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Applied Ecology Explained

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Abstract

Applied ecology differs from other ecological subdisciplines in that it primarily involves the scholarship of application. Many questions asked by applied ecologists cannot be stated as a hypothesis, making the scientific method unsuitable for addressing them. Transdisciplinary scholarship is an approach that can be used to address these kinds of applied ecological questions, involving experts from STREAM disciplines (Science, Technology, Recreation, Engineering, Arts, and Mathematics), social sciences, humanities, community leaders, and stakeholders to solve real-world problems. *Homo sapiens* is the focal species in applied ecology. Peer-reviewed outcomes of applied ecology include scholarly publications, policy creation, establishment of protected areas, community-focused conservation efforts, and activities that improve ecosystem services. A transdisciplinary team addressed the applied ecological question "How can the negative effects of plastic microbeads be reduced or eliminated in aquatic ecosystems?" Unnatural plastic beads were sampled from a local stream, analyzed, and discussed with stakeholders and experts. After this information was aired on television, more stakeholders and policy-makers expressed concern, and pursued efforts to remove plastic microbeads from personal care products. Local efforts grew to a national concern, resulting in President Obama signing the Microbead Free Waters Act (H.R. 1321) on December 28, 2015.

Keywords: HAMSTER disciplines, intervention ecology, Microbead Free Waters Act, scholarship of application, STEM Disciplines, transdisciplinary scholarship

1. INTRODUCTION

ESA President David Lodge recently wrote "*The Ecological Society of America will continue to be the source of information - from discoveries of how nature works to the application of those discoveries for the benefit of all.*" Undoubtedly, ecological knowledge has existed and been applied for as long as humans have interacted with their environment. In this sense, humans are not a unique species. More recently, and uniquely human, ecological knowledge was created using the scholarship of discovery and scientific method (*sensu* Boyer 1990), beginning in earnest with the work of G. Evelyn Hutchinson, known as the "Father of Ecology". Prof. Hutchinson considered Charles Darwin the "Father of Ecology" (Lovejoy 2011). Regardless of which of these great scientists deserves the title, the formal science of ecology is less than two centuries old. Most ecological discoveries communicated in peer-reviewed journals came from government and university researchers. Government agencies, farmers, ranchers, and resource managers have been applying ecological knowledge for decades (Hone et al. 2015). These management activities involve the scholarship of application (Boyer 1990). To my

knowledge, the first American institution of higher education to hire a tenure-track applied ecologist was the University of Colorado Denver. In 1998, I had the good fortune to be hired as that applied ecologist.

With this current manuscript I attempt to explain what applied ecology is, and in some ways, what it is not. I use a recent case study that addressed the applied ecological question "How can the negative effects of plastic microbeads be reduced or eliminated in aquatic ecosystems?" (Marchetta et al. 2014). The impetus for the current manuscript is to improve the esteem of the scholarship of application in ecology. Stated in the negative, it is to argue against the "discovery bias" that exists at some American institutions of higher education (e.g., often called research universities) and among some ecologists. I argue that humankind and the biosphere need the concerted efforts of academics practicing the scholarship of application as vigorously as they practice the scholarship of discovery. I look forward to a day when more universities have an applied ecologist on their faculty.

To preempt criticisms of this manuscript being "too personal", I note that being the only tenured faculty hired as an "applied ecologist" in an America university makes it personal by default. I always try to be objective despite the personal nature, and welcome respectful criticism or debate of my opinions or any issue that I address. I am aware that some will feel that I am stating the obvious in places, but my experience shows that what might be obvious to many, is not so obvious to an influential few. Recommendations on the rewarding of accomplishments in applied ecology are beyond the scope of this manuscript.

2. WHAT IS APPLIED ECOLOGY?

Applied ecology is the use of ecological knowledge to address real-world problems (ESA 2018). Such problems need not be ecological in nature, though they often are. Applied ecology primarily involves the scholarship of application (*sensu* Boyer 1990). Most subdisciplines of ecology involve research (i.e., the scholarship of discovery, *sensu* Boyer 1990). These include habitat-specific subdisciplines such as aquatic ecology, forest ecology, soil ecology, wetland ecology, stream ecology, island ecology, or reef ecology. Also included are scale-dependent subdisciplines such as chemical ecology, physiological ecology, population ecology, community ecology, ecosystem ecology, or landscape ecology. Other subdisciplines conduct research on ecological intervention. Hobbs et al. (2011) suggested the term "intervention ecology" to encompass subdisciplines variously called restoration ecology, ecosystem management, ecosystem engineering, or rehabilitation ecology. All of the subdisciplines mentioned in this paragraph, and others not mentioned, discover or create ecological knowledge. Is there overlap between applied ecology and subdisciplines such as intervention ecology? There certainly is. For example, Hone et al.'s (2015) review of principles is equally helpful for intervention ecology and applied ecology.

Applied ecology involves translating the knowledge generated from the ecological subdisciplines mentioned in the preceding paragraph into real-world action. Applied ecology may also use knowledge generated from a vast array of other STREAM disciplines (Science, Technology, Recreation, Engineering, Arts, and Mathematics; e.g., biology, chemistry, geology, hydrology, political sciences, social sciences, physics, planning, history, communication, music, mathematics, arts, public health), to identify real-world solutions to ecological problems. Palsson et al. (2013) calls for increased involvement of the social sciences and humanities in the transdisciplinary business of forging a sustainable path in the Anthropocene, prompting my student Glee Anderson to suggest the acronym HAMSTER. The focus on the scholarship of application is the fundamental distinction between applied ecology and the ecological subdisciplines that focus on the scholarship of discovery.

Applied ecology can be conducted in any habitat and at any scale. That applied ecology primarily uses the scholarship of application does not mean that it does not involve discoveries. Boyer stated "The scholarship of application, as we define it here, is not a one way street. Indeed, the term itself may be misleading if it suggests that knowledge is first "discovered" and then "applied." The process we have in mind is far more dynamic. New intellectual understandings can arise out of the very act of application--whether in medical diagnosis, serving clients in psychotherapy, shaping public policy,

creating an architectural design, or working with the public schools. In activities such as these, theory and practice vitally interact, and one renews the other." A "new intellectual understanding" that has emerged from my ecological application is an approach I call "transdisciplinary scholarship" (Cronin 2014). Transdisciplinary scholarship integrates transdisciplinary research (Jahn et al. 2012) with Boyer's (1990, 1996) model of scholarship.

Because applied ecology is concerned primarily with the scholarship of application, rather than the scholarship of discovery, the scientific method may not be the preferred approach. The scientific method is a wonderful, prescribed (e.g., observation, experimentation, data collection, analysis, communication) approach for the scholarship of discovery, and has generated a vast wealth of knowledge since the Enlightenment (Web of Science 2018). However, the scientific method is inadequate for many questions addressed by the scholarship of application, such as wicked and super-wicked problems that cannot be stated as a hypothesis (Levin et al. 2012, Cronin 2014).

3. APPLIED ECOLOGY FOCAL SPECIES

Unlike most ecological subdisciplines, applied ecology has one focal species, *Homo sapiens*. Calling Earth's current epoch the Anthropocene recognizes human ecological dominance. *Homo sapiens* causes the problems that applied ecologists address (Ehrlich and Ehrlich 2008). Applied ecologists are humans working with human stakeholders and policy-makers to address problems largely caused by humans. In contrast, many ecologists work in systems that lack humans, or prefer to study "pristine" systems that have experienced minimal human impact. The latter systems are becoming harder to find (Vitousek et al. 1997).

Researchers, including ecologists, are encouraged to maintain unbiased objectivity. The scientific method has little room for biased opinions, cultural appreciation, artistic expression, happiness, sorrow, or compassion. Applied ecologists cannot ignore humanity, and therefore must be aware of cultural differences across the planet. Applied ecologists must be concerned with the happiness and sorrow of people that they work with, and compassionate for people and their environments. It would be heresy for a researcher to analyze their data based on their opinion, though a scholar of application will acknowledge informed opinions, including their own, as they carry out their work. Humans can be friend or foe to the success of applied ecological projects or studies. Applied ecologists need to hone interpersonal skills as well as be expert in ecological knowledge. Familiarity with the social sciences, humanities, and arts benefits applied scientists. When working amidst poverty (i.e., the majority of the planet), the success of applied ecological projects will depend on human conditions. During his Goldman Environmental Prize acceptance speech, my Haitian colleague Jean Wiener (2015) stated "No one will protect any resource until their basic livelihood needs are met. I can guarantee you that there is nowhere in the world where there is a hungry conservationist. The need to provide for oneself and for one's family overrides any type of conservation thought. We must take a holistic approach that addresses their basic needs, mind you, in the most environmentally-friendly and sustainable way possible." Hobbs et al. (2011) wrote, "interventions focused on the socioeconomic and policy contexts may, in fact, be more effective than interventions in the ecosystem itself or may be a prerequisite for enabling effective ecosystem interventions."

Stating that *Homo sapiens* is the focal species does not mean that human concerns have priority over concerns of other species (e.g., endangered species). Rather, it is recognition of human ecological dominance, and that ecological goals and values result from human attitudes and decisions. Human attitudes and decisions can have a larger impact on non-human species than ecosystem properties. Non-human species benefit when humans decide to intervene in positive ways (Hobbs et al. 2011). The focus on *Homo sapiens* also recognizes that we selfishly want to survive as a species, and our survival depends on ecosystem services.

The need to develop the field of applied ecology, just as we have the various research-focused subdisciplines since Hutchinson, is summed up well by Wapner (2010). "The end of nature changes our historical role on earth to the degree that it calls on us to consciously take hold of the steering

wheel of life, and become intelligent, compassionate, and otherwise mindful managers of the planet—quite a daunting challenge."

4. QUESTIONS THAT APPLIED ECOLOGISTS ASK

Applied ecologists often ask questions that cannot be stated as a hypothesis. Many of these questions have traits of wicked or super-wicked problems (Levin et al. 2012, Cronin 2015). An experimental ecologist may ask "How does substance A affect ecosystem function B?", whereas an applied ecologist would ask "How can harmful substance A be prevented from contaminating the environment?". The former question can be stated as a null hypothesis. H_o: Ecosystem function B exposed to substance A will equal ecosystem function B not exposed to substance A. Experiments could be designed and performed to test this hypothesis. The latter question cannot be stated as a null hypothesis, making it unsuitable for the scientific method. Approaches that are conducive to addressing the types of questions asked by applied ecologists are emerging. Though they lack the long history of the scientific method that institutions of higher education have long-embraced, they do show promising successes (Jahn et. al., 2012; Cronin 2014, 2015).

I use a case study with which I was involved as an example of transdisciplinary scholarship (Cronin 2014). Channel 7 News of Denver contacted me about concerns over plastic microbeads in personal care products such as face scrubs and toothpaste. These plastic microbeads are intentionally discarded into sewage systems following normal use. I used existing knowledge about plastic (Fendall and Sewell 2009, Cronin 2011a, Eriksen et al. 2013), wastewater fate and transport (I had served on the Citizens Participation Group of Metro Wastewater Reclamation District, Denver's wastewater treatment facility, Cronin 2011b), and local hydrology (Cronin et al. 2007, unpublished research at the confluence of Sand Creek and South Platte just downstream of MWRD outflow) to predict where the pollutant would likely be found in the South Platte River. The transdisciplinary team isolated unnatural particles in the river as predicted, which chemical analysis confirmed were plastic (Marchetta et al, 2014). The lead investigative reporter interviewed stakeholders, including product users, a dental hygienist who found plastic microbeads in the gums of patients, and a manufacturer of products that included plastic microbeads. I provided information about the ecological effects of plastic on aquatic ecosystems, local hydrology, fate and transport of plastic, and wastewater treatment. 7 News broadcast the story to a broad audience of stakeholders (Marchetta et al., 2014), resulting in a public response and political action.

The scholarship of discovery could have been applied to the topic of plastic microbeads in the South Platte River. It would have been possible to conduct scientific studies to determine the sinking rates of plastic microbeads, temporal and spatial patterns of their distribution, abundances in the digestive tracks of various aquatic species, or affinity of chemical pollutants to the microbead surface. Such studies would have provided additional knowledge. However, our transdisciplinary team felt that there was enough existing knowledge to determine that plastic microbeads should not intentionally be flushed into wastewater to make their way into aquatic ecosystems. Applying the transdisciplinary approach to the applied ecological question "How can the negative effects of plastic microbeads be reduced or eliminated in aquatic ecosystems?" resulted in public education, a call for the plastic pollutants to be removed, and a legislative ban of the plastic pollutant.

This applied ecological study revealed a bias for the scholarship of discovery in the Department of Integrative Biology (IB) at the University of Colorado Denver. Though the study described above is clearly a case study of applied ecology, IB Chair John Swallow refused to reward it as scholarship, and instead rewarded it as service during merit review. I objected to my scholarship being devalued as service, and asked Chair Swallow what I should have done to get credit for scholarship. He had no immediate suggestion on a microbead study that would get credited as scholarship or research, but later responded with "I find your request regarding your micro beads study somewhat disconcerting on several levels. First, your described role in the micro beads study is what I would characterize as scholarly service - you provided a news agency your considered opinion and were quoted in a news article. Second, the fact that you seek advice after a study is complete with regard to where you might publish your work, suggests a lack of the kind of careful planning I would expect from a highly

trained aquatic ecologist with tenure at our institution. As for my advice, I might suggest conferring with Dr. [name removed by GC] if you have questions with regard to how you might design and publish studies in aquatic toxicology. I am sure he would be useful. Again, whether and how we, as a department, will reward the type of work you described above can be discussed at a future faculty meeting." In his efforts to discount my scholarship, he created a category "scholarly service" which does not exist in university merit policies. CU Denver rates faculty according to teaching, research/scholarship/creative activities, and service. I did not "seek advice after a study is complete with regard to where you might publish your work", but was making a point that communicating with stakeholders via public television (e.g., a venue protected by academic freedom, yet not rewarded in research-biased merit review criteria) can be a better outlet than peer-reviewed journals when using the transdisciplinary approach. The Chair's bias for the scholarship of discovery is revealed in his suggestion that the Applied Ecologist of the department should seek advice on conducting an aquatic toxicology study (i.e., scholarship of discovery). Though I have conducted aquatic toxicology studies as a postdoc, it is not my area of expertise, nor is it what CU Denver hired me to do. The point of my inquiry to Chair Swallow was to demonstrate that no "scholarship of discovery" study would match the effectiveness of my transdisciplinary study using the "scholarship of application". There was more than enough ecological and related knowledge to apply to the problem of washing plastic microbeads down sinks. There is also an increasing call for scientists to advocate for scientifically sound policy-making (Blockstein 2002, Garrard et al. 2016).

Others agreed with my opinion. In direct response to our microbead study, Colorado stakeholders and legislators decided that microbeads should be banned from non-prescription personal care products. Representative Dianne Primavera of Broomfield sponsored a bill to remove plastic microbeads from products in the State of Colorado. Governor Hickenlooper signed HB15-1144 into law on March 26, 2015, making Colorado the fourth state to ban plastic microbeads. This ban protected the headwaters of the South Platte (Mississippi watershed), Colorado, Rio Grande, Arkansas, and Gunnison Rivers. At the federal level, Democratic and Republican lawmakers supported a ban of plastic microbeads in personal care products, with both the US House and the Senate voting unanimously in favor of H.R. 1321 (H.R. 2015). President Obama signed the Microbead Free Waters Act on Dec. 28, 2015. Companies that put plastic microbeads in their products supported the Colorado microbead ban, perhaps to include clauses that would allow biodegradable plastics to remain in formulations. Chair Swallow was the only person I know of who was calling for more basic research on plastic microbeads.

5. PEER REVIEW IN THE SCHOLARSHIP OF APPLICATION

Boyer clarified the roles of academics in modern universities by defining the scholarship of discovery, integration, application, engagement, and teaching (1990, 1996). In higher education, the scholarship of application has a longer history in medical and physical sciences than in ecology because of humankind's earlier emphasis on human health and the built environment, compared to efforts to protect, rehabilitate, reclaim, or restore ecosystems. Shapiro and Coleman (2000) offered an excellent assessment of the scholarship of application in patient-oriented fields, and much of what they state is also relevant to applied ecology. Shapiro and Coleman note that the scholarship of application does not necessarily involve hypothesis testing. They discuss disincentives and challenges faced by scholars of application, inadequacies of traditional peer-review, and a need to rigorously evaluate accomplishments that do not result in peer-reviewed publications. Goring et al. (2014) made a similar call for encouraging and rewarding accomplishments in interdisciplinary scholarship of discovery in higher education that is relevant to transdisciplinary applied ecology.

Ideally, the peer-review process should advance a field and assure quality control (Horrobin 1990). A primary peer-review accomplishment of researchers using the scientific method (i.e., scholars of discovery) is publication in a peer-reviewed research journal. Just as researchers are peers of researchers, practitioners of application are peers of practitioners of application. Peers of transdisciplinary scholars are other transdisciplinary scholars. The creation of policy is a peer-reviewed accomplishment of applied ecology, in that it involves peers of the transdisciplinary approach and legislative checks and balances. This type of peer-reviewed accomplishment should be

valued (Cronin 2015), given that policy change can be a more effective intervention than an intervention made to the ecosystem per se (Hobbs et al. 2011). A panel of scholarship experts who met at Western Carolina University in 2010 summarized "The scholarship of application is the application of disciplinary expertise with results that can be shared, perhaps in a way that addresses a community need…and may be exemplified by technical reports, policy statements, guidebooks, economic impact statements or pamphlets." (note: peer-reviewed publication was not listed as an accomplishment by this panel).

6. SUBSEQUENT STUDIES ABOUT PLASTIC MICROBEADS

Since Marchetta et al. (2014), state bans of plastic microbeads, and the 2015 Microbead-Free Waters Act, many related papers have been published. I remain convinced that the state of knowledge in 2014 justified the banning of non-degradable plastic microbeads from personal care products that intentionally get washed down drains and into the wastewater stream that discharge into aquatic ecosystems. Scholars, stakeholders, and policy-makers reviewed the study, and these peers acted swiftly to enact legislation. Such policy creation is a peer-reviewed accomplishment of applied ecology, even if it results in no peer-reviewed journal publication.

Subsequently, the research literature has further justified the banning of plastic microbeads (Doughty and Eriksen 2014, Rochman et al. 2015, 2016), identified wastewater effluent as the source (Graney 2016, Mason et al. 2016. Ziajahromi et al. 2016), determined plastic microbeads to be a concern for dental patients (Greenwall 2015), and identified personal care products as the source of plastic pollution in a variety of aquatic ecosystems (Castañeda et al. 2014, Cheung and Fok 2016, Free et al. 2014, Eerkes-Medrano 2015, Seltenrich 2015). Though this subsequent knowledge would have been beneficial to our 2014 study, it would not have altered our call to ban the plastic microbeads that harm dental health and are intentionally added to the wastewater stream. No subsequent scientific study has justified the use of plastic microbeads in personal care products that intentionally get flushed down drains following one-time use.

Applied ecologists use existing knowledge to advise decisions. The plastic microbeads story is noteworthy in that some researchers were accused of fraudulently using existing knowledge to fabricate knowledge (Lönnstedt and Eklöv. 2016). After investigating allegations of research misconduct, Lönnstedt and Eklöv (2016) was retracted (Berg 2017) and the process criticized for lack of proper oversight (Cressey, 2017). Ethical scholarly practices are necessary for both the scholarship of discovery and the scholarship of application.

Cronin (2015) was also retracted. It was not retracted because it was found to be unethical, inaccurate, plagiarized, or in violation of any scholarly standard. Rather, it was retracted because Chair John Swallow and Assoc. Chair Diana Tomback were offended that accurate quotes from public emails were cited in the paper. These researchers disagreed with me about the scholarship of application being rewarded as scholarship. They share the opinion that the scholarship of application should be rewarded as service, and violated Regental policy on academic freedom to remove my opinion from the literature. To my knowledge, Cronin 2015 is the first accurate, non-plagiarized article to be retracted because of a complaint from university administrators, represented by university counsel. The retracted article remains available online.

A bias for the scholarship of discovery is not surprising in institutions with a long history of rewarding the scholarship of discovery. I am hopeful that exposing the bias will result in conscious and purposeful efforts to eliminate it. I am hopeful that accomplishments in the scholarship of application will someday receive the same level of esteem as accomplishments of discovery. Researchers should ask themselves "what good is the ecological knowledge we generate if it is not applied to solve real-world problems?" By valuing both the knowledge and its application, the opening quote from ESA President David Lodge can be realized.

7. SUMMARY

Oversimplified, basic research ecologists use the prescribed scientific method with the goal of testing a specific hypothesis with proper experimental design, data collection, and statistical analyses resulting in a precise P-value. They seek understanding of the natural and managed world. In contrast, applied ecologists coddiwomple: their purposeful scholarship leads towards vague, uncertain, and changing destinations. Applied ecologists often attempt to address wicked or super-wicked problems. Scholars, administrators, funding agencies, journal editors, reviewers, policy-makers, stake-holders, students, and search committees need to become more comfortable with the non-prescribed, non-scientific method nature of applied ecology. What goals of applied ecological scholarship lack in certainty is more than compensated by what it possesses in importance (i.e., Wapner's daunting challenge). Applied ecology is a young field that may become more prescribed with better-defined goals (goals are set by society at large, and often change) and outcomes. In the meantime, applied ecologists should be allowed, and even encouraged, to coddiwomple.

8. REVIEW OF "APPLIED ECOLOGY EXPLAINED" BY ADAM BRIGGLE

Professor Cronin has written an apology for applied ecology. I do not mean he is expressing regret. Far from it. No, I use the term 'apology' in the same sense as the Platonic dialogue by that name in which Socrates stands trial in Athens on charges of corrupting the youth. This kind of apology is an explanation and a defense of one's *modus operandi*. For Prof. Cronin's goal is not simply to use a case study to explain applied ecology as a species of transdisciplinary scholarship, but to argue that such intellectual labor deserves recognition within the university. As he remarks, the aim is "to improve the esteem of the scholarship of application in ecology."

Like Socrates, Prof. Cronin has been subjected to slanderous accusations. Some in positions of power scoff that he is not a 'real' scientist; his is not an *echt* form of scholarship. It is a maddening situation. Here we are in an age that pays so much lip service to interdisciplinarity, to community engaged research, to broader impacts, and research accountability. Yet here is a scholar who excels in all of these regards and still finds himself the victim of petty and anachronistic intellectual discrimination.

I strongly recommend this article for publication. The "scholarship of application" (to use the term from Boyer) is primarily of service to stakeholders facing real-world problems. However, as Prof. Cronin notes, case studies such as this are important to publish, because they also serve a transdisciplinary peer community by disseminating lessons learned and best practices. As a transdisciplinary scholar based in the humanities, I found much to be gained from his description of the science policy of microbeads.

Further, the scholarship of application is going to be an increasingly vital aspect of the contemporary research university. As tuition skyrockets and federal budgets tighten, universities will need to point to scholarly activities like those of Prof. Cronin as proof of real-world impacts. University administrators should not take the route of Athens – they need to embrace, rather than condemn, those who would challenge their orthodoxies. Perhaps Prof. Cronin does not merit "free meals in the Prytaneum," but he does at least deserve for his scholarship to be counted as genuine intellectual work befitting a university.

Having endorsed this article, I will make just two further points. First, I will restate its most important lesson, because it warrants emphasis. Second, I will offer a criticism drawn from my own attempts to think through transdisciplinary scholarship.

The key lesson of this article – and of transdisciplinary scholarship – is one of rhetoric: know thy audience. The "scholarship of discovery" (another Boyer term) is essentially disciplinary in nature, which means it assumes an audience of fellow specialists. This kind of intellectual labor is certainly fruitful and important. The trouble with it, however, is that it has no governor – it operates by a logic of infinity, because the producers and consumers are one and the same. More knowledge is always

assumed to be a good thing and can always find a home in the expanding ocean of peer-reviewed journals.

But in the context of real-world policy problems, more disciplinary knowledge is not always (or even often) the primary need. Prof. Cronin's most important line is this: "There was more than enough ecological and related knowledge to apply to the problem of washing plastic microbeads down sinks." True, more studies would benefit disciplinary scientists by generating more peer-reviewed articles and citations. But they would not benefit the ecosystems and people being harmed by microbeads. Benefiting this wider community of stakeholders required a different kind of knowledge and, thus, a different kind of scholarly activity. We don't need to know more about how microbeads behave in the environment. We need to know more about how to rid them from the environment.

Note, please, that this is not 'activism' if that term is meant as some non-intellectual advocacy for foregone conclusions. Rather, applied ecology and other forms of "applied scholarship" involve the challenging intellectual work of integrating different sets of knowledge and conflicting values perspectives all in the service of elevating democratic processes and seeking common interest objectives. This requires rigorous work, and what Prof. Cronin is at pains to emphasize is that this is a different kind of rigor than that of disciplinary scholarship…but it is no less difficult and no less deserving of the title 'scholarship.'

Let me conclude with one criticism, which has to do with the term "applied scholarship." The trouble with the word 'applied' is that it makes it sound as if the intellectual work has already been complete and one is simply spackling it onto a real-world case study. As Prof. Cronin notes, this is not true to reality. Real-world problems do not come ready-made with holes shaped like academic disciplines into which we could just 'apply' existing knowledge. Rather, the intellectual contributions of the 'applied' scholar will be interspersed throughout the case study and will require context-sensitive judgments. Indeed, this intellectual work (what Aristotle called *phronesis*) is at the heart of the different kind of rigor discussed above. It requires listening to and learning from the stakeholders in the case, which means the flow of knowledge is multi-directional and dynamic in ways that the 'applied' metaphor does not convey.

For these reasons, some of us in philosophy (e.g., Frodeman and Briggle 2016; Briggle. 2015) have taken to calling our transdisciplinary scholarship "field philosophy" rather than applied philosophy. This is our attempt to denote a form of intellectual work that co-produces knowledge with stakeholders in real-time as a problem space evolves. This is in distinction with "applied philosophy," which primarily conducts its business in academic journals far from the concerns of any would-be stakeholder.

It would seem that "field ecology" already carries a different connotation. So, "applied ecologists" may just be stuck with a rather unfortunate term. Hopefully they can resist the pull of "disciplinary capture" (the temptation to speak only to fellow specialists), which has largely doomed applied philosophy to be just another racket for churning out publications of dubious societal value. Engaged studies, like those of microbead elimination, must remain the beating heart of applied ecology. Prof. Cronin is blazing a path that will be vital to the future of research – in ecology and beyond. It is just unfortunate that he finds himself for the time being in the wilderness, waiting for others to catch up.

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