Guidelines for Assessing Taxa with Widely Distributed or Multiple Populations Against Criterion A

Developed by the Standards and Petitions Subcommittee

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This document addresses the issues related to the presentation and use of the information from subpopulations (or from parts of the range) of a widely distributed taxon, in assessing the taxon against IUCN's criterion A. For such taxa, we recommend that the available data on past reduction be presented in a table that lists all known subpopulations (or parts of the range), and gives at least two of the following three values for each subpopulation:

(i) the estimated abundance at a point in time close to 3 generations ago[1], and the year of this estimate,

(ii) the most recent estimated abundance and its year,

(iii) suspected or inferred reduction (in %) over the last 3 generations.

If there are estimates of abundance for years other than those reported in (*i*) or (*ii*), these should also be reported in separate columns of the same table. Any qualitative information about past trends for each population should be summarized in a separate column, as well as quantities calculated based on the presented data (see examples below).

There are three important requirements:

(a) The values should be based on estimates or indices of the number of mature individuals. If the values are based on indices a note should be included that explains how they are expected to relate to the number of mature individuals, and what assumptions are necessary for this relationship to hold.

(b) The subpopulations should be non-overlapping. This does not mean that there is no or infrequent dispersal among subpopulations. The point of this requirement is to avoid double-counting as much as possible.

(c) Together, the subpopulations should include all of the taxon. If this is not possible, a "subpopulation" named *Remainder* should include an estimate of the total number of mature individuals not included in the listed subpopulations. This estimate, like others, can be uncertain (see below).

If these requirements cannot be met, and the taxon cannot be assessed under another criterion, it should be listed as Data Deficient.

In this document, we refer to subpopulations, but the discussion applies to any type of non-overlapping subunits of the taxon, such as parts of the taxon's range. In the next section on *Estimating reduction*, we discuss the basic methods of using such a data table for assessing a taxon under Criterion A. In many cases, there will be uncertainty, because the

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[1] The criteria are defined in terms of the maximum of 10 years or three generations. However, for clarity of presentation, reference is only made in this document to "three generations".

abundances are not known precisely, are in different units for different subpopulations, or are available only from one or few subpopulations. These cases will be discussed later, in a section on *Dealing with uncertainty.*

Estimating reduction

To assess a taxon against criterion A, it is necessary to estimate the overall reduction in the last 3 generations. All available data should be used to calculate a reduction as an average over all subpopulations, weighted by the estimated size of each subpopulation 3 generations ago. Inferences regarding reductions should not be based on information for any single subpopulation (whether it is the fastest declining, most stable, largest or smallest)[2].

The recommended methods for estimating reduction are explained below by a series of examples. All examples are for a taxon with a generation length of 20 years, assessed in 2001 (i.e. for these examples, the "present" is 2001 and three generations ago is 1941). All examples of this section are based on data with the same units for all subpopulations; we discuss the issue of different units in the next section (*Dealing with uncertainty*).

Example 1: Estimates are available for past (3 generations ago) and current population sizes.

Subpopulation	**Past**	**Present**
Pacific Ocean	10000 (1941)	5000 (2001)
Atlantic Ocean	8000 (1941)	9000 (2001)
Indian Ocean	12000 (1941)	2000 (2001)
Overall	30000 (1941)	16000 (2001)

In this (simplest) case, all past population sizes are added up (30000) and all present population sizes are added up (16000), giving an overall reduction of 46.7% [(30-16)/30]. Note that the changes in individual subpopulations are 50% reduction, 12.5% increase and 83.3% reduction. An average of these numbers, weighted by the initial population sizes, gives the same answer [(-0.5*10+0.125*8-0.833*12)/30].

Example 2: Estimates are available for various past population sizes.

Subpopulation	**Past**	**Present**	**Notes**
Pacific Ocean	10000 (1930s)	7000 (1995)	most of the decline in the last 20 yr
Atlantic Ocean	8000 (1975)		believed to have been stable
Indian Ocean	10000 (1961)	4000 (1981)	

In this case, the "past" and "present" population estimates are not from the same year for all subpopulations. Thus, it is necessary to make projections in order to estimate reduction for each subpopulation in the same time period. There are several types of projection. For example it is necessary to project the population from the "past" census (in the 1930s) to 1941 (3 generations ago) as well as from the most recent census (in 1995) to the present.

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[2] However, see "*Dealing with uncertainty*" below for a discussion of exceptions to this rule.

Any information about past trends can be valuable in making such projections (as in the "Notes" in the example). For instance, given that most of the decline in the Pacific subpopulations has occurred in recent years, the estimate in the 1930s can be assumed to also represent the population in 1941 (3 generations ago). However, in this case, it is necessary to make a projection from the most recent estimate (in 1995) to 2001. If the estimated decline from 10000 to 7000 occurred in 20 years, then assuming a constant rate of decline during this period, annual rate of decline can be calculated as 1.77% [1-$(7000/10000)^{(1/20)}$], giving a projected decline of about 10.1% in the 6 years from the last census (in 1995) to 2001, and a projected 2001 population of 6290 ($=7000*(7000/10000)^{(6/20)}$). This means a 3-generation decline of 37% (10000 to 6290).

When there is no evidence that the rate of decline is changing, exponential decline can be assumed. For example, for the "Indian Ocean" subpopulation, the 20-year reduction from 1961 to 1981 is 60% per generation; corresponding to 4.48% per year [$=(4000/10000)^{(1/20)}-1$]. Thus, 3-generation decline can be estimated as 93.6% [$=(4000/10000)^{(60/20)}-1$. Another way to calculate the 3-generation decline is based on annual rate of change, which is 0.9552 (1-4.48%). Thus, 60-year population change is $0.9552^{60}=0.064$; i.e., only 6.4% of the population will remain after 60 years, which is a 93.6% decline].

The population size 3 generations ago can be estimated as 25000 [=10000/(1-0.6)], and the current population as 1600 [=4000*(4000/10000)].

It is important to note that the assumption of the pattern of decline can make an important difference to the estimated reduction, and that exponential decline is not the only possible assumption. See the discussion in the next section (*Dealing with uncertainty*).

The "Atlantic" subpopulation has been stable, so a reduction of 0% is assumed. Combining the three estimates, the weighted average of reduction for the taxon is estimated as 63% [(-0.37*10+0*8-0.936*25)/43].

When such projections are used in estimating the overall reduction, the projected declines and projected population sizes should be given in different columns of the table than those that are used for the data (see completed table below).

Subpop.	**Past**	**Present**	**Notes**	**Population 3 gen. ago (est.)**	**Current population (est.)**	**Estimated 3-generation reduction**
Pacific Ocean	10000 (1930s)	7000 (1995)	most of the decline in the last 20yr	10000	6290	37.1%
Atlantic Ocean	8000 (1975)		believed to have been stable	8000	8000	0%
Indian Ocean	10000 (1961)	4000 (1981)		25000	1600	93.6%
Overall				43000	15890	63.0%

Example 3: Estimates are available for various past population sizes for some subpopulations only.

Subpopulation	Past	Present	Reduction	Notes
Pacific Ocean	unknown	5000 (1990)	50%	suspected reduction over 3 generations
Atlantic Ocean	8000 (1955)	9000 (1998)		
Indian Ocean	unknown	2000 (1980)	70%	inferred reduction over 3 generations

In this case, for some regions, there is no information about the past population size, but there is a suspected or inferred reduction. In this case, such suspected or inferred values must be averaged, weighted by the population size 3 generations ago. Since this number is not known, it must be projected using the present estimates and the reduction amount, using the methods discussed under Example 2. Assuming exponential decline or growth, the table is completed as follows.

Subpop.	**Past**	**Present**	**Reduction**	**Population 3 gen. ago (est.)**	**Current population (est.)**	**3-generation change**
Pacific Ocean	?	5000 (1990)	50% (suspected)	8807[a]	4403[a]	50% suspected reduction
Atlantic Ocean	8000 (1955)	9000 (1998)		7699[b]	9074[b]	17.9% estimated increase
Indian Ocean	?	2000 (1980)	70% (inferred)	4374[c]	1312[c]	70% inferred reduction
Overall				20880	14789	29.2% reduction

[a] Annual proportional population change is 0.9885 [=(1-0.5)$^{(1/60)}$], which is a 1.15% decrease per year. Population change from 1941 until the census in 1990 is 0.5678 [=0.9885$^{(1990\text{-}1941)}$]. Thus, population size in 1941 is 8807 (5000/0.5678). Population change from the census in 1990 to 2001 is 0.8807 [=0.9885$^{(2001\text{-}1990)}$]. Thus, population size in 2001 is 4403 (5000*0.8807).

[b] Population change from 1955 to 1998 is 1.125 (=9000/8000; 12.5% increase). Thus, annual change is 1.00274, or 0.27% increase per year [=1.125$^{1/(1998\text{-}1955)}$]. Population size in 1941 is 7699 [=8000/1.00274$^{(1955\text{-}1941)}$]. Population size in 2001 is 9074 [=9000*1.00274$^{(2001\text{-}1998)}$].

[c] Annual population change is 0.9801 [=(1-0.7)$^{(1/60)}$]. Population change from 1941 until the census in 1980 is 0.4572 [=0.9801$^{(1980\text{-}1941)}$]. Thus, population size in 1941 is 4374 (2000/0.4572). Population change from the census in 1980 to 2001 is 0.6561 [=0.9801$^{(2001\text{-}1980)}$]. Thus, population size in 2001 is 1312 (2000*0.6561).

Example 4: Multiple estimates are available for various past population sizes.

Subpopulation	Past-1	Past-2	Past-3	Present
Pacific Ocean	10000 (1935)	10200 (1956)	8000 (1977)	5000 (1994)
Atlantic Ocean	8000 (1955)			9000 (1998)
Indian Ocean	13000 (1946)	9000 (1953)	5000 (1965)	3500 (1980)

In this case, as in example 2, the “past” and “present” population estimates are not from the same year for all subpopulations. However, there are estimates for additional years, which provide information for making projections. For example, for the Pacific Ocean subpopulation, the annual rate of change has changed from a 0.09% increase in the first period (1935 to 1956) to a 1.15% decrease in the second and a 2.73% decrease in the third period, suggesting an accelerated decline. One option is to assume that the final rate of decline will apply from 1994 to 2001 as well. Another option is to perform a non-linear regression. For example, a 2nd degree polynomial regression on the natural logarithms of the four population estimates predicts population size as $exp(-1328+1.373t -0.0003524t^2)$, where t is year from 1935 to 2001. This equation gives a 1941 population of 10389 and a 2001 population of 3942, which correspond to a 62% decline. The Indian Ocean subpopulation shows a different pattern; the annual rate of decline decelerates from 5.12% in the first period to 4.78% in the second and 2.35% in the third period. The same regression method predicts population size as $exp(2881-2.887t+0.0007255t^2)$, giving a 1941 population of 18481 and a 2001 population of 3538, which correspond to a 80.9% decline (thus, the regression has predicted a slight increase from 1980 to 2001). The completed table is below.

To decide what form of decline curve to apply over the three-generation period, assessors should use the best information they have about the processes that contribute to these changing rates. For example, if other information suggests that threat processes have increased in severity over time and that these are affecting the population in an increasingly severe manner, then it will be appropriate to assume an accelerating decline rate. If, however, recording intensity has changed over time and is emphasizing recent declines, then it will be appropriate to use the best estimate of decline rate overall. Assessors should indicate the basis on which they have decided the form of the decline function.

Subpop.	Past-1	Past-2	Past-3	Present (closest to 2001)	Population 3 gen. ago (1941; est.)	Current population (2001; est.)	Estimated 3-generation change
Pacific Ocean	10000 (1935)	10200 (1956)	8000 (1977)	5000 (1994)	10389	3942	62.1% reduction
Atlantic Ocean	8000 (1955)			9000 (1998)	7699	9074	17.9% increase
Indian Ocean	13000 (1946)	9000 (1953)	5000 (1965)	3500 (1980)	18481	3538	80.9% reduction
Overall					36569	16554	54.7% reduction

Dealing with uncertainty

In many cases, data from some or even most of sub-populations (or, regions) will be unavailable or uncertain. Even for taxa with very uncertain data, we recommend that the available data be organized in the same way as described above.

Using uncertain estimates

Uncertain values can be entered as plausible and realistic ranges (intervals). In specifying uncertainty, it is important to separate natural (temporal or spatial) variability from uncertainty due to lack of information. Because criterion A refers to a specific period, temporal variability should not contribute to uncertainty. In other words, the uncertainty you specify should not include year-to-year variation. Criterion A refers to the overall reduction of the taxon, so spatial variability should also not contribute to uncertainty. For example, if the reduction in different subpopulations ranges from 10% to 80%, this range ([10,80]%) should not be used to represent uncertainty. Instead, the estimated reduction in different subpopulations should be averaged as described above.

This leaves uncertainty due to lack of information, which can be specified by entering each estimate as an interval, as in the following table.

Subpopulation	**Past**	**Present**
Pacific Ocean	8000-10000 (1941)	4000-6000 (2001)
Atlantic Ocean	7000-8000 (1941)	8000-10000 (2001)
Indian Ocean	10000-15000 (1941)	1500-2500 (2001)

In this case, a simple approach is to calculate the minimum and maximum estimates for the reduction in each subpopulation using the lower and upper estimates[3]. For example, for the "Pacific" subpopulation, the minimum reduction can be estimated as a reduction from 8000 to 6000 (25%) and the maximum reduction can be estimated as 60% (from 10000 to 4000). If "best" estimates for past and present populations are also available, they can be used to estimate the best estimate for reduction. Otherwise, the best estimate for reduction can be estimated as 44% (9000 to 5000), using the midpoints of the intervals for the past and the present population sizes.

If similar uncertainty exists for all subpopulations (as in this example), a simple approach is to add all lower and all upper bounds of estimates. In this case, the total population size would be 25000-33000 in the past and 13500-18500 in the present. Using the same approach as outlined above, the best estimate of reduction can be calculated as 45% (29000 to 16000), with plausible range of reductions from 26% (from 25000 to 18500) to 59% (from 33000 to 13500).

An alternative method is to use a probabilistic (Monte Carlo) approach. If the uncertainty of past and present population sizes are given as probability distributions, and the correlation between these distributions are known, then the probability distribution of the reduction can be estimated by randomly selecting a pair of past and present population sizes (using the given distributions), calculating the reduction based on this pair, and repeating this with hundreds of randomly selected pairs.

Uncertainty about the pattern of decline

When it is necessary to extrapolate population trends, the assumed pattern of decline can make an important difference. Here, we briefly discuss various assumptions, and where they might be applicable. Suppose for a subpopulation of the same taxon discussed in the examples above, population was estimated as 20000 in 1961 and 14000 in 1981 (these are shown as square markers in the graphs below). We need to extrapolate back in time to

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[3] This is the method used in RAMAS Red List to calculate reduction based on abundances, when you click the "Calculate" button in the Value editor window for past or future reduction.

1941 and forward to 2001. The simplest assumptions are those that involve no change in early or late years. For example, if it is assumed that decline did not start until the early 1960s, the reduction can be based on the initial population of 20000. If it can be assumed that the decline stopped before 1981, then 14000 can be used as the current population. However, if the decline is suspected to have occurred outside this period, then it is necessary to make an assumption about the pattern of decline. The documentation should include a rationale for the assumed pattern of decline.

Exponential decline

Exponential decline can be assumed in cases where the proportional rate of decline of the population is believed to be constant. For example, if the taxon is threatened by exploitation, and the hunting mortality (proportion of individuals taken) does not change as the population size declines, then exponential decline can be assumed.

Using the method discussed in Example 2 above, exponential decline would give a population of 28571 for 1941 and 9800 for 2001 (triangle markers in Figure 1 below), giving a 3-generation reduction of about 66%.

Linear decline

In some cases, the number of individuals taken (rather than their proportion to the total population) may remain constant. For example, if a species is threatened with habitat loss, and a similar sized area of habitat is lost every year, this could lead to a linear decline in number of individuals. Note that this means that the rate of decline is increasing every year, because the same amount of habitat is lost out of a decreasing amount of remaining habitat.

With linear decline, the population would be estimated as 26000 for 1941 and 8000 for 2001 (triangle markers in Figure 2 below), giving a 3-generation reduction of about 69%. In this case, the rate of decline is only 23% for the 1st generation, but increases to 43% for the 3rd generation.

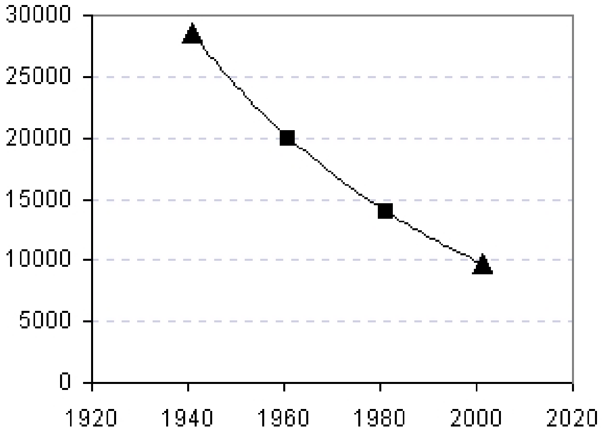

Figure 1. Exponential decline

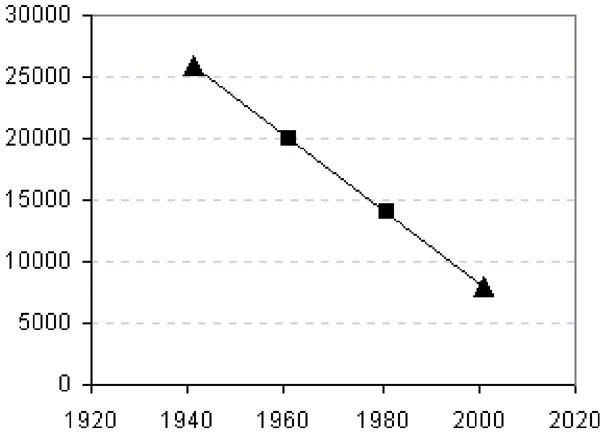

Figure 2. Linear decline

Accelerated decline

Although a linear decline in the number of individuals means that the rate of decline is increasing, this increase can be even faster, leading to an accelerated decline in the number of individuals. This may happen when the exploitation level increases, for example when the number of individuals killed is larger every year because of increasing human population, or improving harvest efficiency when catch-per-unit-effort (CPUE) is used as an index of abundance.

To extrapolate under an assumption of accelerated decline, it is necessary to know or guess how the rate of decline has changed. For instance, in the above example, the observed 1-generation decline (from 1961 to 1981) is 30%. One assumption might be that the rate of decline doubled in each generation, from 15% in the 1st generation to 30% in the 2nd and 60% in the 3rd. This assumption would give a population of 23529 for 1941 (20000/(1-0.15)) and 5600 for 2001 (14000*(1-0.6)), giving a 3-generation reduction of about 76% (Figure 3). Of course, different assumptions about how the rates of decline may have changed in the past might give very different results.

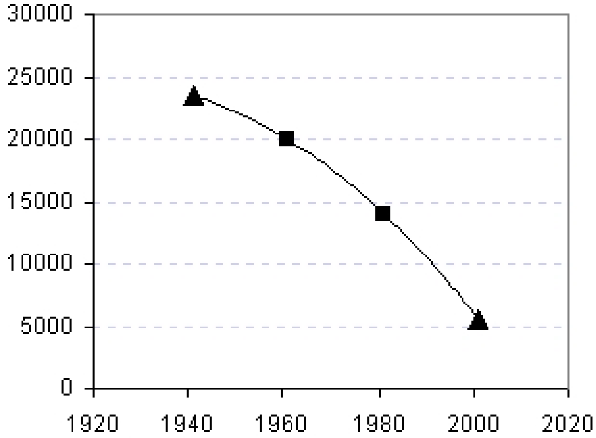

Figure 3. Accelerated decline

The same approach can be used to make the calculation based on an assumption of decelerating decline.

It is also possible to assume different patterns of decline for different periods. For example, decline can be assumed to be zero until the first observation, and then exponential. Thus would give a population of 20000 for 1941 and 9800 for 2001, giving a 3-generation reduction of about 51%.

When there is no basis for deciding among various patterns of decline, the rate of decline can be specified as an uncertain number, based on the declines predicted by the different patterns. For example, in the examples above, the rate of decline can be expressed as the interval 66%-69%, if both exponential and linear patterns of decline are considered plausible.

Using data with different units

All the examples discussed above assumed that the population data were in the same units (such as number of mature individuals). In some cases, data from different populations may be in different units (such as CPUE or other indices). In such cases, we recommend that a separate table be prepared for each data type. If the past and current population sizes are in the same units for any subpopulation, they can be used to calculate (perhaps with extrapolation as discussed above) the reduction for that subpopulation. Such a calculation assumes that the index is linearly related to the number of mature individuals. The assessment should discuss the validity of this assumption, and make the necessary transformation (of the index to one that linearly relates to the number of mature individuals) before reduction is calculated (also see requirement (a) on page 1).

It is also important that an effort is made to combine the tables by converting all units to a common one. This is because it is necessary to know the relative sizes of the subpopulations in order to combine the reduction estimates, unless the subpopulations are known to be similar sizes or have declined by similar percentages. If the percent reduction is similar (within 1 or 2 percentage points) for different subpopulations, their relative sizes will not play an important role, and a simple (arithmetic) average can be used instead of a weighted average. If population sizes are known to be similar (e.g., if 3 generations ago, the smallest subpopulation was not any smaller than, say, 90% of the largest), again a simple average can be used.

If population sizes and reduction amounts are different among subpopulations, then reductions (in percent) based on different units can be combined only if relative sizes of the subpopulations can be estimated. However, this need not be a very precise estimate. Ranges (intervals) can be used to calculate uncertain results. For example, suppose that the estimates of reduction in two subpopulations are 60% and 80%, and that precise estimates of relative population sizes are not available (because these reduction estimates are based on different indices). In this case, crude estimates of relative sizes can be used. If the relative size of the first subpopulation is estimated as a proportion between 0.40 and 0.70 of the total population, then the overall reduction can be calculated as follows. The high estimate would be (60%*0.4)+ (80%*0.6), or 72%. The low estimate would be (60%*0.7)+(80%*0.3), or 66%. Thus, the overall reduction can be expressed as the interval 66%-72%.

Using data from a few subpopulations

In some cases, reliable data exist from only one or few subpopulations. In such cases, the available data can be used under the following conditions.

1. If the subpopulation for which a reduction estimate is available was by far the largest subpopulation three generations ago, then this estimate can be used for the whole taxon. This process can also be formalized using the methods outlined above. For example, suppose that the largest subpopulation has declined by 60%, and that it had represented 90 to 99% of the mature individuals in the taxon three generation ago. If there is no information on the rest of the subpopulations (representing 1-10% of mature individuals), these subpopulations can be assumed to have declined by 0 to 100% (although, of course,

this range does not include all the possibilities, as it excludes the possibility that the other subpopulation have increased). With these assumptions, the low estimate would be 54% (if the rest of the subpopulations had 10% of the individuals, and declined by 0%), and the high estimate would be 64% (if the rest of the subpopulations had 10% of the individuals, and declined by 100%). Thus, the overall reduction can be expressed as the interval 54%-64%, which includes the estimate (60%) based on the largest subpopulation, but also incorporates the uncertainty due to lack of knowledge from other subpopulations.

2. If it can be assumed that all (or all the large) subpopulations are declining at the same rate, then the reduction estimated for a subset of subpopulations can be used for the whole taxon. In this case, it is important to document any evidence that indicates that the rates are the same, and discuss and rule out various factors that may lead to different rates of reduction in different subpopulations.