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Achieving and communicating globally relevant applied ecological research

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Introduction

The publication of scientific papers in peer-reviewed journals is arguably among the most important and time-consuming activities performed by academics. Articles are a key component of any researcher's CV, while metrics derived from citations and Altmetric scores are commonly used to assess the quality and impact of research. Publishing is perceived by many as a necessity ('Publish or Perish!'), and options for scientific publication are constantly on the rise (Larsen & von Ins 2010).

To an inexperienced eye, many scientific journals potentially represent an appropriate outlet for a given study. In reality, journals differ in terms of niche and targeted audience; a failure to appreciate these subtle differences in scope can lead to the frustration of work being rejected without review. With >1000 submissions a year for c. 180 published articles, our criteria for acceptance have to be strictly tied to the Journal's scope. Many initial rejections are directly linked to a lack of adherence to the Journal's applied ethos, which we have decided to spell out more clearly.

Journal of Applied Ecology aims to publish research that meets the twin challenges of being sufficiently applied to have immediate management implications, yet of broad enough interest that the inferences and insights are relevant far beyond the study system. Our focus covers all major themes in applied ecology, such as conservation biology, global change, ecosystem services, environmental pollution, wildlife and habitat management, land use and management, aquatic resources, restoration ecology, and the management of pests, weeds and disease. Articles that use concepts, models or data from any other scientific field (e.g. social science) are also welcomed, provided that their ecological relevance is clear. Likewise, the Journal accepts papers with a methodological focus, but only where there is a very high (and explicitly demonstrated) potential to contribute directly to management or to directly inform policy.

Here, we use our editorial and academic experiences to provide guidance for potential authors of *Journal of Applied Ecology* papers. Specifically, we consider how to meet the challenges associated with producing articles that report cutting-edge ecological research of international relevance and demonstrate clear implications for the management of natural systems. We focus on three key stages of the research process: (i) planning and execution; (ii) writing; and (iii) dissemination and communication of the findings. We hope this editorial will be of interest to all potential contributors, and will become a useful resource for those who are new to publishing applied ecological research.

Planning and execution

ENSURING APPLIED RELEVANCE

Many standard research papers are rejected from *Journal of Applied Ecology* because they lack clear management or direct policy relevance (i.e. can be used explicitly as evidence to inform policy). Often, this is because authors have tried to retrofit the applied angle after completing the work. Before writing the paper, it is essential to consider what actions are recommended by existing management strategies and policies, who will benefit from the new research to be published and who is likely to enact the recommendations. Sometimes the research itself can be co-designed with practitioners and policymakers. Even when this is not possible, applied relevance can still be maximized by relating the research to appropriate applied articles and policy or management documents.

Management relevance is not a binary property of research but lies on a continuum, from potential relevance well downstream from the current focus, to clear and immediate relevance to policy or practice. For example, an improvement to the way detection is modelled in occupancy studies clearly bears some relevance to environmental management; however, that relevance could be considered to be marginal if (i) the improvements are not demonstrated to lead to estimates that are significantly different from the old methodology; (ii) the data required to implement these improvements are not cost-effective to collect; or (iii) the process associated with the implementation of these adjustments is unlikely to be accessible to managers, perhaps because code is not freely available or mainstream platforms for managers to use it are absent. Being published in *Journal of Applied Ecology* requires more than stating that the research findings could be useful to management or policy: the paper needs to demonstrate how and why the new findings matter.

Deciding when the management implications are too remote from the current focus is not a straightforward endeavour. It is very unlikely that any given paper will provide the final word on a particular policy or management implementation, and novel papers should spur further research. Certainly papers that expose critical flaws in management and policy can be very important contributions, even if they do not provide immediate solutions. In these cases, the need for solutions can serve as an important impetus for further applied research. However, papers identifying a small incremental improvement are much less likely to be of broad interest. Where editorial decision-making becomes difficult is when a paper shows a new relationship or tests a new hypothesis that may be of interest to applied practitioners, without

actually evaluating management outcomes or making explicit management recommendations. For example, a paper might show a new relationship between plant diversity and non-native generalist pollinators but this, in itself, is not sufficient to alter the management of non-native insects, despite the high potential for broad interest. In this case, *Journal of Applied Ecology* requires that authors consider potential management options and provide clear guidance for studies to model or experimentally test the efficacy of these management options.

Of course, both practitioners and policymakers also need to communicate their needs to the scientific community. *Journal of Applied Ecology* provides for this via the Practitioner's Perspective and Policy Directions articles, which are designed to provide a platform for those dealing with applied problems to inform the academic community about their concerns and needs. These have proven very popular since their inception, with average download figures for these article types around 50% higher than the Journal average (which is fairly high overall – a total of 980 000 article downloads in 2014). These contributions help to break down the much discussed gap between research and implementation (Knight et al. 2008), and we hope they stimulate policy and management-relevant research.

ENSURING RELEVANCE BEYOND THE STUDY SYSTEM

Journal of Applied Ecology aims to publish high-quality robust science that is of use to environmental managers. Nonetheless, some papers that are genuinely applied in nature and focus on key issues of interest to managers and/ or policymakers may not be a good fit for the Journal due to issues with scientific robustness or relevance beyond the study system. While most non-academic stakeholders and conservation practitioners focus their interests on a specific region, species or system, many of the problems they face are similar. Lessons learned in one system may thus offer important insights or guidance to the management of other systems. It is therefore important that researchers ensure the implications of their work extend beyond the study system they consider. Here, we outline two ways in which applied studies can achieve broad relevance.

First, studies of a single species or region may be of broad interest if the research is embedded within appropriate ecological theories or management paradigms so that the conclusions contribute to broad advances in scientific knowledge. For example, a study of a particular species of invasive plant will be of little general interest if it only reports on the factors influencing the plant's spread in a given area. However, the research would be far more compelling if the data were used to test generally applicable and management-relevant hypotheses about the absence of factors that limit the fitness of the invasive plant, as it would then be applicable outside of the range in which the study itself takes place; it would also be reasonable to infer that the findings could apply to other species.

Secondly, the chances of revealing novel and generally applicable inferences will be greatly enhanced by a robust sampling design, and sufficient spatial and temporal replication. Put simply, it can be difficult to develop generalizable inferences from fieldwork conducted in a single season or year, or from a relatively small geographic region, and reviewers are often critical of inferences based on limited sampling.

Yet there is often a tension between site-specific and management-relevant research questions and the level of replication needed for appropriate scientific conclusions. One scenario often faced by managers is the need for expert advice on a single site about an issue that cannot be studied using a traditional replicated experimental approach. For example, local authorities may want to know why wigeon *Anas penelope* populations are declining at a single site. However, while general rules can be brought to bear on the problem (such as using optimal foraging theory, disturbance ecology and habitat management to develop a site plan) the ultimate reasons for proving why the population is changing at this one site lie beyond the scope of experimental science; such a site-specific study case would stand low chances of making it through the Journal's editorial process. This can be a challenging message to convey to practitioners because while we wholeheartedly support the use of science to inform management and policy, including at local (e.g. site specific) scales, the evidence base on which this is founded needs to be broad and robust. Advances in our scientific understanding are best served by long-term data across multiple sites to tease apart the role of various possible drivers such as climate, human disturbance and interspecific competition; these types of broad, comprehensive data sets are more likely to be found in our published research articles.

This apparent trade-off between local relevance and global significance is not insurmountable – indeed, overcoming it is the hallmark of the papers we aim to publish. Again, the co-creation of research questions between practitioners, policymakers and academics will help ensure that both good replicated science and suitable evidence for management and policy are established. The co-design of research questions does not mean communication between researchers and practitioners should stop there. A sustained working relationship with stakeholders throughout the life cycle of a research project is likely to enhance take-up and use of the management or policies that result from the work.

Writing a clear and effective applied paper

Research papers are the cornerstone of scientific dissemination. Writing them is challenging, and not just for early career researchers or those with English as a second language, but also for established researchers. While they need to be technical and precise, many of the best papers are also written in a very straightforward and simple style that is easy to understand. A good paper will also have a logical flow and a high information content-to-word count ratio. Readers should come away with an understanding of the science, impetus and implications of the research, but without the impression that the paper was difficult or exhausting to read. Each section of a paper is important to the overall story, and there are strategies to maximize the impact of each section. There are many sources that provide guidance on scientific writing (e.g. BES 2015a) so we only provide brief insights and pointers focussing on issues that are most relevant to standard research papers in *Journal of Applied Ecology*. We hope that this will be of particular interest to those new to publishing or to experienced scientists with less experience of communicating their science in an applied context.

Title and Summary (Abstract): These are critical to communicating your main message, and the only part that many casual readers, journalists and practitioners will read. The title needs to be relatively short, informative and jargon free and to communicate the main finding or implication. The Abstract, which is called a Summary in *Journal of Applied Ecology*, must clearly state the main problem (i.e. what we do not know and why this study is needed) in a broad context, questions, methods and conclusions in a manner both concise and precise. *Journal of Applied Ecology* requires the summary to end with a 'Synthesis and applications' or 'Policy implications' paragraph. This is of paramount importance as it tells the reader, especially those from applied communities, the key implications for management and policy. Policy implications should clearly identify the specific policy instruments that should be modified as a result of the findings of the study.

Introduction: This must clarify the scale and generality of the societal problem that the article addresses and its relevance to the wider ecological literature. Introductions used to be short and concise – typical *Journal of Applied Ecology* papers in the 1960s extended to just two short paragraphs (e.g. Thomas & Pratt 1967). The increase in length over time represents the expanding ecological knowledge base – put simply, there is so much more ecological science to build upon now. However, introductions should not be confused with literature reviews, and it is possible to outline the importance, novelty, context and aims by adhering to the classical four-part introduction. This is used across disciplines and examines (i) why the topic is important in the broadest sense, which for an applied study should highlight the societal importance; (ii) the state of the science, including the narrower subject, region, community and species-specific context; (iii) the key knowledge gaps and why they matter; and (iv) an outline of how this paper will meet the knowledge gaps, why this is novel, and the aims and hypotheses it will test. These sections often fit neatly into four paragraphs, such as in Inclán et al. (2015) or Scheper et al. (2015).

Materials and Methods: The reader needs to understand what has been done and why, and to repeat it, should she/he wish to do so. It is important to demonstrate that the approach is informed by the most recent literature and that biases have been corrected for to the best of the research team's ability. This is particularly important as much applied ecological research relies on the use of proxies (Stephens et al. 2015), the adequacy of which must be established for robust evidence to be generated.

Results: A good results section will be clear and concise – features which are common to all science. To achieve this, it is very helpful to sketch the key figures and tables before you start collecting or analysing data. As the manuscript develops, it can be tempting to introduce results and patterns that emerge along the way. This should be avoided, as the story needs to be a quick, straight trip and not a meandering stroll. However, analyses that are important to aspects of the paper but not central to the hypotheses being tested (e.g. sensitivity analyses, non-significant environmental variables) can be included in the online supporting information. This can also be used to strengthen arguments (e.g. presenting a minor result that is needed simply to support one assumption or assertion) without including surplus material in the main text.

Discussion: Discussions should not simply restate the results; rather, the results should be put into the context of the main questions. When the introduction is clearly structured, the discussion can mirror it, starting with a critical examination of the main hypotheses in relation to other studies and the knowledge gaps, and ending with the broader implications for management and policy that explicitly links back to the applied issues stated in the opening paragraphs of the introduction. It can be helpful to divide the implications of the study into two parts: the local relevance, including the support for improving current management practices or region-specific laws; and the global relevance, including theoretical advances.

Dissemination and communication

While it is immensely gratifying to see years of hard work captured for posterity in a published journal article, this should not be the end of the research process. Across the world, funding bodies and governments are paying increasing attention to scientific impact. And what is the purpose of applied science if it is not going to reach those who make management decisions? While it can be very difficult to link specific work to changes in policy that happen much later and at very different scales (Milner-Gulland et al. 2012), the difficulties should not justify inaction. The recent Policy Directions paper by Durant et al. (2015) provides an excellent recent example where science was used to influence policy, through the creation, at the Convention on Migratory Species, of a new working group on issues surrounding the use of fences in dry lands. But with almost two million scientific publications a year, and scientific output doubling every 9 years (Bornmann & Mutz 2015), it is clearly important to help direct the paper to the relevant academics and non-academics. This can be as simple as sending your manuscript to interested academics, but reaching non-academic audiences will likely require further communication effort. Developing a short, compelling summary of the research can be particularly effective if you plan to use press releases or social media. Such summaries need to be free of jargon, distil the information into a simple message and state why the research is important. Depending on the local context, it can be important to translate the dissemination material into other languages. The Journal's social media channels and The Applied Ecologist's blog (The Applied Ecologist's blog 2015) are available for authors who wish to communicate their research to a broader audience. In 2015, the Journal's Twitter account reached over 8000 followers and we mention every article published at least once on both Twitter and Facebook. The Applied Ecologist's blog received c. 20 000 views from over 12 000 visitors, in the same period. Authors are encouraged to promote their articles actively. To help them do this, a page on the Journal website is now dedicated to providing tips for disseminating applied research more widely and describing some of the new tools available to authors (BES 2015b).

The greatest local impact will arise where results are disseminated in person. For example, a study of the ecological implications of urban storm water run-off can make for a compelling and interesting press release or blog post, but the authors should also consider giving a public lecture in the city or region where the study was conducted. Many field biologists find themselves promising these types of dissemination during research, but they rarely happen unless planned and budgeted for from the start (Toomey 2015). Ultimately, the dissemination

of the hard-won data should be one of the most rewarding parts of the research process, although it is often too easily dismissed in favour of further academic activities.

Conclusion

The growing influence of humans on the world's ecosystems and species defines a new geological epoch, the Anthropocene (Lewis & Maslin 2015). Applied ecological research can directly inform management and policies that will mitigate human impacts on biodiversity, ecosystem services and human well-being. Ecology itself is adapting to meet these challenges; there is a growing requirement for scientists to consider research impact and a growing focus on longer-term research (Milner-Gulland et al. 2012; Stephens et al. 2015), which is reflected by the growing number of submissions to applied ecological journals. We hope that this editorial provides a useful guide to developing, writing and disseminating your globally relevant applied ecological research.

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