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Arguments for biodiversity conservation in Natura 2000 sites: An analysis based on LIFE projects

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Abstract

Achieving acceptance among local stakeholders is crucial for biodiversity conservation, as their often diverging interests can hamper the success of conservation projects. While research exists on the different narratives and arguments used in the international policy debates, there is not much evidence on how effective alternative arguments are in communicating the value of biodiversity to local stakeholders. This paper used a multiple case study design for sites of the European Union's Natura 2000 network to investigate which arguments have been successfully used to persuade local stakeholders of restoration projects, funded under the EU's LIFE program. Particular focus is given to the role of ecosystem services as arguments for nature conservation and how these relate to other instrumental and non-instrumental arguments. Instrumental arguments appeared particularly effective for commercial users, where economic interests stood against the conservation activities. But also stakeholders without commercial interest tended to be more receptive to arguments that implied a benefit for themselves or their communities, such as recreation or a cultural value. Regarding ecosystem services this study found that they should be understood as an addition to the category of instrumental arguments. Where pure economic factors were not sufficient to create a business case for conservation, ecosystem services were frequently applied to make the case for conservation stronger. Finding consensus among the different stakeholders is a key factor in achieving any conservation at all. The argument strategy should therefore always consist of a mix of instrumental and non-instrumental arguments, as only focusing on instrumental arguments might repel those individuals who seek a strong ethical motivation.

Keywords

Biodiversity conservation, stakeholder communication, Europe, argumentation strategies, Natura 2000

Introduction

Despite global political efforts under the Convention of Biological Diversity to conserve the world's biodiversity, it is still declining with unrestrained speed. In 2010 it became apparent that the global and European targets to halt biodiversity loss by then had not been achieved (Butchart et al. 2010). In response policy-makers came up with a new set of convention targets to be met by 2020 (Secretariat of the Convention of Biological Diversity 2010, European Commission 2011, Harrop 2011). To support the achievement of these new political targets, the scientific community has investigated various factors responsible for the past failure and has come up with suggestions for improvements (Mace et al. 2010, Rand et al. 2010).

One of these factors are conflicts between the conservation goals and the interest of different stakeholder groups at local scale (Folke et al. 2007). Building acceptance of the conservation actions among local stakeholders is therefore generally seen as pivotal to reduce conflicts and promote the achievement of conservation goals (Young et al. 2010). In particular implementing agencies of governmental conservation efforts have to deal with conflicting values or preferences of local stakeholders. While the conservation activities derive their normative justification from values expressed in regulation, neither the values underlying the law nor the normativity of the law itself, are uniformly recognized by local stakeholders. Implementing agencies can therefore employ alternative arguments that better relate to stakeholders' values and preferences in order to resolve potential conflicts.

Two main categories of arguments for nature conservation can be distinguished: instrumental arguments and non-instrumental arguments. Both lines of argumentation have been commonly used across cultures and periods. For instance, the political awareness shift towards environmental values and the need to protect these by specific regulation in western societies in the second half of the 20th century was on the one side driven by instrumental arguments about human dependence on nature in publications such as 'The Tragedy of the Commons' (Hardin 1968) or ´The Limits to Growth` by the Club of Rome (Meadows et al. 1972). On the other side Aldo Leopold created with his 'Land Ethics' (Leopold 1949) one of the most influential ecological approaches about the inherent value of all life and strongly influenced the emerging environmentalism of that period. Both argument categories appeal to different people and can also sometimes lead to very different conclusions about what action should be taken.

While various scholars have investigated the political discourses at national or international level on biodiversity conservation (Väliverronen and Hellsten 2002, Hutton et al. 2005, Evans 2012), there has so far not been much research on the discourses at local level, in particular between implementing agencies and local stakeholders.

The Natura 2000 network is the European Union's main instrument for biodiversity conservation. It offers an ideal example to study the effectiveness of alternative arguments at local level, because it allows for comparisons between different sites, while all sites receive their normative motivation from the same legislative foundation. The network was established in 1992 under the Habitats Directive in order to protect key habitats and

species in Europe (Evans 2012). Its declared aim is 'to contribute towards ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora in the European territory' (Council of the European Communities 1992). Thus biodiversity conservation is framed as a matter of conserving certain species and habitats. In the same line the criteria for site selection are based on a list of species and habitats.

While this perspective on biodiversity offers a high potential for operational action, it has been criticized by environmental philosophers as an 'itemizing approach' that neglects that people value biodiversity for reasons related to a contextual narrative (O'Neill et al. 2008)[1]. From this perspective it can therefore be expected that local stakeholders will not always share the normative values expressed in the Habitats Directive.

In fact many Natura 2000 sites have to deal with conflicts with local stakeholders. This paper will take a descriptive approach drawing on persuasion theory (O'Keefe 2002, Dainton and Zelley 2004) to explore which alternative arguments are effective in resolving conflicts with local stakeholders. It will do so in a multi-case study design that analyses experiences from different sites of the Natura 2000 network funded under the LIFE+ Nature fund. The study forms part of the EU funded project BESAFE, which investigates the effectiveness of alternative arguments for biodiversity. The main research question is which argumentation strategy proofs most effective in mitigating local conflicts or aversion against the conservation projects.

Methods

Data selection and data analysis

This case study uses the Natura 2000 sites as example for analyzing which arguments are effective in communicating the value of biodiversity to local stakeholders. The multiple-case design was chosen because it generally offers stronger robustness of the results (Yin 2009, Stake 2013). This particular set-up allows to draw conclusions about transferability of arguments to other socio-economic and cultural contexts. At the same time the multiple-case design helps to extract suggestive evidence on mediating factors that might explain variations in effectiveness.

Our study used both document analysis and in-depth interviews to create a methodological triangulation. For the document analysis 365 Natura 2000 projects were selected from the LIFE online database. This database provides information on all projects funded under the LIFE fund, the main EU funding instrument for the environment. Only LIFE projects, classified under the strand 'Nature' were considered since these projects target restoration activities in Natura 2000 sites. Next we analyzed all the projects submitted and approved in the years 1992 to 1996, 2000, 2004, 2008,

1 However, the Habitats Directive also makes a reference to 'natural habitats' which indicates a value for the historical concept of 'naturalness' (Lanzerath and Friele 2014). Nevertheless it can be argued that the site selection criteria of the habitats directive are clearly dominated by the 'itemizing approach'. Therefore our argumentation focuses on this aspect.

2010, and 2011. Follow-up projects (projects which received funding more than once and encoded separately in the database) were not considered as separate projects in our analysis but analyzed together with the first project to avoid double or triple counting of arguments. In sum, our sample represents almost 25% of all the Nature projects funded under the LIFE program between 1992 and 2013.

The selected cases were analyzed with respect to the arguments which were used to present the project in the LIFE database, on the project website and in other public communication materials. As a result of this analysis the relative frequency of all appearing arguments was determined.

The frequency analysis yielded first insights into which arguments project managers expected to be effective. In addition, the results were used to guide the subsequent in-depth interviews with LIFE project managers. In total 55 project managers were invited to participate in the study. Out of these 14 responded and attended the interviews. The in-depth interviews aimed at exploring the perceptions of project managers about the effectiveness of alternative arguments. The interview protocol (Suppl. material 1) started with open questions for identifying the most relevant stakeholders and arguments. Open-ended questions are commonly used in qualitative research to encourage the interviewee to give his definition and structure of the situation as recommended (Dexter 2006). These questions were followed by targeted questions about specific stakeholder groups or arguments in order to deeper discuss certain aspects or to verify that the omission of certain arguments meant that they were perceived as irrelevant. The interviews were recorded and transcribed. Subsequently transcripts were coded based on stakeholder groups and argument types.

Codes of argument types were predefined and based on categories which were identified by Howard et al. (2013) through a literature review on potential arguments at an earlier stage of the BESAFE project. For the purpose of this case study the list of Howard et al. (2013) was simplified to a number of 20 different categories (Table 1).

In contrast codes for stakeholder groups were created by first using open coding and in a second step building meaningful categories. Stakeholder categories were based on their expected interest in the ecosystem. Many common frameworks for stakeholder analysis use interest as criterion. For instance Mitchell's stakeholder matrix categorizes stakeholders by interest and the power to influence outcomes (Mitchell et al. 1997). Similarly, Mendelow (1981) proposes a power-interest grid. Interest was chosen in this study as main criterion because it gives a first insight in the expected attitude towards certain arguments. While both frameworks measure interest as cardinal variable based on its intensity, we built qualitative categories. These distinguish between stakeholders whose interest in the ecosystem is primarily commercial, non-commercial or political.

After coding, the interviews were analyzed according to the structural framework which is presented in more detail hereafter. The results on different argument types were organized in tables for greater manageability. These tables present effectiveness of arguments by stakeholder group. The effectiveness of arguments is understood in this paper as a combination of observed and potential effectiveness. The full concept is described in a later paragraph. The table content should be understood as qualitative

Table 1. Classification of arguments (Argument types) and types of premise statements. Frequency of use of the argumentation in LIFE projects. The short names between brackets are used in Tables 2-5.

Argument types		**Type of premise statement (short name)**	**Frequency**	**Relative frequency (%)**
Instrumental	Economic	Productivity, resources, industrial use of nature, market products (Productivity)	20	4.1
		Contribution to regional economic growth (Growth)	24	5.0
		Livelihoods, employment (Employment)	11	2.3
		Direct payment/subsidy (monetary and non-monetary forms) (Subsidy)	0	0
	Social	Provisioning services, emphasis on quality, naturalness, impacts on human well-being (Provisioning ecosystem services)	15	3.1
		Regulating services, carbon, nutrients, water-functions leading to indirect benefits (Regulating ecosystem services)	10	2.1
		Recreation, aesthetic value/experience (Recreation and cultural ecosystem services)	38	7.9
		Human health, reduction in disease risk (Health)	2	0.4
		Precaution, risk reduction, resilience of services (Resilience)	9	1.9
		Intellectual stimulus (Intellect)	24	5.0
		Legal obligation (Legal)	18	3.7
		Reputation, looking good, winning customers/staff/voters (Reputation)	1	0.2
		Options for future use, bio-prospecting (Options)	1	0.2
Non-instrumental	Inherent	Rights/values of nature itself, intrinsic value (Intrinsic)	151	31.3
		Ethical, moral and religious obligations to nature (Ethical)	8	1.7
		Achieving balance of nature, healthy systems, natural functions (Functions)	25	5.2
	Human happiness	Social/cultural/heritage/collective well-being and welfare (Social well-being)	41	8.5
		Psychological/spiritual/individual well-being and biophilia (Individual well-being)	0	0
		Sustainable development, obligation or values for future generation (Sustainability)	34	7.0
Goal not expressed		Species conservation matters (Reason not specified)	51	10.6

information that describes the observed cases of this study. Tables should not be read as 'average' or 'universal' indicators of effectiveness, but solely summarize observations of our study. The transferability of these observations to other contexts is part of our analysis and is discussed accordingly in the respective paragraphs.

Limitations

Ideally an investigation of the effectiveness of arguments triangulates information on the perceptions of the communicator (in our case the project manager) with those of the recipient (in our case the stakeholders). However, data on stakeholder perceptions was difficult to obtain, because in many cases representative members of the stakeholder groups were difficult to identify. For the scope of this study we chose therefore to concentrate on the project managers as primary data source. This limitation bears the risk of a systematic bias if project managers willingly or unwillingly favored specific arguments or neglected others. Based on the interviews we assessed the risk of a willingly produced bias as low. The concern of an unwillingly produced bias, however, is more difficult to dispel. The persuasion through a specific argument is a cognitive process that takes place in the mind of the individual stakeholder. It is therefore only indirectly observable by project managers. Yet what project managers can observe is if the change in attitude translates into a change in behavior. For instance, a stakeholder that previously opposed the project might finally demonstrate acceptance but this was not recorded. Nevertheless the possibility of unwillingly produced bias remains and has to be considered when discussing the results.

A second limitation of the research design is the self-selection of interviewees into the study, as participants might systematically differ from project managers who did not respond to the invitation. In fact, it is likely that study participants have a higher than average level of awareness and interest in the topic of the study (the effective persuasion of stakeholder groups). Most likely participants have been more deeply engaged with the question as to how to communicate the value of their projects to relevant stakeholders. This should imply, however, that the study participants command over a more accurate perception about the effectiveness of arguments than their colleagues. Given these consideration self-selection seems no threat, but rather a quality feature of the study results.

Structural framework

Our research question about the effectiveness of arguments is at its core effect-oriented. Therefore, this study draws on literature from persuasion theory (O'Keefe 2002, Dainton and Zelley 2004). Persuasion is understood as the process of changing behavior by means of argumentation. This paper does not use the classical differentiation between persuasion and conviction which distinguishes these by 'rational' and 'emo-

tional' means of influence. Following O'Keefe (2002) it rather understands conviction as process to change attitudes as means in itself to achieve persuasion. The paper uses a relatively simple effect-oriented communication model to guide the analysis. It is builds on the classic understanding of communication as a linear process (Lasswell 1948). Although simple in its form, Lasswell's model is one of the most influential communication models (Shoemaker et al. 2004) and well suited for content analysis based on a quantitative approach. Hence we consider it as a useful method for our study which is based on the frequency of arguments and which has a clear focus on the effects of communication. As Lasswell's model does not account for context factors, we introduced some degree of non-linearity in our model and recognized that messages cannot be understood freely from their context, as first highlighted by Jakobson (1960). We therefore incorporated certain mediating factors in the model. Howard et al. (2013) identified already at an earlier stage of the BESAFE project the socio-economic context, the ecological context, the stage in the policy cycle and the way of presenting the argument as relevant context factors. After accounting for these factors our model took the form as illustrated in Figure 1.

Type of arguments. As explained earlier the categorization of argument was also built on the work of Howard et al. (2013). Following their recommendations we used a framework that understands arguments as consisting in a premise statement and a conclusion. The premise statement itself typically consists of a claim and a reason. In our study the conclusion of each argument consists of the normative claim that a certain conservation action should be taken. Following Howard et al. (2013) our structural framework categorizes premise statements by the explicit or implicit reason expressed in the claim. It distinguishes between instrumental arguments, non-instrumental arguments and those where the goal is not expressed. Instrumental arguments are further divided in those referring to an 'economic benefit' and those referring to a 'social benefit'. Similarly, non-instrumental arguments are divided in those referring to 'human welfare' and to an 'inherent value'. In a next step we sorted all expected 20 arguments into these categories, which resulted in the argument categorization illustrated in Table 1.

Message communicator and message recipient. This study neglected for the most part to analyze the impact of communicator characteristics on message effectiveness for two reasons. Firstly, message communicators did not differ vastly as they were in each case the LIFE project manager. Typically these project managers were working for public authorities. Some project managers were employed by non-governmental organizations which receive government subsidies.

Secondly, the study focused on the argumentation and its effect on persuasion. The communicator identity played therefore a subordinated role and was consciously kept comparable among cases. Yet the possibility of an effect of the communicator identity was considered during the analysis of the observations.

In contrast, the identity of the message recipient varied strongly between and within single cases. It was expected to find strong variation in argument effectiveness between different stakeholder groups, as they share different norms, values and interests. After the open coding procedure stakeholders from single cases were categorized in four

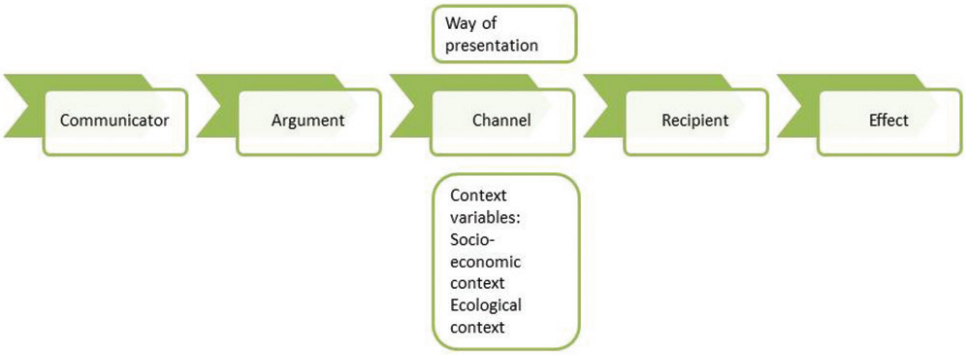

Figure 1. Structural framework used for the assessment of arguments to protect and restore biodiversity in LIFE projects across Europe.

groups to create a higher degree of abstraction of the results: commercial users of the ecosystem, non-commercial users, public agencies and civil society organizations.

Socio-economic and ecological context and way of presenting the argument. It did not appear useful to analyze the socio-economic and ecological context using a predefined classification, because the number of single cases was relatively small. The context varied largely among the single cases, which would have resulted in individual categories for each single case. Instead, context variables were analyzed on a case by case basis to create suggestive evidence on their impacts. Similarly, the way of presenting the argument was not analyzed by a pre-defined framework, but on a case by case basis.

Stage of the policy cycle/time dimension. Primmer et al. (2014a) observed that arguments for biodiversity can affect the policy cycle at three stages. Arguments can appear before the policy framing and goal setting and influence its outcome. They can be used to operationalize goals into sub-goals, standards and working principles and thereby determine the implementation of the policy. In addition, arguments can be used in implementing the practice and in measuring its effects (ibid.). All argumentation of our multi-case study happened at the stage of implementation of the practice. Therefore, the policy stage was not a determining factor in our analysis.

Argument effectiveness. For measuring the effectiveness of an argument we used a framework developed by Primmer et al. (2014a). They distinguish between observed and potential effectiveness. While observed effectiveness can be studied by analyzing actual policy processes whose effects can be observed, potential effectiveness refers to how alternative arguments are valued by stakeholders or how effective they appear in experiments.

Measures for observed effectiveness are: persistence, accumulation, level-crossing, diffusion, and replacement. The persistence of an argument can be understood as its enduring over time (Primmer et al. 2014a). The accumulation signifies that an argument is growing in importance over time. Diffusion of an argument means that it

reaches new audiences within the same level, whereas level-crossing implies that new levels or actors take up the argument in their discussion. Finally, replacing or overriding of one argument through another implies a low observed effectiveness.

Potential effectiveness can either be analyzed in a purely logical exercise or in assessing the attitudes of stakeholders to certain arguments. In this study we focused on the latter. In particular, we asked project managers about their expectations with respect to the effectiveness of specific arguments for particular stakeholders. The difference to observed effectiveness lies in the fact that project managers do not necessarily have the evidence from directly testing the arguments, but instead base their statements on their general knowledge of the stakeholders. Therefore data on potential effectiveness should be treated with care. Potential effectiveness was mainly used to backup findings formed on observed effectiveness and made up a relatively small part of the analysis.

Results

General description of the arguments used in the LIFE database

A first assessment screened 365 LIFE projects for the argumentation on biodiversity they contain. The spatial distribution of the sample is presented in Figure 2 while the frequency in the use of the different arguments is available in the Table 1.

Studies were selected from all countries of the EU but there is some perceived bias towards Northern Italy and South Belgium, since several LIFE projects in these regions covered more than one Natura 2000 site which results in a clustered presentation in these areas.

Our study found a rich variety of arguments used to make a case for nature protection in Natura 2000 sites. The inherent argument that nature has a right or value of its own reappeared in almost a third of the of the Life projects included in the first screening phase. People also often underline the importance of conservation without going into detail (10.6% of the projects screened). Natura 2000 sites are also related to the cultural heritage of a region which is seen as important to protect.

Natura 2000 sites provide multiple ecosystem services which is reflected in the argumentation found in the project information sheets (13% of the projects used ecosystem services as argumentation). The role of the network in providing cultural ecosystem services, notably recreation and aesthetic values, is used to argue for the conservation of a site. Regulating and provisioning services appear as arguments as well but they are mostly not framed as ecosystem services. An argument which is regularly used is the water regulation capacity of Natura 2000 sites to store water and maintain hydrological functions.

Several projects also stress the importance of Natura 2000 sites for their contribution to the regional economy (5%), and in particular, to help achieve a more sustainable development (7%)

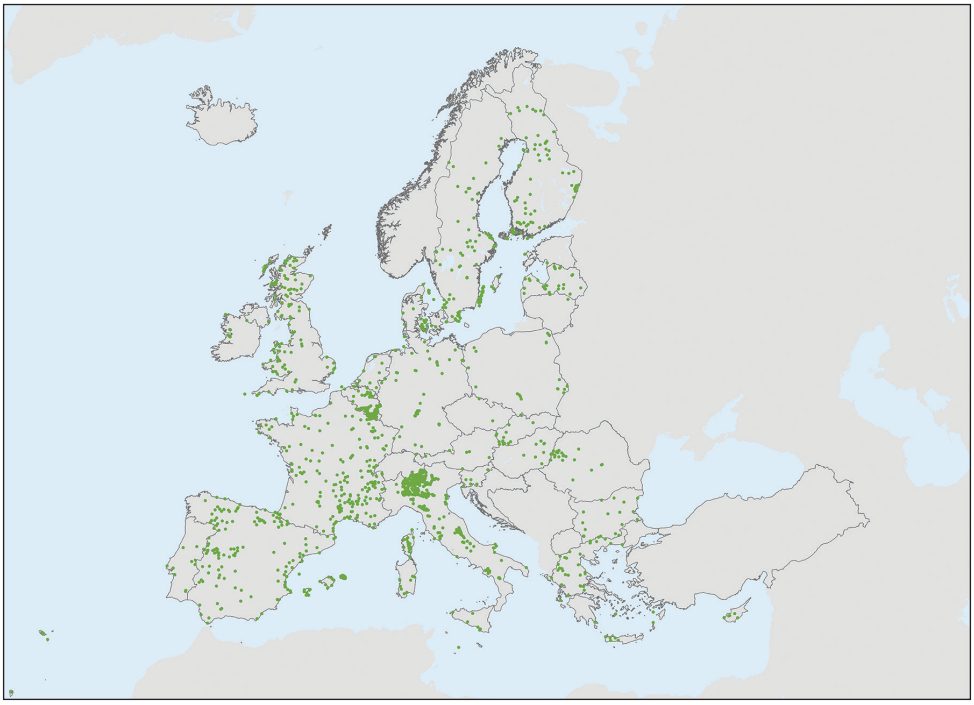

Figure 2. Sample of LIFE projects selected for the assessment. LIFE projects were mapped by linking the project number to the Natura 2000 sites where the project was implemented. Several projects cover more than one site, in particular in Northern Italy and Southern Belgium, which results in some clustering.

In-depth assessment

The in-depth assessments are based on interviews with project managers. Here we present a summary of the results per argument type (see Table 1). Tables 2–5 summarize the effectiveness of the argumentation per stakeholder group as well as the effectiveness assessment.

Instrumental arguments – economic. The most frequently used argument in this category was the general claim of a contribution to economic growth (Table 2) which was mentioned in nine out of the 14 interviews. This argument was several times paired with a reference to business opportunities through eco-tourism. In addition, project managers often argued with a direct payment or subsidy, particularly where it was intended to persuade commercial users. Increased productivity also found some mentioning, but project managers referred rarely directly to employment or livelihoods.

In general economic arguments showed high effectiveness among commercial users and public authorities. However, in several cases the economic arguments were actually not applicable to the context because commercial interests and conservation aims required opposing management options. For instance one project manager in Bulgaria stated that

'*the government wanted to build a ski area, a ski resort. And this is of course for the bear population very dangerous*.'

Table 2. Effectiveness of economic arguments per stakeholder group.

Stakeholder group		Productivity	Growth	Employment	Subsidy
Non-commercial interest	General public	Medium to low effectiveness	Effective	-	-
	Schools	Low effectiveness	Not effective	-	-
	Visitors/Recreationists	-	-	-	-
Commercial users interest	Landowners/ Farmers/ Fisheries	If applicable, very high effectiveness; often not applicable, as productivity and conservation interests diverge	If applicable, effective; often not applicable, as economic and conservation interests diverge	If applicable, effective; often not applicable, as no direct impact on employment observable	Effectiveness strongly varies; also cases of counterproductive subsidies observed
	Stock breeders	If applicable, very high effectiveness; often not applicable, as productivity and conservation interests diverge	If applicable, effectiveness; often not applicable, as economic and conservation interests diverge	-	Effective
	Forestry	Not applicable, as productivity and conservation interests diverge	Often not applicable, as economic and conservation interests diverge	-	-
Political interest	Environmental NGOs	-	-	-	-
	Animal rights associations	-	-	-	-
	Municipalities and other public agencies	High effectiveness	High effectiveness; often not applicable, as economic and conservation interests diverge	-	Effective
Effectiveness assessment					
Persistence		Persistent	Persistent	-	Persistent for commercial users
Accumulation		If applicable, accumulating	If applicable, accumulating	-	No accumulation
Level-crossing		If applicable, used by both local government, civil society and sometimes commercial users	If applicable, used by regional and local government and sometimes civil society	-	No level-crossing
Diffusion		Some diffusion to general public	Some diffusion to municipality	-	No diffusion
Replacing		If applicable, no replacing; if not applicable replacing by legal	If applicable, no replacing; often in combination with recreation/ tourism	-	-

The same was true for arguments about increased productivity. In almost all cases it was impossible to make this argument, as the demanded conservation measures were expected to deter optimal productivity. Consequently, in many cases conservation projects had to deal with strong opposition from commercial users.

Economic theory would typically suggest dealing with these conflicting interests by creating a business case for conservation. For instance this could be done through subsidizing the desired behavior. The examined cases in this study did not contain any incidence where the project management paid direct subsidies to the commercial users. Yet in several cases the project management employed commercial users in some of their activities, provided non-monetary assistance or highlighted the possibility to apply for other public subsidies. On the downside several cases reported financial incentives to be counterproductive. For instance, one interview partner stated that financial incentives were in his eyes not capable of introducing permanent behavioral change:

And then we talk about the pragmatic motivation, this is very easy to convince maybe (…), because you will receive a payment. This is easy to convince, economic motivation. But this is very short term, because we have a very rapid change of values, we have economic inflation, but we have also a values' inflation.

In another case public subsidies were found to be directly undermining conservation purposes. In a land conservation project the manager explained that they had failed to include fallow area in the project because land owners were receiving subsidies for these areas which were still classified as agricultural land.

For public authorities the case was more favorable. Economic aspects seemed to persuade municipalities in several cases. For example one project manager described the synergies between bird conservation and economic interest of the region like this:

And we say, ok, guys, if you want nature tourism, you need angling and birding there. So if you want birds there, you have to have appropriate farming there which is favorable for the birds. So you want birds, you need to have extensive farming, extensive farming means late mowing, late mowing means that the farmers have a problem with the biomass, we don't know where to put the biomass because the hay is not anymore useable for animal feeding. And they say, ok, the biomass maybe can be used for biofuel, you can make pellets out of this biomass and you can heat houses. But then we say, ok, this means if the municipality would change their heating system into a heating from the biomass we would create a pre-condition that there could be a lot of birds and this would be a pre-condition for nature tourism. So we try to put this logic scheme, we try to come with economic figures.

Economic arguments were rarely used for non-commercial users of the ecosystem, because project managers expected them not to be effective with that group. Two of the examined cases suggest that local social cohesion may be a factor that makes the general public more receptive to economic arguments.

Finally, economic arguments were in none of the examined cases used for civil society organizations. However, environmental organization used this type of argument repeatedly in addition to their normative claims to persuade other stakeholder groups.

Instrumental arguments – social. In general the examined cases suggest that social arguments are for all stakeholder groups relatively convincing (Table 3). The legal argument was among all the most frequently used of this group as it was directly referred to by 12 interviewees. Despite being very effective for most stakeholders, it showed large variance in its effect on commercial users of the ecosystem. In some cases commercial users expressed strong reluctance against legal obligations. Project managers indicated different explanations for this effect, for instance the distance between regulator (EU institutions) and the regulated local context or a weak legal enforcement. The latter can be illustrated by a case where the project manager found a large contrast between the effect of the Habitats Directive versus the Water Framework Directive—an EU Directive which governs the quality of water bodies. The project manager stated:

There is a legal obligation because pearl mussels are protected under the Wildlife and Countryside Act and there is the Habitats directive and the legislation in Scotland and the UK. But then there is the other legislation which comes through the Water Framework Directive. (…). But some of their actions could be potentially illegal under pearl mussel legislation, but to them that wasn't important because it was the Water Framework Directive which carries potentially a lot more weight and more enforcement, so they were more concerned about if we use that legislation to talk to them and to tell them how can we help them lead their Water Framework Directive obligations (…)

Another factor that seems to determine the effect of the legal argument is the normative attitude to the conservation purpose and to public regulation in general. One example illustrated this very clearly. We interviewed two managers of large carnivore projects, out of which one reported the legal argument to be very effective while the other stated the opposite. These deviating effects came along with very different attitudes to the large carnivores in question and legal obligations in general.

Arguments about provisioning or regulating services were used in six different cases. In many cases project managers seemed to find it difficult to identify which ecosystem services their project generated. Yet, individual cases hinted that ecosystem services can be very effective arguments, if applicable. One project manager, for instance, claimed that the carbon storage potential of his project was very effective in convincing various stakeholder groups. Other interviewees mentioned flood prevention as a very effective argument. For non-commercial users recreation and intellectual stimulus seemed to be particularly strong arguments. However, the same arguments appeared weak in persuading public authorities or commercial users.

In addition, ecosystem services were most effective, where the benefits were easily understood. Many project managers highlighted that the concept of ecosystem services was too complex or scientific for stakeholder communication. Instead pro-

Table 3. Effectiveness of social arguments per stakeholder group.

Stakeholder groups		Provisioning ecosystem services	Regulating ecosystem services	Recreation and cultural ecosystem services	Health	Resilience	Intellect	Legal	Reputation	Options
Non-commercial interest	General Public	If applicable, effective	-	Effective	Effective	If applicable, effective	Effective	Effective	-	-
	Schools	-	Not effective	Effective	-	-	Effective	Not effective	-	-
	Visitors/ Recreationists	-	Effective	Effective	-	Effective	-	-	-	-
Commercial interest	Landowners/ Farmers/ Fisheries	-	Effectiveness varies depending on beneficiary of the services	Not effective	-	If applicable effective	-	Effectiveness varies strongly by context; determinants are regulatory level, strength of enforcement and acceptance of normative base of the regulation	Effective, if social environment in favor of conservation	-
	Stock breeders	-	Effective	-	-	-	-	Effectiveness depending on country context; similar projects were very differently perceived in different countries; possible determinant is attitude towards law in general	-	-
	Forestry	-	Effective	Not effective	-	If applicable, effective	-	Effective	-	-
Political interest	Environmental NGOs	-	-	-	-	-	-	-	Effective, if general public is not opposing intervention	-
	Animal rights associations	-	-	-	-	-	-	Not effective	-	-
	Municipalities and other public agencies	If applicable, effective	Effective	Effective when paired with ecotourism	-	Effective	-	Effective	Varies strongly; depending on public opinion about the interventions	-

Stakeholder groups	Provisioning ecosystem services	Regulating ecosystem services	Recreation and cultural ecosystem services	Health	Resilience	Intellect	Legal	Reputation	Options
Effectiveness assessment									
Persistence	Not persistent	Persistent	Persistent	-	Persistent	Persistent use in context of schools; in other context not used	Persistent	Not persistent	-
Accumulation	Not accumulating, often too abstract for many stakeholder groups	No accumulation observed	Accumulating if tourism industry is growing	-	No accumulation	No accumulation	Accumulation if EU law reinforced through national law	No accumulation	-
Level-crossing	No level-crossing observed	Level-crossing	-	-	Depending on the concrete threat	No level-crossing	If level-crossing depends on country context; may also lead to reactance	Level-crossing both of agreement with argument or reactance to the argument	-
Diffusion	No diffusion observed	No diffusion observed	-	-	Often combined with Ecosystem Services etc. (e.g. flood prevention)	No diffusion	If diffusing depends on country context; may also lead to reactance	-	-
Replacing	Replacing through direct economic benefits or moral obligations	-	Often accompanied by biophilia or local economic growth	-	Depending on the concrete threat	No replacing	Replacing or combining with consensus seeking management solutions	-	-

ject managers referred to the service itself. Where the service could be easily understood, as in the case of recreation or flood control, they ultimately appeared to be strong arguments.

Reputational benefits seemed to be another strong argument, as it was quite frequently used. Particularly, it seemed to be a strong argument to persuade municipalities. However, in some cases it appeared counterproductive, because its effect depended—unsurprisingly—on the public opinion about the conservation measures in question. For instance, protection against invasive species seemed to be a very controversial intervention. One project manager stated:

[the municipality] perceive[s] this problem, because for example they had the red squirrel some years ago and now they have only the grey one. But they don't want to be exposed, because it also involves a political exposure.

Bioprospecting and benefits to human health were used very rarely in the examined cases.

Non-instrumental arguments—inherent value. The most frequently used argument of this category was the intrinsic value of nature (Table 4) which was referred to by 11 interview partners. However, the effectiveness of this argument varied strongly. Five out of the ten cases which used the argument for commercial users found it effective, the other five cases found it not effective. The most positive results of this argument were observed for non-commercial users, as in five out seven cases it was found effective for this group. Project managers used the argument in four cases for education or awareness raising at school. They reported univocally that school children were very receptive to the intrinsic argument. Due to the low effectiveness among commercial users, this argument was however often replaced by or complemented with instrumental arguments.

The argument about a moral obligation was only used in three interviews, but it followed a similar pattern. Finally, the argument about maintaining the balance of nature was not effective for commercial users, but very effective for non-commercial users such as recreationists or the general public

Non-instrumental arguments—human happiness. Arguments that refer to inherent human benefits were particularly effective for non-commercial users (Table 4). This argument type was rarely used for commercial users and, if used, it was generally not effective.

Remarkable were the findings on a psychological benefit/biophilia. Biophilia was an argument often applied to persuade non-commercial users. Particularly recreationists appeared to be receptive to this argument. In addition, project managers seemed to try to trigger biophilia in other groups such as school children or the general public through activities in and with nature. In one case for instance, the project manager explained that the local population was alienated from their immediate natural environment and organized tours had been used to re-establish their emotional relationship to nature.

Table 4. Effectiveness of non-instrumental arguments per stakeholder group.

Stakeholder groups		Intrinsic	Ethical	Functions	Social well-being	Individual well-being	Sustainability
Non-commercial interest	General Public	Effectiveness varies	Effective	Effectiveness varies	Effective	Effectiveness varies, can even be counterproductive in case of invasive species	Effective, but rarely used
	Visitors/ Recreationists	Not effective	-	Effective	Effective	-	
	Schools	Effective	Effective	Effective	-	High effectiveness; particularly if strengthened by education programs that involved visits to nature, engagement with specific species etc.	-
Commercial interest	Stock breeders	Not effective	Usually not used, only for some effective	Effectiveness varies; depending on explicit link between balance of nature and livestock breeding	-	-	-
	Forestry	-	-	-	-	-	-
	Landowners/ Farmers	Persistent, but effectiveness varies strongly	Usually not used, only for some effective	Effectiveness varies	-	-	Effective
Political interest	Environmental NGOs	Effectiveness varies strongly; depending on context can even produce counterproductive results	-	Effective	-	-	-
	Animal rights associations	Counterproductive in context of invasive species	-	Not effective in context of invasive species	-	Counterproductive in case of invasive species	-
	Municipalities and other public agencies	Not effective	Effective	-	Effective	-	-

Stakeholder groups	Intrinsic	Ethical	Functions	Social well-being	Individual well-being	Sustainability
Effectiveness assessment						
Persistence	Persistent	Persistent, but mainly not explicitly referred to	Persistent in some context	Not persistent	Persistent if communication activities are repeatedly reinforced	Not persistent
Accumulation	Accumulation only observed in context of invasive species, where it has adverse effect	Not accumulation	No accumulation observed	-	No accumulation	-
Level-crossing	level-crossing from animal rights associations to general public	No level-crossing	No level-crossing observed	No level-crossing observed	-	-
Diffusion	Potential diffusion from school children to parents	Potential diffusion from school children to parents	No diffusion observed	-	School children as mediator to adults, but no clear evidence for that	-
Replacing	Typically replaced by legal and economic arguments	Typically replaced by legal and economic arguments	Often replaced by recreation or regulating services	-	Accompanied by intrinsic or moral arguments	-

Table 5. Effectiveness of argument with goal not expressed per stakeholder group.

Stakeholder groups		Species conservation matters
Non-commercial interest	General Public	Effectiveness varies
	Visitors/Recreationists	-
	Schools	Effective
Commercial interest	Stock breeders	Effectiveness unclear
	Forestry	-
	Landowners/ Farmers	Effectiveness unclear
Political interest	Environmental NGOs	Effective
	Animal rights associations	-
	Municipalities and other public agencies	Effectiveness unclear
Effectiveness assessment		
Persistence		Very persistent
Accumulation		Accumulating
Level-crossing		No level-crossing observed
Diffusion		Different directions
Replacing		No replacing observed

Goal not expressed. The claim that conservation matters without giving underlying reasons was found in seven of the observed cases. At the same time however, it was reported to have a very mixed effectiveness (Table 5).

Discussion

Argument types: Ecosystem services, instrumental and non-instrumental arguments

Non-instrumental arguments are among the oldest and most widespread arguments for a value of nature. They contributed largely to a policy shift in the 1970s and 1980s which brought environmental problems to the forefront of public awareness (Næss 1973, Callicott 1989) and they have influenced European environmental governance and policy since. In our study we found that non-instrumental arguments were quite frequently used – both in the general and the in-depth assessments – but they were not always described as effective. It seemed that non-instrumental arguments for conservation were a widely accepted paradigm. Nevertheless, it appeared that these arguments possessed limited effectiveness in ultimately persuading stakeholders of the value of the project. School children were the exception for this rule. The fact that intrinsic arguments were frequently used despite their ambiguous effectiveness can possibly be explained by project managers expecting it to possess a normative power of any kind. In addition non-instrumental arguments were seen as a longer lasting motivation while for instance economic arguments were understood as short term incentives by the project managers.

Economic arguments were often vague and did avoid to consider concrete benefits such as job creation. In many cases it was obvious that the vagueness of the argument was caused by the impossibility to claim concrete economic benefits for the project. In most cases commercial users did not directly benefit through the project, thus economic arguments were not applicable in these cases. Indirect benefits may occur e.g. through productivity gains due to maintaining ecological functionality. As described earlier productivity gains were hardly used by project managers as arguments. We can therefore not make any conclusive statement about these benefits. At the same time, the findings show parallels to the findings of the corporate social responsibility (CSR) literature, where most authors agree that companies can only be expected to produce environmental (and social) co-benefits when doing so does not diminish the economic profitability (Blowfield and Murray 2004, Delmas and Toffel 2004). While the CSR literature focuses on large corporations of mainly the secondary sector, our findings suggest that a similar logic applies to the agricultural sector and other primary industries. However, the cases discussed in our study differ in an important characteristic from cases of the CSR literature. While CSR refers to large cooperations, our cases describe local stakeholders whose identity as economic agents and as private persons is much stronger entangled. For that reason factors such as norms and values or social cohesion which go beyond profit play a certain role in their decision-making. Our findings suggest however, that in many cases value-oriented argumentation was not sufficient to persuade commercial users.

In those cases where commercial users were directly benefitting economically, economic arguments were perceived as effective. However, project managers in this study also referred to the risk of motivation crowding out by suggesting the possibility of deterring intrinsic motivations by subsidizing stakeholders for conservation actions. One project manager described economic arguments as a short-lived solution, because the motivation for action would disappear as soon as the economic incentive was gone. At the same time, however, non-instrumental motivations would get lost if focus was given to economic arguments. These findings are in line with literature on motivation crowding out (Stern 2006). As a solution project managers suggested to argue for conservation at different levels, maintaining both non-instrumental and instrumental lines of argumentation.

Instrumental arguments that refer to social benefits can be understood as an addition to economic arguments, because they appeal to the self-interest of individuals or groups. While in many cases creating a business case for conservation through purely economic arguments was not possible, social arguments were added to the argumentation in many cases with success. Arguments about ecosystem services are one type of non-economic arguments that refer to instrumental values. As our results have shown they succeeded in some, but not all, cases to create a business case for conservation by drawing the attention to non-monetary benefits such as flood prevention. Our findings confirm a trend identified by other scholars (Plant and Ryan 2013) towards increasing use of arguments that highlight benefits from ecosystems that go beyond purely economic terms. The finding that specific ecosystem services such as flood prevention or recreation appeared particularly effective suggests that ecosystem services are most

effective, where they coincided with the self-interest of the stakeholder. Henceforth, ecosystem service arguments can be understood as an extension of economic arguments in the sense that they can help to create a business case for conservation.

At the same time, however, the findings suggest that the concept of ecosystem services may be very theoretical and often not appropriate to communicate to local stakeholders. A large number of project developers used arguments that can be framed under the ecosystem services concept, without being aware that these benefits could fit under this concept. Other project developers refused the terminology of ecosystem services because they saw it as too scientific or too technical to communicate to local stakeholder groups. This finding has to be treated carefully, because it is possible that project managers underestimated the ability of stakeholders to relate to the ecosystem services terminology. While we can therefore not be completely certain about the effectiveness of references to the term 'ecosystem services', our findings provide clear evidence that specific ecosystem services are often used by project managers to communicate with local stakeholders and that these arguments are effective in many cases.

Bringing these findings together, project managers favored usually a mix of different arguments. While the non-instrumental arguments were widely used and appeared to be generally accepted by stakeholders, they were in the majority of cases combined with instrumental arguments. Instrumental arguments were used to create a business case for conservation and to appeal to the self-interest of stakeholders. In our study no project manager saw a risk of crowding out intrinsic motivations by economic arguments, as long as the intrinsic arguments continued to be used. This argumentation strategy was described as having the advantage to speak to individuals of the same stakeholder group who had different values and preferences as well as to address different dimensions in the considerations of the same individual.

The popularity of arguments that do not express a clear goal possibly relates to the advantage of being vague. By leaving out the premise of the claim, it remains open to interpretation. It is possible therefore, that the argument speaks to a wider audience. At the same time, however, the vagueness could also weaken its persuasive power, which seemed to be case in several of our observed cases.

Mediating factors

As expected the socio-economic context of a project has an impact on the effectiveness of arguments. Several cases gave suggestive evidence of the importance of the relationship to nature or the species in question in explaining the effect that an argument had on stakeholder groups. For cases where the project developer reported that a stakeholder group commanded over solid knowledge or has an emotional connotation to the respective natural environment, it seemed that intrinsic arguments were more effective than otherwise. However, where there was no strong previous relationship with nature, several project managers reported to have succeeded in fostering it through activities that made stakeholders engage with and in nature, e.g. through guided tours.

While in general economic arguments seemed to be hardly effective for non-commercial users, our cases contained some exceptions. For instance a Greek project manager reported that arguments about the economic dependence of local stock breeders on the ecosystem, was an effective argument for the general public. Social cohesion seemed to be the underlying mediating factor, which made unaffected stakeholders more receptive to benefits borne by others. While the evidence of this mechanism in our study is only narrative, it is in line with other studies that found that economic arguments are not only effective for directly affected individuals, but may be used as a general welfare argument (cf. Primmer et al. 2014b).

In our structural framework we outlined that the way of presenting the argument is further expected to be a determining factor. We identified three general modes of how the message was communicated that went beyond wording of the message. One of these factors was already mentioned - the communication of nature's value through experiences in and with nature. This experience-oriented way of presenting was reported to be effective, particularly for non-commercial users.

It links closely to the second method of communication that we identified as mediating factor. This second method is participatory practices. Participation appeared in the examined cases in various forms. For instance, several projects involved stakeholders directly in their project activities, e.g. in monitoring of an animal population or management practices. In other cases the project management held participatory meetings with local stakeholder to provide information, identify concerns and try to resolve them. These findings have to be seen in lights of the literature dedicated to participatory approaches (Arnstein 1969, Rowe and Lynn 2000, Newig and Fritsch 2009, Rauschmayer et al. 2009). Participation proofed to be effective to reduce conflicts by creating a two-way communication. Some participatory approaches actually sought to create consensus, thus going beyond pure persuasion of the stakeholder. It can therefore not be understood as promoting the stakeholder acceptance of a predefined conservation outcome. However, in many cases it appeared that a consensus seeking approach was a key factor to achieve any conservation at all. Hence, consensus seeking practices should also be understood as one of the mediating factors for stakeholder persuasion.

Finally, the identity of the message communicator plays an important role for persuasion. In our study, we found that sometimes third parties were employed to communicate the message who had potentially a better relationship to the stakeholders. For example, one forest project used the foresters to communicate with hunters, as these had a mutually trustful relationship.

In other cases project managers attempted to improve their own relationship with stakeholders through various techniques. For instance, information provision and general transparency were reported as a way to create trust. As already mentioned, consensus seeking approaches pursued the same aim. These findings are in line with general theories on how trust can facilitate cooperation and under which conditions it can be built (Mishra 1996, Cook et al. 2007) and how lasting relationship of trust can be established (Primmer 2011).

Conclusions

The results of this study showed a certain pattern in the effectiveness of instrumental and non-instrumental arguments used in conservation. The non-instrumental argument about the moral base of biodiversity conservation was usually an accepted paradigm with which stakeholders did not generally disagree. However, the acceptance of this norm was in most cases not sufficient to motivate action against economic interests. Instrumental arguments were decisive among commercial users of the ecosystem. Whereas their economic interests seemed to diverge from conservation interests, additional instrumental arguments, including ecosystem services, could be used to create a business case for conservation. Instrumental arguments are hence not replacing but adding to non-instrumental arguments to guarantee political feasibility.

Stakeholders without commercial interest tended to be more receptive to arguments that implied a benefit to themselves or their communities, such as recreation or cultural value. While non-instrumental arguments found acceptance, it was typically the mix of instrumental with non-instrumental arguments that appeared effective for this group.

Overall the study showed a mixed picture, where different individuals of the same stakeholder group could be persuaded by very different arguments.

Project managers thus recommended in general a mixed communication strategy that deploys both instrumental and non-instrumental arguments. While it would be possible that a mixed communication strategy blurs the intended message, project managers in this study were convinced that a mix of instrumental and non-instrumental arguments made the communication more effective. First, they suggested that a mix of arguments helped to reach different individuals in the same stakeholder group who might differ in their values and preferences. Second, instrumental and non-instrumental arguments were seen as complementary in simultaneously relating to different dimensions of an individual's values or preferences.

The findings of this study add to the recent field of environmental communication by showing that conflicts with local stakeholders can be reduced by effective communication. To create effective stakeholder communication this study suggests that managers of conservation projects should avoid focusing on single arguments, regardless whether or not they are instrumental or non-instrumental. In order to be effective environmental stakeholder communication has to account for the multiple values and preferences within stakeholder groups and within individuals by employing a mixed communication strategy.

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Supplementary material 1

Interview protocol

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Data type: Text

Explanation note: List of questions used by the interviewer during the telephone interview with project managers.

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Aging nestling Carnaby's cockatoo, *Calyptorhynchus latirostris*, and estimating the timing and length of the breeding season

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Abstract

It is important to know the age of nestling birds for many ecological and behavioural studies. Various methods have been developed for individual species; most are based on measurements of growth in wings, tarsi or heads/bills, or observations of changes in size, plumage and behaviour over time. However, techniques for aging nestlings have not been established for most avian species. This paper sets out two methods to age nestling Carnaby's cockatoo, *Calyptorhynchus latirostris*, an endangered species endemic to southwestern Australia. One method is based on the physical changes in size and plumage during the 10 to 11 weeks of the nestling period, and the other on the relationship between the length of the nestling's folded left wing and its age developed from data obtained from nestlings of known age. The estimated age of nestlings may be used to extrapolate egg-laying, hatching and fledging dates by taking the 29 days of incubation and the 76 days of the nestling period into account. The method of estimating nestling age based on length of folded left wing provides a more accurate estimate of nestling age than observations of changes in nestling size and plumage. However in situations where it is not possible to handle nestlings, the observation method should provide a reasonable basis for calculating the commencement and end of the breeding season, the length of egg-laying and nestling periods; important population parameters specified for monitoring under the species' recovery plan.

Keywords

Carnaby's Cockatoo, *Calyptorhynchus latirostris*, aging nestlings, relationship between wing length and age, sexing nestlings

Introduction

Knowing the age of nestlings is important for many ecological studies, including those investigating population dynamics, life histories, behaviour, longevity, conservation planning and management (Boal 1994, Wails et al. 2014). Aging data are also important for planning the timing of visits to breeding areas to maximise the numbers of nestlings banded/ringed for the minimum number of visits (Saunders and Ingram 1998), thus minimising the disturbance to breeding populations. Methods for estimating the ages of nestlings have been developed for some avian species, especially raptors (Steenhof and Newton 2007, Penak et al. 2013). Methods for aging have been based on measurements (Petersen and Thompson 1977, Bortolotti 1984, Poole 1989, Gosler et al. 1998, Pande et al. 2011, Penteriani et al. 2004, Penak et al. 2013, Wails et al. 2014) and observations of changes in plumage and size (Boal 1994, Gossett and Makela 2007, Becker and Weisberg 2013).

There are two species of black cockatoo with white tail bands in southwestern Australia; Carnaby's cockatoo, *Calyptorhynchus latirostris* and Baudin's cockatoo *C. baudinii* (Saunders 1974, 1979a). Carnaby's cockatoo has the widest distribution of the two species, occurring in the area of the southwest receiving more than 300 mm of annual average rainfall (Saunders 1974). As a result of changes in land use associated with clearing of native vegetation for the establishment of broadscale agriculture and urban development, Carnaby's cockatoo has undergone a major contraction of its range, and decrease in its total population (Saunders 1990). Baudin's cockatoo occurs in the forested southwest and is also believed to have declined in numbers (Department of Environment and Conservation 2008). Both species are listed as endangered under the Australian Federal Government's *Environment Protection and Biodiversity Conservation Act* 1999, listed as "Fauna that is rare or likely to become extinct" in Schedule 1 of the Western Australian *Wildlife Conservation Specially Protected Fauna Notice 2013* under the *Wildlife Conservation Act 1950*, and listed as endangered under IUCN Red List category and criteria (IUCN 2014). Both are subject of recovery plans: Cale (2003) and Department of Environment and Conservation (2012) for Carnaby's cockatoo and Department of Environment and Conservation (2008) for Baudin's cockatoo. Carnaby's cockatoo has been the subject of extensive research (Saunders et al. 2013 and references therein) while there is little published research relating to the ecology of Baudin's cockatoo.

Carnaby's cockatoo's recovery plan specifies the need for regular monitoring to provide information on breeding populations, and any changes in breeding parameters over time (Action 14.3, Department of Environment and Conservation 2012). Two of those breeding parameters are the commencement and length of the breeding season. Commencement and length of the breeding season may be established by frequent visits to breeding populations to establish when egg-laying commences and when the last nestlings for the season leave their nest hollows. The need for frequent visits is time consuming, logistically expensive and is unlikely to be undertaken (Wails et al. 2014), especially on species such as Carnaby's cockatoo whose egg-laying period may

extend over several months. This information may also be generated by estimating the age of nestlings from one or more visits each breeding season and extrapolating back for laying and hatching dates and forward for fledging dates (Boal 1994, Petersen and Thompson 1977, Penteriani et al. 2004).

In this paper we describe two methods of aging Carnaby's cockatoo nestlings when the hatching dates are not known. One of the methods for aging is based on changes in the physical appearance of nestlings over the nestling period, and the other by comparing the length of a nestling's folded left wing against a growth curve constructed from measurements of nestlings of known age. We also report on the possibility of using the same techniques on the closely related, but poorly researched Baudin's cockatoo.

Methods

Study areas and data collected from nestlings: Two breeding populations of Carnaby's cockatoo were studied in detail from 1970–1976; one at Coomallo Creek in the northern wheatbelt of Western Australia and the other at Manmanning in the central wheatbelt (Saunders 1982). Both areas are described by Saunders (1982) and Saunders and Ingram (1998). Manmanning was visited at weekly intervals during the breeding seasons of 1970–1976, and the length of the nestlings' folded left wings (mm) were measured once during each visit from the time the nestlings were large enough to handle safely (at least 13 days old), until just before they fledged (after 10 weeks from hatching).

The folded left wing was measured with a stainless steel ruler marked in mm with a right-angled steel butt (or stop) at the zero end. The bird's left wing was folded and the carpal joint held against the butt end with the primary feathers flattened along the ruler with the length taken at the tip of the longest primary feather. This is the method described in Lowe (1989 Fig 6.5). Provided the wing is held against the butt end of the ruler and the chord flattened, the measurement is accurate and repeatable by others.

Some individual nestlings were measured up to nine times. For reasons explained by Saunders (1982), the breeding population at Manmanning was extirpated by 1977. At Coomallo Creek, visits were made each week during the breeding seasons of 1970-1974, and the folded left wings of the nestlings were measured once during each visit, but subsequently, during each breeding season the area was visited, nestlings were only measured once or twice in their nestling period. Since 1974, the Coomallo Creek population has been monitored (and nestlings measured) in 22 of the years until 2014, including each year 2009–2014.

In addition to measuring the length of the folded left wing, nestlings were weighed, the shape and colour of their cheek patches were noted and, in the breeding season of 2014 they were photographed in order to prepare descriptions of the changes in their physical appearance with age.

From 1969 to 1973 inclusive, the following measurements were also taken with vernier callipers from each nestling whenever it was handled; culmen length and width, tarsus length, length of the claw on the longest toe, and tail length (Saunders 1982).

The length of the folded left wing was found to be the easiest to measure accurately and so the other linear measurements were not recorded from 1974.

Analyses of growth data of length of folded left wing with age: As there is no difference in the lengths of the wings of adult males and females or juvenile males and females (Saunders 1974), data from both sexes of nestlings were combined for the analyses.

Analyses were undertaken to develop an inverse calibration between the length of the folded left wing (mm) and the age (days) of the nestling using data collected from Coomallo Creek (1970–1974) and Manmanning (1970–1976). The data were obtained from nestlings of known age; that is, their date of hatching was known accurately, not from extrapolation or estimation. In a sense these data were collected opportunistically; that is, we were fortunate enough to examine the hollows on the days when the nestlings hatched. The relationship between age and length of folded left wing for nestlings of known age is described by a three parameter logistic curve. Methods were then developed to use the length of the folded left wing to allow the estimation of the age of nestlings whose day of hatching was not observed; 95% confidence intervals of the estimated age were derived by inverting fitted logistic growth models.

Following Saunders's (1982) analyses of growth in length of folded left wing using methods set out by Ricklefs (1967), a three parameter logistic model was fitted to the data. This model takes the form:

$$\mathrm{FLW} = \mathit{Asym}/[1 + \exp\{(\mathit{xmid} - \mathrm{age}) / \mathit{scal}\}]$$

where "FLW" is the length of the folded left wing (mm) and "age" is the nestling's known age (days). The parameters are "*Asym*", the asymptotic length (mm), "*xmid*", the location parameter, namely the age (days) at which half the asymptotic FLW is reached, and "*scal*", a scaling parameter (days/mm) that controls the maximum steepness of the growth curve. Due to the repeated measures on individuals observed during the course of the nestling phase of growth, a non-linear mixed model was fitted to the data using R (R Core Team 2014) and the self-starting model function, SSlogis, from the package nlme (Pinheiro et al. 2014) for fitting non-linear mixed effect models.

The fixed effect of primary interest was location, "*xmid*", to compare growth rates of nestlings from Coomallo Creek with those from Manmanning. In addition to the fixed part, under the model each parameter was assumed to have a zero mean random perturbation added to it, which varied across the combination of year and nest hollow. The random effects can be thought of as having two roles: firstly as a parametrically economic way of allowing for unobserved influences on the growth; and secondly, as a way of allowing for the growth outcomes in the nestlings from the same hollow in the same year to be correlated.

The potential significance of both random and fixed effects was assessed using a log likelihood ratio test.

A total of 163 measurements of the length of the folded left wing from known aged nestlings were available for analysis, of which a number of measurements represented a single observation of one individual nestling. The data were screened to exclude data

from known aged nestlings measured on less than three occasions. This resulted in a total of 147 observations from 28 individuals.

The random effects were assessed with a full model fitted where all three parameters were allowed to vary according to location of the observation and single deletion of the random effects fitted and compared to the full model.

At Coomallo Creek between 2009 and 2014, the lengths of the folded left wing were available for 17 nestlings whose hatching date was known and subsequently measured at ages ranging from 23 to 65 days. Their measurements were compared with the inverse calibration of age on length of folded left wing (table in Appendix) to assess the accuracy of the estimation of age with nestlings this century compared with those of the period 1970-1976.

Comparison of nestling age based on observations of physical appearance with age based on length of folded left wing: Both RD and DAS have extensive experience of observing and handling Carnabys cockatoo nestlings. Following the example of Boal (1994) we have prepared a series of 10 photographs to illustrate changes in size and plumage of nestlings over the 10–11 weeks of the nestling period. In November 2014, one of us (RD) provided an estimate of the age of ten nestlings at Coomallo Creek based on their appearance at the bottom of the nest hollow, the situation those not authorised to handle nestlings would be in. RD's estimate of age was then compared with the age estimated on the basis of the length of the nestling's folded left wing. The estimates of age based on length of folded left wing were made after RD's more informal, visual estimates were made.

Results

Aging nestlings based on plumage characteristics: The changes in size and plumage of nestlings from hatching until fledging, a period of between 10 and 11 weeks (Saunders 1979b), are shown in Figure 1A–J. Nestlings can be aged approximately by comparing their appearance with the nestlings illustrated in the figures. Aging on appearance is possible up to about nine weeks, but becomes more difficult from then on as they have no distinguishing physical changes as they grow larger. By the time they fledge they are nearly the same size as their parents (Saunders 1979b).

RD estimated the age of ten nestlings (subsequently aged from 18–67 days on the basis of length of folded left wing). On the basis of plumage characteristics, he underestimated nestling ages by an average of three days (range -11 to +5). His average accuracy was 90% (range 80–100%) of the age estimated on the basis of the length of the folded left wing.

Aging nestlings based on the length of the folded left wing: The three parameter logistic models fitted to the Coomallo Creek and Manmanning data have location-specific fixed effects for the asymptotic length *Asym*, but common fixed effect values assumed for the other two parameters, *xmid* and *scal*. The asymptotic length (mm) for the Coomallo Creek population is 353 (standard error 4.19) and 328 for the Manman-

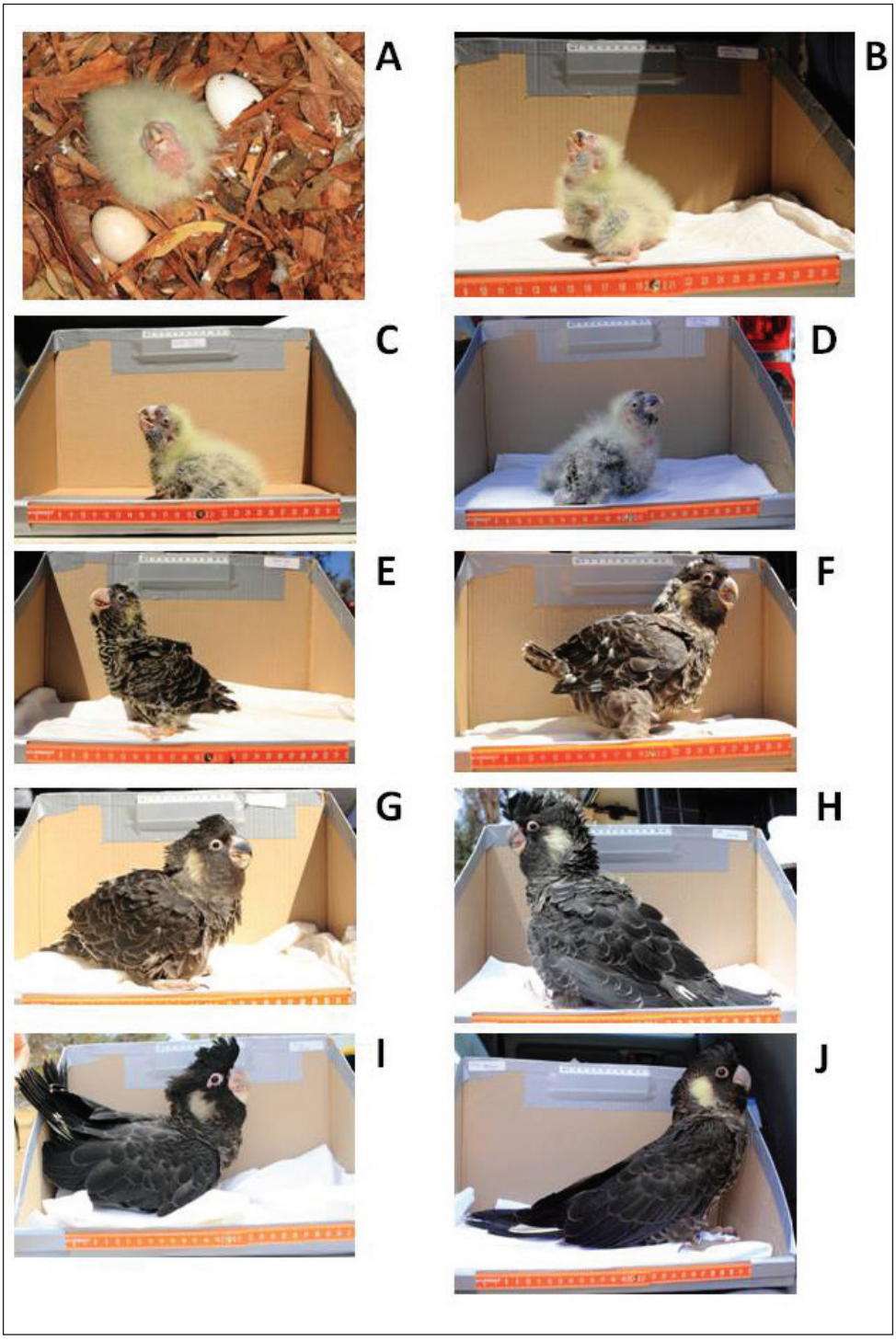
A
B
C
D
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Figure 1. A Week 1 (days 1–7, with day 1 being hatching day): On hatching, Carnaby's cockatoo nestlings are covered in pale yellow down. They are blind, can sit unaided and have a prominent egg tooth. Note the size of the nestling in relation to the width of the hatched egg which is about 34.5 mm (Saunders and Smith 1981) **B** Week 2: The nestling's eyes remain closed, it is still covered with pale yellow down with small developing dark pin feathers, the egg tooth is still present and, if touched the nestling will beg immediately. The scale in the foreground is numbered in cm **C** Week 3: The nestling's eyes begin to open, pin feathers burst through the skin on all feather tracts, giving the nestling a greyish appearance because of the feather sheaths under the down. The egg tooth starts to disappear **D** Week 4: Eyes are completely open, grey stripes become more prominent on the upper bill, down feathers are lost progressively as black feathers burst from their sheaths. The tail feathers begin to emerge and the cheek patch begins to appear **E** Week 5: The cheek patch is now clearly visible and sexing based on colour and shape of the cheek patch is possible from this age (Saunders 1979b), most down feathers are gone and black feathers with scalloping are prominent. The remnant of the egg tooth is no longer visible **F** Week 6: Tail feathers are a 2–3 cm long, down feathers continue to disappear, with body feathers almost full size and primary feathers extend almost to the tail. The small size of the cheek patch with darker suffusion and the non-circular shape indicates the nestling pictured is a male **G** Week 7: Very few down feathers, white tail band starts to emerge, bill end sharpens and crest becomes more prominent. The dusky shading and non-circular shape of the cheek patch indicate the nestling illustrated is a male **H** Week 8: White bands in tail feathers are 3–4 cm long, body feathers have a black sheen and are the same size as those of an adult, primary feathers are longer than the tail and some down feathers may be still be present. The size, clarity and more rounded shape of the cheek patch indicate the nestling illustrated is a female **I** Week 9: White bands in tail are 5–6 cm long, down feathers no longer present, nestling now resembles a small adult. It may be aggressive when handled or when an observer checks its nest hollow. The dirty colour of the cheek patch indicates the nestling illustrated is a male **J** Week 10: The size of the white bands in the tail feathers and the length of the primary feathers are close to those of adults. The nestling resembles an adult. It is capable of flight and if disturbed may fledge. The clarity of the cheek patch indicates the nestling illustrated is a female.

ning population (standard error 6.63). The other two parameters have values of 42.2 (standard error 0.62) (*xmid* in days) and 13.1 (standard error 0.22) (*scal* in days/mm). The two regression lines are shown on Figure 2 together with 95% confidence limits. There is increasing separation of the two regression lines as the ages of the nestlings increase, with nestlings from Manmanning having shorter folded left wing lengths for a given age compared with nestlings from Coomallo Creek.

These models have been used in an inverse way to estimate a nestling's age for a particular length of folded left wing as well as to provide confidence intervals around this estimate. As the regression lines approach the asymptote, the ability to estimate an upper confidence interval for nestling age is lost, as is implied by the model. The inverse calibration is given in the Appendix, together with the confidence intervals for the estimated age of nestlings given particular measurements of the length (mm) of folded left wings for nestlings in the Coomallo Creek and Manmanning populations.

The lengths of the folded left wings of the 17 nestlings of known age at Coomallo Creek 2009–2014 were compared with the data in the Appendix. These nestlings ranged in age from 27–67 days when measured. The ages of 12 (70.6%) of these were as estimated by the data for Coomallo Creek in the Appendix, or +/- 2 days of the estimate. The remainder were within the 95% confidence intervals, indicating that

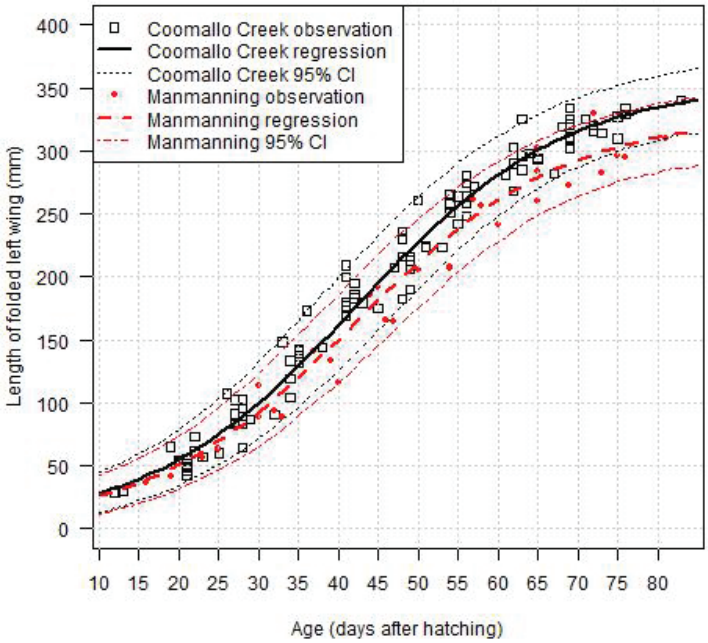

Figure 2. Fitted regressions and 95% confidence intervals for the relationship between length of folded left wing (mm) as a function of age (days) since hatching for nestlings of known age from populations of Carnaby's cockatoo at Coomallo Creek (1970–1974) and Manmanning (1970–1976).

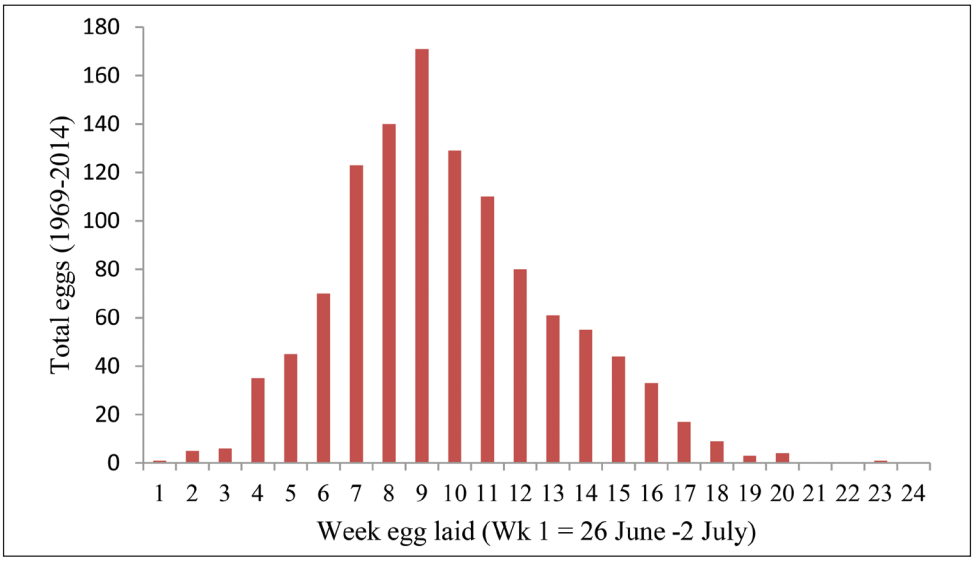

Figure 3. Mean number of eggs laid per week for the 28 years data were available from 1969–2014 (total eggs = 1143). Survey in second week of September (week 11) ensures that all early breeding attempts will be recorded (except those that have failed with no evidence left) and survey in the second week in November (week 20) allows all but 3.1% of breeding attempts to be recorded with some chance of establishing nestling age.

the table based on nestling data from the 1970s is accurate for estimating the age of nestlings this century from the length of its folded left wing.

Egg-laying period: Data are available on laying dates of 1143 breeding attempts at Coomallo Creek over 28 years between 1969 and 2014. These dates were extrapolated from the ages of nestlings. The mean number of eggs laid per week is shown on Figure 3. Because of the length of the egg-laying period, one survey each breeding season would not allow the length of the egg-laying period to be established; at least two visits are required. A survey in the second week of September (week 11 on Figure 3) would enable the commencement of egg-laying to be extrapolated as well as the number of breeding attempts to that time, with the exception of those that had failed before the visit and leaving no evidence of an attempt. A survey in the second week of November (week 20 on Figure 3) would have not been able to estimate the laying dates of 3.1% of the breeding attempts, as the eggs would not have hatched when the survey was being conducted.

Discussion

Under Western Australian Government regulations it is illegal to handle nestling Carnaby's cockatoo unless taking part in an authorised research project. However, not all those engaged in active research are authorised to handle nestlings, but they are authorised to make observations of the contents of active nest hollows in order to advise those authorised to actually handle and band/ring nestlings of the best time to visit particular populations to measure and band/ring nestlings (Matt Swan, WA Department of Parks and Wildlife *pers. comm.*).

In order to provide those engaged in research on the species with methods to age nestlings appropriate with their authorisations, we consider two methods for aging Carnaby's cockatoo nestlings when the hatching date is unknown; by looking at a nestling's physical appearance, or by comparing the length of the nestling's folded left wing against a growth curve for length of folded left wing and age developed from nestlings of known age. The former is not as accurate as the latter, but with experience it may be useful for gaining an approximation of the commencement and end of the breeding season without having to handle nestlings to take measurements. Aging nestlings by assessing changes in size and plumage has been used for a range of species, particularly raptors (Boal 1994, Gossett and Makela 2007, Becker and Weisberg 2013).

However, when more accurate estimations about commencement of breeding and the length of the breeding season are required, then measurements of the folded left wing of nestlings and aging them on some benchmark of length of folded left wing and age correlation is more appropriate. It has been found that wing length is the most reliable aging technique for a range of non-passerine and passerine species (Petersen and Thompson 1977, Bortolotti 1984, Poole 1989, Gosler et al. 1998, Pande et al. 2011, Penteriani et al. 2004, Penak et al. 2013, Wails et al. 2014), as it is for Carnaby's cockatoo. Hatching dates may then be extrapolated from the estimated age. Dates for egg-laying and fledging may also be extrapolated by taking the 29 days of incubation

and the 76 (72–80) days of the nestling period into account (Saunders 1979b). The sample should consist of as many nestlings as possible from a breeding population to establish commencement of egg-laying and length of breeding season.

Which regression line should be used; that derived from the Coomallo Creek or Manmanning data? What is apparent from Figure 2 and the table in the Appendix is the increasing separation of the two regression lines as nestlings age, with those from Manmanning having shorter folded left wings for a given age compared with nestlings from Coomallo Creek, although the difference in estimate of age is only 2.9% with the oldest birds. Saunders (1982, 1986) demonstrated that the population breeding at Manmanning was under stress, most likely related to shortages of food, particularly later in the breeding season. The Manmanning population had lower breeding success, changed breeding behaviour, and lower nestling growth rates than the population at Coomallo Creek (Saunders 1979b, 1982), which is still extant, with a breeding population similar in size to that of the early 1970s (Saunders et al. 2014). The Manmanning population had ceased breeding in the area by 1977. The facts that the breeding success of the Coomallo Creek population is similar to that of the 1970s, the breeding population is of a similar size and that growth rates for folded left wing is similar to that of the 1970s indicates that the regression line for the Coomallo Creek population should be used as the benchmark on which to age nestlings from other areas.

When is the most effective time to examine nestlings? Saunders and Ingram (1987) analysed egg-laying dates and established that two visits to breeding areas in the second week in September and the second week in November were the most likely to make sure all early and most late breeding attempts were recorded. Saunders et al. (2013) demonstrated that commencement of egg-laying in Carnaby's cockatoo is correlated with rainfall in the Austral autumn. The wetter the autumn the earlier egg-laying commences. In dry autumns, when egg-laying commences later, the second visit should be made in early December. If resources are available for only one visit a season, then the middle of October would result in recording most breeding attempts, with the caveat that some late breeding attempts may not be recorded.

Baudin's cockatoo is closely related to Carnaby's cockatoo and is of similar size and colouring (Saunders 1979a). The mean length of the folded left wing of Baudin's cockatoo is 379 mm (n = 102) compared with Carnaby's cockatoo's 364 mm (n = 293), a difference of 4.1%. Considering the lack of information on the nestling period and nestling growth of Baudin's cockatoo, the data presented for Carnaby's cockatoo should be used to age Baudin's cockatoo, until the methods described in this paper are used with data generated for Baudin's cockatoo to prepare more accurate aging methods.

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Appendix

Estimated age (days) since hatching of nestlings at Coomallo Creek and Manmanning based on the length of the folded left wing (mm) for lengths from 50 mm to 324 mm. The lower and upper 95% confidence intervals of the estimates are also given. Nestlings may be aged by taking the length of the folded left wing and looking up the predicted age for that length of folded left wing. Hatching dates can be extrapolated from that age, as can laying dates by taking the 29 days of incubation into account. Fledging dates can be extrapolated by taking the 76 days of the nestling period into account. For reasons explained in the text, the data from Coomallo Creek should be used the benchmark to age nestlings from other areas.

		Coomallo			Manmanning	
FLW (mm)	**Lower estimate**	**Predicted age**	**Upper estimate**	**Lower estimate**	**Predicted age**	**Upper estimate**
50	12	19	25	13	20	26
52	13	19	25	14	20	26
54	13	20	26	14	21	27
56	14	20	26	15	22	28
58	15	21	27	16	22	28
60	15	21	27	16	23	29
62	16	22	28	17	23	29
64	16	22	28	18	24	29
66	17	23	29	18	24	30
68	17	23	29	19	25	30
70	18	24	30	19	25	31
72	18	24	30	20	26	31
74	19	25	31	20	26	32
76	19	25	31	21	27	32
78	20	26	31	21	27	33
80	20	26	32	21	27	33
82	21	27	32	22	28	34
84	21	27	33	22	28	34
86	22	27	33	23	29	34
88	22	28	33	23	29	35
90	22	28	34	24	29	35

		Coomallo			Manmanning	
FLW (mm)	Lower estimate	Predicted age	Upper estimate	Lower estimate	Predicted age	Upper estimate
92	23	29	34	24	30	36
94	23	29	34	25	30	36
96	24	29	35	25	31	36
98	24	30	35	25	31	37
100	24	30	36	26	31	37
102	25	30	36	26	32	37
104	25	31	36	27	32	38
106	25	31	37	27	33	38
108	26	31	37	27	33	39
110	26	32	37	28	33	39
112	26	32	38	28	34	39
114	27	33	38	28	34	40
116	27	33	38	29	34	40
118	27	33	39	29	35	40
120	28	34	39	29	35	41
122	28	34	39	30	35	41
124	28	34	40	30	36	41
126	29	35	40	30	36	42
128	29	35	40	31	36	42
130	30	35	41	31	37	42
132	30	35	41	31	37	43
134	30	36	41	32	37	43
136	31	36	42	32	38	43
138	31	36	42	32	38	44
140	31	37	42	33	38	44
142	31	37	43	33	39	44
144	32	37	43	33	39	45
146	32	38	43	34	39	45
148	32	38	44	34	40	45
150	33	38	44	34	40	46
152	33	39	44	35	40	46
154	33	39	44	35	41	46
156	33	39	45	35	41	47
158	34	39	45	36	41	47
160	34	40	45	36	42	47
162	34	40	46	36	42	48
164	35	40	46	36	42	48
166	35	41	46	37	43	48
168	35	41	47	37	43	49
170	36	41	47	37	43	49
172	36	42	47	38	44	49
174	36	42	47	38	44	50
176	36	42	48	38	44	50

	Coomallo			Manmanning		
FLW (mm)	**Lower estimate**	**Predicted age**	**Upper estimate**	**Lower estimate**	**Predicted age**	**Upper estimate**
178	37	42	48	39	44	50
180	37	43	48	39	45	51
182	37	43	49	39	45	51
184	38	43	49	40	45	51
186	38	44	49	40	46	52
188	38	44	50	40	46	52
190	39	44	50	40	46	52
192	39	45	50	41	47	53
194	39	45	50	41	47	53
196	39	45	51	41	47	53
198	40	45	51	42	48	54
200	40	46	51	42	48	54
202	40	46	52	42	48	55
204	41	46	52	43	49	55
206	41	47	52	43	49	55
208	41	47	53	43	49	56
210	42	47	53	44	50	56
212	42	48	53	44	50	56
214	42	48	54	44	50	57
216	42	48	54	45	51	57
218	43	48	54	45	51	58
220	43	49	55	45	52	58
222	43	49	55	46	52	58
224	44	49	55	46	52	59
226	44	50	56	46	53	59
228	44	50	56	47	53	60
230	45	50	56	47	53	60
232	45	51	57	48	54	61
234	45	51	57	48	54	61
236	45	51	57	48	55	62
238	46	52	58	48	55	62
240	46	52	58	49	55	62
242	46	52	59	49	56	63
244	47	53	59	50	56	63
246	47	53	59	50	57	64
248	47	53	60	50	57	65
250	48	54	60	51	58	65
252	48	54	61	51	58	66
254	48	55	61	51	58	66
256	49	55	61	52	59	67
258	49	55	62	52	59	68
260	49	56	62	53	60	68
262	50	56	63	53	60	69

		Coomallo			Manmanning	
FLW (mm)	Lower estimate	Predicted age	Upper estimate	Lower estimate	Predicted age	Upper estimate
264	50	56	63	54	61	70
266	50	57	64	54	61	70
268	51	57	64	54	62	71
270	51	58	65	55	62	72
272	51	58	65	55	63	73
274	52	58	66	56	64	74
276	52	59	66	56	64	75
278	53	59	67	57	65	76
280	53	60	67	57	65	77
282	53	60	68	58	66	79
284	54	61	69	58	67	80
286	54	61	69	59	67	82
288	55	62	70	59	68	83
290	55	62	71	60	69	
292	56	63	72	60	70	
294	56	63	72	61	70	
296	56	64	73	61	71	
298	57	64	74	62	72	
300	57	65	75	62	73	
302	58	65	76	63	74	
304	58	66	77	64	75	
306	59	67	78	64	77	
308	59	67	79	65	78	
310	60	68	81	66	80	
312	60	69	82	67	81	
314	61	69	84	67	83	
316	61	70	85	68		
318	62	71		69		
320	62	72		70		
322	63	73		71		
324	63	74		72		

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The New Age of the Nagoya Protocol

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Abstract

The entry into force of the Nagoya Protocol of the Convention on Biological Diversity will lead to new legislation and regulations that could change international collaborative research in biology. This article suggests a new approach that researchers can use in negotiating international Access and Benefit Sharing agreements under the Protocol. Research on medicinal plants is used as a case study because it is a domain with many competing stakeholders involving non-commercial and commercial research, as well as national and international commercial markets. We propose a decision-based framework to aid all participants as they negotiate ABS agreements for non-commercial biodiversity research. Our proposed approach promotes transparency and builds trust, reflects the principles in the *Convention on Biological Diversity*, and respects and protects the interests of biodiversity rich developing countries. This approach is an alternative to often-used adversarial approaches.

Keywords

Nagoya Protocol, Access and Benefit Sharing, DNA barcoding, medicinal plants, Convention on Biological Diversity, international agreements

Introduction

The Nagoya Protocol (full name: *The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity*; CBD Secretariat 2011) was approved by the Conference of the Parties to the *Convention on Biological Diversity* in October 2010 after eight years of negotiation (see analyses in EU Parliament Directorate General for Internal Policy 2013; Laird and Wynberg 2012; Kamau et al. 2010). As of 14 July 2014, the Protocol had been ratified by the required 51 countries which triggered its entry into force on 12 October 2014, partway through the Conference of the Parties to the Convention on Biological Diversity (CBD) in Korea. From that point forward, all Parties to the Nagoya Protocol are expected to create implementing legislation and regulations. This will be no easy process and is likely to deepen long-standing divisions among stakeholders in this domain. Developing countries that are rich in biodiversity but poor in terms of wealth and technology are pinning great hopes on the economic value of their biodiversity. In implementing the Nagoya Protocol, these countries might tend towards restrictive legislation that erects barriers against perceived risk of misappropriation of their genetic resources by any and all potential users. Such protectionist regulations are not unreasonable responses but when the costs, benefits and unintended consequences are considered, they may not be the optimal route to long-term benefits and development. Specifically, a protectionist regulatory system might reduce unapproved uses of genetic resources but it may also erect barriers to the development and sharing of knowledge about national biodiversity. Such systems may limit access to training (in-country or international), technology transfer, capacity building and other benefits that international partnerships can offer. They also reduce incentives for the conservation of biodiversity when it is more profitable in the short-term to convert land to agriculture and other purposes than it is to study, preserve, and sustainably develop biodiversity. It need not be so.

Background

Prior to the *Convention on Biological Diversity*'s (CBD) entry into force in December 1993, biological samples flowed across most international borders with relative ease. Regulations focused on customs control for taxation purposes and to prevent the import of pests, pathogens and protected endangered species. The motivation for international transport of scientific samples varied widely. Some transfers were part of biological exploration for taxonomic and ecological studies and for education and public display, predominantly in developed country institutions. Some were part of academic biodiscovery projects on biological systems, including human diseases. The end-products were scholarly publications, museum exhibits, some capacity-building and training, and expanded awareness of and appreciation for biodiversity. Others were driven by the desire to develop commercial markets for cash crops, foods, medi-

cines, textiles, and the broad range of products that could be derived from living organisms. Some began as the former and developed into the latter, either by conscious design or through serendipitous discoveries of the economic value of particular species. Researchers in industrialized countries reflect back on those open borders as a golden age of research and development. Memories of this early period are markedly different in many biodiversity-rich countries whose species were exported and created wealth for others with little, if any, return. The term "biopiracy" is often used to summarize this view.

Rather than considering biodiversity as the common heritage of humankind, the CBD affirmed Sovereign States' control over the utilization of their genetic resources. The CBD established three objectives: (1) the conservation of biological diversity; (2) the sustainable use of its components; and (3) the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. In September 2002, Parties to CBD called for the establishment of an "International Regime" that would achieve the third objective, setting in motion eight years of negotiations that culminated in approval of the Nagoya Protocol. Under the Nagoya Protocol, obligations to share benefits are triggered by the utilization of genetic resources and are based on a requirement for potential users to seek Prior Informed Consent (PIC) and negotiate Mutually Agreed Terms (MAT) with governments and local indigenous peoples that hold traditional knowledge associated with the genetic resources.

Some countries enacted laws during the negotiation process to protect their genetic resources by requiring PIC and MAT. Such laws, empowered by the CBD and now clarified by the Nagoya Protocol, could create a level playing field for joint activities with mutual benefits between industrialized and developing countries. However, many of these laws have gone beyond international regulation to also cover domestic access. New barriers in some countries limit access by in-country researchers to genetic resources, especially in areas inhabited by local communities or indigenous peoples (Beas-Rodriguez 2012). This suggests that mistrust over the misappropriation of genetic resources without due compensation can apply to both domestic and international research.

The likely entry into force of the Nagoya Protocol stimulated several efforts to facilitate the process of drafting ABS agreements. For example, the Swiss Academy of Sciences provided a useful ABS management tool with best practices (Stratos, Inc. 2012) and developed a template for non-commercial ABS agreements with model clauses that negotiators could plug into the template (Biber-Klemm, Martinez and Jacob, 2010). We suggest, however, that one-size-fits-all solutions, even those with selections of model clauses, (a) will be difficult to use, (b) may not align with the specific interests of the parties, and (c) may not satisfy national ABS and other laws. The numbers and types of participating stakeholders will be highly variable, their concerns and sensitivities will depend on many factors, and the capabilities and ambitions of participating researchers will be important but unpredictable factors. Indeed, use of off-the-shelf agreements runs the risk of including spurious terms and conditions or, conversely, omitting terms and conditions that are required to meet the needs and

interests of the parties. It also misses a critical opportunity offered by the negotiating process - the chance to engage potential partners in meaningful discussions that promote the development of long-term, trust-based research relationships (Cragg et al. 2012; Geary et al. 2013).

Non-commercial biodiversity research (sometimes termed 'basic'), both domestic and international, is becoming a casualty in the struggle over potential monetary benefits from commercialization of genetic resources and derivative products (Vernooy et al. 2010). Most of the interest in international biodiversity research is from the academic sector, not commercial companies. The stated goals of this academic research are the generation of greater knowledge and scholarly publications in taxonomy, chemistry, ecology, ecosystems science and related fields such as ethnobotany, in this case. History has shown that intentionally or not, some non-commercial research projects have uncovered potential commercial value. This has led many to conclude that commercial and non-commercial research can no longer be distinguished *a priori* and should therefore be treated as a single indivisible enterprise in the negotiation of ABS agreements. However, non-commercial research is at the core of one CBD objective (the conservation of biological diversity) and provides the basis for another (sustainable use of biodiversity). Indeed, the Nagoya Protocol specifically calls on states to "Create conditions to promote and encourage research which contributes to the conservation and sustainable use of biological diversity, particularly in developing countries, including through *simplified measures on access for non-commercial research purposes*, taking into account the need to address a change of intent for such research" (*Nagoya Protocol, Article 8(a)*).

To assist in the implementation of the Nagoya Protocol at the moment of its launch, we propose a framework to assist in the negotiation of ABS agreements for non-commercial research. It includes a mechanism to separate non-commercial from commercial projects, or, alternatively, to anticipate potential changes of utilization of genetic resources from non-commercial to commercial research.

Case study: a DNA barcode registry for medicinal plants

We convened an international, multi-stakeholder workshop in Mexico City in 2013 to advance the debate on access to genetic resources and the sharing of benefits as they may relate to an emerging taxonomic tool called DNA barcoding. Representatives from academic, government and non-governmental organizations from 11 countries in the Americas, Europe and Africa participated (see Workshop Participants). Our focus was the design of a negotiating framework for ABS agreements that would enable construction of a species registry for medicinal plants based on "DNA barcodes". DNA barcoding has been used primarily by taxonomists and ecologists for non-commercial research leading to academic publications. However, the barcoding process raises many of the concerns that led to creation of the Nagoya Protocol: expatriation of biological samples, DNA sequencing, the public release of sequence and other data with potential

monetary value, risks of unapproved changes in utilization of genetic resources from academic to commercial, and lack of benefits shared with provider countries.

We selected medicinal plants as the focus because of the diversity of both commercial and non-commercial stakeholders interested in medicinal plants and the global commercial potential of natural health products (NHPs) derived from these species. Because barcoding can unquestionably "utilize" genetic resources for both non-commercial research and commercial activities, ABS agreements that meet the interests of divergent stakeholders will be essential in the development of a registry, especially if plant samples need to cross international borders.

DNA barcodes are short gene sequences taken from a standardized portion of the genome that can be used to identify biological samples to the species level. The gene regions used for animals, plants and fungi were chosen because they evolve fast enough to separate closely related species but slowly enough that the members of any species are identical or nearly identical (Hebert et al. 2003; CBOL Plant Working Group 2009; Hollingsworth 2011; Schoch et al. 2012). As a result, barcode data separate species well but cannot normally diagnose the regions of origin within a species. The standard barcode regions are well-studied and have no known commercial value such as in drug development or GMO foods. DNA sequences from the approved barcode regions are submitted to GenBank or other members of the International Nucleotide Sequence Database Collaborative (INSDC). Each sequence is linked to a voucher specimen whose species identification has been verified by taxonomic experts. These vouchers are available for examination and confirmation in research biorepositories. Barcode sequences are then taken from unidentified samples and compared with the sequences in the GenBank reference library. This makes it possible to identify species using their DNA in an objective, repeatable way, including medicinal plants growing in the field or processed into powdered mixtures such as those found in herbal remedy capsules.

Since barcoding was proposed, a global network of researchers (primarily taxonomists and ecologists) has submitted more than 400,000 standardized high-quality BARCODE records to GenBank. The Consortium for the Barcode of Life (CBOL) created a Database Working Group that developed the BARCODE data standard after a year of community consultation (Hanner and the CBOL Database Working Group 2005). Data records in INSDC that meet this data standard have the reserved keyword "BARCODE". In addition, more than 2 million have been submitted to the Barcode of Life Data Systems (Ratnasingham and Hebert 2007), a public workbench for barcode projects. The International Barcode of Life project (iBOL), led by the University of Guelph in Canada is the largest coordinated barcoding effort, and initiatives have been launched within taxonomic groups (e.g., fish, Steinke and Hanner 2011; birds, Kerr et al. 2007).

DNA barcoding has already been put to use for similar regulatory applications. The US Food and Drug Administration has tested and adopted DNA barcoding as a tool for regulating seafood in the marketplace (Handy et al. 2011). DNA barcodes are also being put to work for the investigation and prosecution of wildlife crimes against endangered species (see Barcode of Wildlife Project). Several barcode-based analyses

of medicinal plants in the marketplace have already been published (Baker et al. 2012; Newmaster et al. 2013), demonstrating how data from taxonomic studies can be used for consumer protection. The Attorney General of New York State recently took legal action against manufacturers for inaccurate labeling of herbal remedies based on DNA barcoding analyses (O'Connor 2015).

Sharing benefits and risks

An objective, reliable registration and identification system for medicinal plants would enable research on their basic biology, ecology and evolution in ways that would support species conservation programs. Provider country partners in the construction of the registry could benefit from training, capacity-building activities, co-authorship and participation in related research networks. The registry could also provide an arena in which a globally sustainable NHP industry can develop and be regulated. The barcode registry could: (1) open markets for wild crafters and local communities by assuring purchasers that their plants belong to the medicinal plant species that have been tested by regulators and approved for trade; (2) assist the NHP industry in establishing measures of quality assurance tied to each species; (3) assist public health agencies in verifying the species they are testing for clinical efficacy; (4) assist regulatory agencies in confirming the accuracy of product labeling; (5) provide customs and trade authorities with tools to monitor cross-border trade; and (6) enhance consumer confidence in the authenticity of the natural health products they purchase. Indeed, the registry would provide all stakeholders with an objective, transparent taxonomic vocabulary for discussing access to genetic resources, monitoring the resulting flow of medicinal plant materials, and enabling informed discussion of benefits generated by each species. Over time, the DNA barcode registry of medicinal plants would grow through the work of globally-distributed taxonomists and conservation biologists and would complement the content and impact of pharmacopeia.

We see three main challenges along the way to attaining these longer-term benefits. First, all stakeholders in provider countries will want assurances that an approved non-commercial research process of creating the registry will not lead to unapproved commercial use of their genetic resources and associated traditional knowledge, whether by domestic or foreign researchers. The fear of unapproved use is greatest for expatriated samples. Second, all stakeholders in both provider and receiver countries will need to stipulate all non-commercial research activities enabled by the agreement and the benefits they can expect to receive from such activities. The Nagoya Protocol articulates an expansive view of benefits which include collaborative research, access to technology, training and other forms of capacity building.

The final challenge in defining reasonable expectations is the delineation of non-commercial versus commercial research (Popp 2012). CBOL convened an international, cross-sectoral workshop on this topic in Bonn, Germany in November 2008. We agree with the findings of that workshop (CBOL 2008; Schindel 2010) and be-

lieve that non-commercial and commercial intent can be separated in the process of negotiating ABS agreements with the aid of our framework. Box 1 presents a list of activities that reflect commercial intent. An agreement to develop a barcode-based registry of medicinal plants could include a statement that these activities will be considered potentially commercial in character. Parties would agree not to participate in any of these activities under the Barcoding agreement, and that interest in initiating any of these would trigger a halt to all research activities and require the parties to negotiate a new ABS agreement based on commercial intent. In our view, this approach is preferable to the pre-negotiation of clauses for a possible shift to commercial intent, which add to the complexity of agreements and delay negotiations. The nature of commercial activities and the scope of potential benefits that may arise are extremely difficult to determine *a priori*.

Since DNA barcoding is currently beyond the technical capabilities of many developing countries, the construction of a reference library will often require international collaboration. Plant material may need to cross national boundaries to reach secure biorepositories and molecular biology labs capable of DNA barcoding. Even if a provider country has a secure repository, participants may decide that there is value in having duplicate specimens in another repository for reasons of security. In addition, providers would have to give permission to sequence the very short DNA barcode regions and agree to release the sequences into a publicly accessible reference library. Each of these conditions could conceivably raise concerns related to "biopiracy". How then could an ABS agreement be negotiated for the relatively straightforward task of characterizing and registering species, while protecting the commercial potential of medicinal plants and the higher-stakes that would be involved in ABS agreements to follow?

A decision-based framework for ABS agreements

To facilitate the process of negotiating and drafting ABS agreements, especially for non-commercial uses of genetic resources, we propose a decision-based framework. The framework guides representatives of provider and user countries through a series of decisions related to real or perceived risks and suggests choices (see examples, Box 2). The structure of the resulting ABS agreement is shown in Box 3. The goal is to develop agreements that are as simple as possible while addressing the needs, constraints and interests of the parties involved in the negotiation. Since relationships may evolve over time, a decision framework must reflect evolving best practices in negotiating ABS agreements (Biber-Klemm et al. 2010) and allow the parties to develop a narrative of the relationship that captures the expectations of all stakeholders, including those not directly party to the agreement. This narrative becomes the preamble to the agreement and the lens through which the terms of the agreement are interpreted and any disputes resolved (Gold and Bubela 2007). By guiding the negotiation and serving as a communications tool, the proposed framework can strengthen the negotiating position of a developing country partner who may have more limited access to legal

advice. It has the added benefit of informing legal counsel from developed country institutions, who may have limited understanding of ABS agreements, of the needs and interests of developing country partners.

We are in the process of developing a software tool that will enable researchers and provider countries to use the decision-based approach we propose here. The tool will use an interview format to guide potential partners, separately and then together, through the identification and resolution of their interests and concerns. This will then enable them to develop specific agreements with the aid of legal counsel, using terms that are compliant with local laws and conditions.

In conclusion, our framework takes a pragmatic and adaptable approach to the negotiation and development of ABS agreements that are specific to non-commercial research. Our framework will reduce the power imbalances in the negotiation of research agreements between institutions in the Global South and Global North and will aid in building ongoing relationships reliant on trust and good faith. In the process, it will develop the necessary capacity in ABS negotiations and will help to overcome the history of mistrust and exploitation in the use of genetic resources. More specifically, the proposed approach will facilitate the success of barcoding initiatives such as the construction of a registry for medicinal plants. Initiatives such as this will support conservation efforts and will serve the interests of stakeholders in biodiversity rich regions.

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Box 1. List of activities that might be prohibited in non-commercial ABS agreements

A. The following actions could be considered indications of commercial intent:

- Negotiation of fees by either party beyond cost-recovery for access to data, technology, or materials resulting from the research;
- Retention of monetary benefits from sale or lease for profit, patenting, or licensing of research results;
- Transfer of material to commercial third parties;
- The filing of a disclosure of invention with an institutional technology transfer office;
- The filing of a patents or other Intellectual Property Right (IPR);
- Intent to investigate commercial applications, contract with a commercial body or entity, or conduct market research;
- Product development or testing of technology or products as part of a wider undisclosed project; or
- Other forms of contractual restrictions on the dissemination and subsequent use of the results.

B. The following actions could be considered contrary to best practices for non-commercial research:

- Restrictions on the release of research findings (e.g., non-disclosure agreements or unwillingness to publish results) if agreement terms are observed;
- Limitations placed on the involvement of provider country researchers in a project as collaborators and co-authors;
- Publication of results without providing pre-publication access to results by designated institutions in the provider country;
- Delays in the public release of data resulting from the research

Box 2. Examples from a decision-based framework for developing ABS agreements

The following excerpts from a larger treatment (in development) demonstrate how a decision-based approach can be used to negotiate terms of an ABS agreement in the

area of international transfer of genetic resources. Decisions shown in brackets arise from higher-level decisions in a multi-level decision tree.

1. Does the provider country have repositories in which voucher specimens can be archived securely and accessed by researchers?
   a. Yes {What in-country access will the users have to voucher specimens? Can some of the vouchers or subsamples be expatriated?}
   b. No, but the provider country is seeking help in developing one {What specific support and capacity-building is sought?}
   c. No {Proceed to next decision}
2. Can voucher specimens be expatriated?
   a. Yes {What access will the provider country have to their voucher specimens?}
   b. Yes, but only if duplicate specimens and/or subsamples remain in-country {What exchange of information will take place to synchronize the data associated with samples from the same voucher?}
   c. Yes, but with monitoring and safeguards against unapproved use {What specific conditions would be acceptable?}
   d. No {How will secure long-term storage and access by the user country be assured?}
3. Where will tissue samples be analyzed?
   a. In a provider country lab {How can in-country lab capabilities be assured? Is additional training needed? What access to analytical results will user countries have?}
   b. In a provider country lab following capacity-building and training {What training and capacity-building is sought?}
   c. In a user country lab with monitoring and safeguards against any use other than barcoding {What specific conditions would be acceptable?}

Box 3. Example of high-level structure for an ABS Agreement Framework.

Each topic area will link to multiple options for consideration and discussion by the intended non-commercial research partners.

Background

1. Identify the Parties to the Agreement (generally at the institutional level)
2. Identify those with interests in the Agreement, including researchers and indigenous/local communities.
3. Which national ABS laws, regulations or ethics/permitting requirements apply, if any?
4. Which agencies/departments administer (3)?
5. Are there requirements for Prior Informed Consent (depends on answers to 2-3)?

Prior Informed Consent

6. What is the general relationship between providers and users concerning international transfer of material (see examples, 2)?
7. What are the overall scientific or other goals of the project, for example:
   a. Bio-conservation Goals;
   b. Taxonomic Goals;
   c. Regulatory Goals.
8. What are the methodological and sampling details, for example:
   a. Taxonomic groups and number of species;
   b. Geographic area, habitats, numbers of collecting sites;
   c. Methods for collection, preservation, etc.

Mutually Agreed Terms

9. Anticipated outputs, outcomes, and impacts, for example:
   a. Curated collections of whole specimens;
   b. Preserved tissue samples;
   c. Publications;
   d. Publicly released data;
   e. Policy and other impacts.
10. Benefits to providers, for example:
   a. New knowledge;
   b. Collaborative research in local priority topics;
   c. Training and capacity development;
   d. Equipment.
11. Roles and Responsibilities of the Parties, for example
   a. Responsibilities for licensing, funding, sample collection, shipping, handling of materials and data, sequencing, storage;
   b. Responsibility for destruction of samples and/or data;
   c. Constraints on replication or transfer of materials.
12. Declaration of non-commercial intent with identification of terms that trigger a change in purpose (See Box 1).
13. Standard legal terms, for example, termination, liability, warranty, jurisdiction.