proposals and the return of the ark concept to global species conservation. Cons Biol 23:773–776

EEA (European Environment Agency) (2009) Progress towards the European 2010 biodiversity target. EEA report no 4/2009, Copenhagen

Ehrenfeld D (1970) Biological conservation. Holt, Rinehart and Winston, New York

Frankel OH (1970) Sir William Macleay memorial lecture 1970: variation—the essence of life. Proc Linnean Soc NSW 95:158–169

Frankel OH, Soulé ME (1981) Conservation and evolution. Cambridge University Press, Cambridge

Frankham R (2005) Genetics and extinction. Biol Conserv 126:131–140

Frankham R, Ballou JD, Briscoe DA (2004) A primer of conservation genetics. University Press, Cambridge

Laikre L, Palmé A, Josefsson M, Utter F, Ryman N (2006) Release of alien populations in Sweden. Ambio 35:255–261

Laikre L, Larsson LC, Palmé A, Charlier J, Josefsson M, Ryman N (2008a) Potentials for monitoring gene level biodiversity: using Sweden as an example. Biodiv Conserv 17:893–910

Laikre L, Jonsson B-G, Ihse M, Marissink M, Dock Gustafsson A-M, Ebenhard T, Hagberg L, Piriz L, Stål P-O, von Walter S, Wramner P (2008b) Wanted: scientists in the CBD process. Conserv Biol 22:814–815

Laikre L, Nilsson T, Primmer C, Ryman N, Allendorf FW (2009) Importance of genetics in the interpretation of favourable conservation status. Conserv Biol 23:1378–1380

Laikre L, Allendorf FW, Aroner LC, Baker CS, Gregovich DP, Hansen MM, Jackson JJ, Kendall KC, McKelvey K, Neel MC, Olivieri I, Ryman N, Schwartz MK, Short Bull R, Stetz JB, Tallmon DA, Taylor BL, Vojta CD, Waller DM, Waples RS (2010) Neglect of genetic diversity in implementation of the convention on biological diversity. Conserv Biol 24:86–88

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

Nielsen EE, Hansen MM (2008) Waking the dead: the valve of population genetic analyses of historical samples. Fish Fish 9:450–461

O′Grady JJ, Brook BW, Reed DH, Ballou JD, Tonkyn DW, Frankham R (2006) Realistic levels of inbreeding depression strongly affect extinction risk in wild populations. Biol Conserv 133:42–51

Ryman N, Laikre L (1991) Effects of supportive breeding on the genetically effective population size. Conserv Biol 5:325–329

Ryman N, Utter FM (1987) Population genetics and fishery management. Washington Sea Grant Publications/University of Washington Press, Seattle and London

Schonewald-Cox CM, Chambers SM, MacBryde B, Thomas L (1983) Genetics and conservation, a reference for managing wild animal and plant populations. Benjamin/Cummings, Menlo Park, California

Secretariat of the Convention on Biological Diversity (2006) Global biodiversity outlook 2. Montreal, 81+vii p

Soulé ME, Wilcox BA (eds) (1980) Conservation biology, an evolutionary-ecological perspective. Sinauer Associates, Sunderland, Massachusetts

Swaminathan MS (2009) Gene banks for a warming planet. Science 325:517