CHAPTER 19

Optimism and opportunities for conservation physiology in the Anthropocene: a synthesis and conclusions

Steven J. Cooke, Christine L. Madliger, Jordanna N. Bergman, Vivian M. Nguyen, Sean J. Landsman, Oliver P. Love, Jodie L. Rummer, and Craig E. Franklin

19.1 Introduction

Conservation physiology arose as a 'discipline' based on the promise of using physiological knowledge, concepts, and tools to understand and solve conservation problems (Wikelski and Cooke 2006; Cooke et al. 2013). As such, the discipline is inherently mission-oriented. The success of conservation physiology should thus be assessed not just by the number of citations or other traditional measures of 'academic impact' but rather by the extent that conservation physiology delivers on its promise. Successes in conservation physiology are already being recognized (see Madliger et al. 2016); yet, there remain challenges in recognizing the success stories. Rather than waiting for the discipline to mature on its own, efforts have been taken to create a conceptual framework (Coristine et al. 2014) and to help build capacity within the conservation physiology community to ensure that research has impact (Cooke and O'Connor 2010; Madliger et al. 2017b).

Today, there is an urgency associated with conservation that likely extends beyond what Michael Soulé could have envisioned when he first described conservation science as a crisis discipline (Soulé 1985). We are in a biodiversity crisis unlike anything ever witnessed before in human history and with direct consequences on ecosystems, their functions, as well as the ecosystem services upon which humans depend (Cardinale et al. 2012). Amphibians (Beebee and Griffiths 2005) and other freshwater life are facing declines that have exceeded 80 per cent since 1970 (Reid et al. 2019). Novel stressors and threats continue to emerge and combine with existing ones to make life even more challenging for wildlife (Folt et al. 1999). Indeed, climate change is regarded as one of the major threats facing biodiversity and humanity today and for the coming decades (Bellard et al. 2012). Perhaps now, more than ever, there is urgent need for robust science to address these and other issues facing life on Earth.

Although it is easy to become despondent and frustrated about the threats to the natural world, it is also a time for optimism, given collective interest in rejecting a dystopian future and that changing attitudes and human behaviour is possible. For example, despite the fact that it is now accepted that we have entered the Anthropocene epoch (Lewis and Maslin 2015), there are efforts to identify what

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is needed to achieve a 'good' Anthropocene and how to do so (Bennett et al. 2016; Dalby 2016; Madliger et al. 2017b). Similarly, rather than accepting the fact that biodiversity declines continue, some are advocating for strategies to 'bend the curve' and reverse this trend (Mace et al. 2018). To this end, in March of 2019, the United Nations Environment Programme (UNEP) announced the start of the 'Decade of Ecosystem Restoration'. There is also evidence of public support (e.g. climate change rallies and marches for extinction), which gives hope and suggests that the masses are ready for meaningful action. In that sense, the conservation science community needs to be poised to support and inform efforts to tackle these problems with the best available evidence (Ripple et al. 2017). We submit that conservation physiology has much to offer (as outlined in our introductory chapter) in this realm.

The chapters presented in this book span taxa, continents, tools, and issues that collectively provide a rich tapestry to explore and identify emergent themes. Here, we synthesize key themes that emerge from the case studies, providing an optimistic overview of future opportunities for conservation physiology. For each theme, we provide referenced commentary with the hope of providing today's conservation physiologists and those of the future with strategies and perspectives to help them deliver on the promise of conservation physiology. Finally, we consider what type of institutional and training changes are needed to build capacity for conservation physiology.

19.2 Emergent themes

19.2.1 Mechanisms matter in conservation

Simply documenting declines in wild populations through demographic studies often fails to identify the mechanistic basis for decline. An important aspect of conservation science is therefore to identify the threats that are negatively affecting the health, fitness, or survival of wild organisms. Only when threats are clearly identified and—ideally—mitigated, is it possible to expect populations to recover. Physiology can reveal the mechanisms underpinning population declines, changes in distribution patterns, alterations in health and fitness, and even drivers of mortality (Seebacher and Franklin 2012). When investigated within an experimental context, the mechanisms that are revealed are particularly powerful in that they contribute to understanding cause-and-effect relationships that are relevant in a regulatory context (Cooke and O'Connor 2010). Attempting to 'recover' a population without knowledge of the underlying mechanisms that are causing the declines can lead to wasted resources, as conservation efforts can be misdirected. As conservation physiology has matured, the field has become a trusted source of knowledge in the context of evidence-based conservation. These strengths have been highlighted repeatedly in the case studies presented in the preceding chapters. For example, the case study on Pacific salmon (Chapter 3) revealed the link between water temperature and disease and thus the interactive mechanisms driving migration failure during spawning migrations. It is clear that conservation science and practice have become far more mechanistic in the past decade or so, and conservation physiology has been a major driver of that trend.

19.2.2 Physiology is but one source of knowledge

When one settles down to read a book on conservation physiology, it might be assumed that the collective work will focus solely on conservation. That is not the case here, nor does that notion recognize the fact that conservation is best delivered from a holistic and integrated perspective. Although conservation science tends to be somewhat reductionist (e.g. consider subdisciplines such as conservation genetics, conservation medicine, and conservation physiology), at the end of the day, conservation is complex. So, applying diverse tools to identify solutions is essential. Consider a problem related to reproductive failure in a species. One approach might be to invest in genetic studies to determine if there is evidence of inbreeding. If that study takes 2 years, and it turns out that there is no evidence of inbreeding, then the community is no closer to being able to address the problem. However, if a problem is tackled from multiple dimensions using a diverse toolbox, it is possible to rapidly and accurately identify problems and therefore solutions. In this book, that concept was particularly relevant in the case study on Arctic fishes. Madigan et al. (Chapter 5) used both stable isotope analysis and biotelemetry to identify critical habitats and migration routes and predict population distribution change. Similarly, the research by Dzal and Willis (Chapter 9) involved applying tools from epidemiology and physiology to better understand how to respond to white-nose syndrome in bats. Finally, Ohmer et al. (Chapter 10) discussed how multiple metrics of immune function and stress physiology can be combined to understand disease susceptibility and improve management practices aimed at reversing population declines in some of the world's most imperilled amphibian species. Although it is quite common to take a reductionist approach in conservation, there is ample evidence that highlights the effectiveness and efficiency of bringing together multiple perspectives and approaches (i.e. interdisciplinarity) to problem solving when dealing with a crisis discipline (Balmford and Cowling 2006).

19.2.3 Physiology and behaviour are intertwined

When studying animals, it is impossible to consider behavioural or physiological aspects in isolation. Indeed, physiology and behaviour are inherently and intimately connected. Behaviour is underpinned by physiological mechanisms, processes, and systems. Consider locomotion. Moving from one site to another to avoid a disturbance represents a behavioural choice. Yet, the behaviour was prefaced by the sensory physiology apparatus identifying a relevant threat. Similarly, once the organism decided to move, say at a high speed, it was the physiological capacity of the organism that both enabled locomotion but also constrained it. And, after a high-speed retreat, there would have been a physiological recovery period during which behaviour would have been impaired. The same scenario can even be understood for sessile organisms, given that many organ systems, such as those related to feeding/digestion and reproduction, involve aspects of physiology and behaviour. For those reasons, it is common for conservation studies on animals to include both physiological and behavioural components (Cooke et al. 2014). Cooke et al. (2014) advocated for better recognition of the intersection of behaviour, physiology, and conservation, which rang true in the case studies covered in this book. For example, Cree et al. (Chapter 16) explored the thermal biology of imperilled endemic reptiles in New Zealand, thinking about aspects of thermal stress as well as behavioural thermoregulation. In combination with many other case studies here and throughout the literature, it becomes clear that it is wise to couple behaviour and physiology when trying to solve conservation problems.

19.2.4 Embrace emerging tools and technologies

Conservation physiology is continually benefiting from novel developments in tools and technology. Some of these tools and technologies enable us to, for example, do more with less tissue, thus negating the need for lethal sampling. The work presented here by Hunt et al. (Chapter 12) was made possible by the rapid expansion of hormone measurement in non-traditional sample media such as whale blow. Other tools and technologies (e.g. point-of-care devices; Stoot et al. 2014; Harter et al. 2015; Talwar et al. 2017; Schwieterman et al. 2019) allow research to occur in remote locations, far from laboratory infrastructure. Some technologies, such as biotelemetry and biologging, allow us to study the behaviour and physiology of wild animals in their natural environment (Cooke et al. 2004; Wilson et al. 2015) to understand how animals respond to different stressors. For example, Tyson et al. (2017) used such technologies to understand how noise pollution affects sea turtles. In the laboratory, 'omics' technologies (e.g. genomics, proteomics, metabolomics, transcriptomics; see McMahon et al. 2014) are revolutionizing what we can do with small amounts of tissue. For instance, He et al. (2016) describe how transcriptomics can be used to inform how source populations are selected for species reintroduction programmes, and the case studies presented by Whitehead et al. (Chapter 7) here indicate that these novel techniques also contribute to pinpointing cause–effect relationships in species facing anthropogenic change, such as pollution. Even work on stable isotopes has evolved such that it is possible to understand not only what animals have been eating but also the environments that they encounter (Meier et al. 2017; Chapter 5).

Of course, technology is constantly evolving and improving. There have been new developments in nanosensors that could potentially be implanted into organisms to assess physiological state (e.g. blood biochemistry) in real time (Lee et al. 2018). A key message is that those working in the realm of conservation physiology are often at the frontier of biology, working to develop, refine, and apply new tools and approaches. Similarly, there are many efforts by conservation physiologists to refine their methods of interacting with animals to minimize welfare impacts and ensure that research does not impede conservation goals (Swaisgood 2007). As demonstrated by the case studies presented here, the conservation physiology toolbox is expanding rapidly (Madliger et al. 2018), but it is important to ensure that new tools and techniques are validated and ground-truthed along the way.

19.2.5 Physiology is relevant to conservation programmes in zoos and aquaria

Although a core aspect of conservation physiology emphasises 'field' research (i.e. field physiology; Costa and Sinervo 2004), that certainly does not preclude research on captive organisms, especially in zoos and aquaria. The concept of *ex situ* conservation (for a discussion, see Pritchard et al. 2012) embraces the idea that *in situ* conservation has failed or is otherwise insufficient. Most would agree that *ex situ* conservation means that a species is in an 'emergency state'; yet, the reality is such that *ex situ* opportunities are becoming more common, and we therefore need to embrace them and make them more efficient (Conde et al. 2013). Some have argued that zoos and aquaria have yet to fully recognize their potential for research and practice (Andrews and Kaufman 1994; Fa et al. 2014), and so the field of conservation physiology has much scope to contribute to concepts such as 'rewilding' (Lorimer et al. 2015) and captive breeding programmes. In this book we included an entire subsection that focused on aspects of *ex situ* conservation and wildlife rehabilitation in captivity, including sea turtles (Chapter 14), koalas (Chapter 15), various New Zealand reptiles (Chapter 16), and rhinos (Chapter 17). Physiological approaches are particularly effective in identifying what organisms need to succeed (i.e. basic environmental and nutritional needs) while also providing objective tools for tracking the success of such activities. Increasingly, zoos and aquaria are employing experts with a physiological foundation (e.g. reproductive physiology, stress physiology), which is promising.

19.2.6 Conservation physiology extends across scales

The concept of 'scale' is intrinsically relevant in conservation physiology and its applications in management (Noss 1992). Various aspects of scale exist, with biological, spatial, temporal, allometric, and phylogenetic scales being the five most relevant to conservation physiology research (Cooke et al. 2014). Scale is critical to consider, as the scale at which we measure a biomarker may not be the same scale at which we are interested in its consequences, as Helmuth (Chapter 13) discussed here. With respect to biological scale, which refers to the hierarchy of biological organization (e.g. spanning genes, individuals, populations, and ecosystems), to understand causal mechanisms underlying demographic-level declines, physiological responses must first be assessed on an individual level. Although essential in designing effective conservation strategies, scaling physiology along the biological hierarchy from an individual- to a population level as a result of a specific environmental stressor is difficult to accomplish, as it requires multi-disciplinary expertise, longitudinal monitoring, and uninterrupted funding (Lindenmayer and Likens, 2018; Bergman et al. 2019). Furthermore, addressing temporal scale is important in interpreting acute versus chronic physiological responses. Understanding spatial scale is key in determining species distributions and physiological capacities with changing environmental conditions. Allometric scale (White et al. 2019) provides information on how traits scale with conservation implications (e.g. if certain size classes are more reproductively valuable or less vulnerable to exploitation). Finally, phylogenetic scale refers to genetic relationships between species shaped by evolutionary processes, offering information on adaptive physiological divergences between congeners. It is especially important to consider the various scales in policy application, including both upscaling and downscaling, to explore and determine best conservation practices and management strategies (Cooke et al. 2014). Synchronously investigating multiple physiological subdisciplines (e.g. reproductive physiology, stress physiology, genetics) may help reveal the mechanisms that are driving declines or changes in wild populations. Additionally, long-term datasets are needed, as they may provide a more comprehensive understanding of the physiological changes across scales, as different biomarkers vary in their response time to environmental perturbation (e.g. ranging from days to weeks), and could reflect seasonal variations or, for example, warming regimes.

19.2.7 Physiology can be incorporated into long-term monitoring programmes

Proactive conservation and management strategies, which rely on early identification and monitoring of potential threats, focus on ensuring demographic stability and are generally more cost- and time-effective for managing risks than reactive strategies (Drechsler et al. 2011). Recently, biomarkers (e.g. glucocorticoids, reproductive hormones, telomeres) have gained recognition as tools to measure organismal responses to environmental change with the potential to inform conservation policy. To use physiological indices for management strategies, it is essential to validate that they are both reflective of changing environmental conditions and predictive of population changes (Madliger and Love, 2014). Once the link between individual physiological responses and demographic changes as a result of an environmental perturbation is established, that biomarker can be incorporated into long-term monitoring programmes and used to proactively develop and enforce recovery strategies prior to demographic collapse or extinction (Bergman et al. 2019). For example, Dupoué et al. (2017) identified a genetic biomarker, the telomere (i.e. specifically telomere length), as a reliable physiological parameter in predicting extinction risk in the common lizard (*Zootoca vivipara*). Telomere attrition (i.e. telomere shortening) is linked to repeated exposure to chronic life stress (Breuner et al. 2013) and can reflect biological age (i.e. in contrast to chronological age) and thus tell us a lot about reproductive status and capability (Monaghan and Haussmann 2006). The authors found that common lizard populations undergoing intense warming regimes due to climate change showed significantly shorter telomeres and higher risks of extinction when compared with their cooler habitat counterparts. By including this biomarker into long-term population monitoring, managers can determine when populations may be experiencing demographic-level declines so that they can proactively work to prevent extinction. Further, here, Crossin and Williams (Chapter 2) highlighted how longitudinal monitoring of energetic and stress physiology has assisted in determining predictors of breeding status and reproductive success in seabirds. As global biodiversity continues to decline, it is vital to develop strategies that prevent populations from reaching demographic instability or collapse. When monitored, biomarkers can indicate when populations are experiencing stress and undergoing declines, offering wildlife and resource managers the opportunity to implement recovery strategies before extinctions occur.

19.2.8 Conservation physiology is not just about vertebrates

A strong bias in conservation science exists, unfortunately, as high-level taxa, including charismatic mammals and other vertebrates, are disproportionately studied in comparison with invertebrate species and plants (Donaldson et al. 2016). The Red List of Threatened Species of the International Union for Conservation of Nature (IUCN) is a highly referenced, leading organization that monitors the status of species worldwide. Yet, even this international agency is still heavily biased towards vertebrates

(Eisenhauer et al. 2019). Although limited, conservation physiology research focused on invertebrate species has produced meaningful information. For example, physiological investigations in various invertebrate species have been relevant to a multitude of conservation-related questions including: How do reef-building scleractinian corals (i.e. *Agaricia agaricites* and *Agaricia tenuifolia*) respond (i.e. at the level of heat shock proteins) to high sea surface temperatures (Robbart et al. 2004)? How does the Baltic clam (*Macoma balthica*) respond (i.e. at the level of enzyme activities) to hypoxic conditions (Villnäs et al. 2019)? And, how do grasshoppers (*Chorthippus albonemus*) change gene regulation patterns in response to herbivore grazing intensity (Qin et al. 2017)? The case study by Alaux et al. (Chapter 4) illustrates how physiological information can allow for better management of bee populations, with great potential for expansion in this context. With invertebrates representing the most speciose and diverse group of animals globally, it is critical that physiological studies extend more often to underrepresented invertebrate species.

19.2.9 Conservation physiology informs sustainable resource management of non-imperilled species

The word 'conservation' inherently evokes connotations of science and practice that deals with imperilled species. Unfortunately, it is all too common to wait until organisms are imperilled before devoting resources or intellect. Yet, if management is successful, populations are sustained and ecosystems are left intact, such that no species or habitats become or remain at risk. In that context, a well-managed population or ecosystem can be a perfect example of conservation physiology in practice. That notion was represented throughout this book; indeed, many of the case studies did not focus on an imperilled organism. For example, Bouyoucos and Rummer (Chapter 11) herein discuss how combining ecophysiology techniques with community outreach and education are valuable steps towards conservation of shark populations predicted to be vulnerable to climate change in the future. Conservation 'wins' are best characterized by organisms and ecosystems that are not degraded to the point of requiring emergency recovery plans. Overall, we all win if sustainable management leads to populations and ecosystems that are resilient to anthropogenic change.

19.2.10 Co-production increases likelihood of success

Co-production means working hand-in-hand with partners (i.e. stakeholders) from the idea-generation phase (i.e. before pen is put to paper, so to speak) right through to the project wrap-up (Chapter 18). Doing so ensures that the project has relevance, credibility, and legitimacy, while increasing the likelihood that the co-produced science results in responsible engagement, balanced, respectful knowledge exchange, and greater impact within the scientific community and the community at large (Nel et al. 2016). Co-production is simply the only way to ensure that the findings generated through this research will be embraced by stakeholders and other knowledge users. Co-production and effective knowledge mobilization hinge on sustained and iterative bidirectional communication (Young et al. 2016). In the context of conservation physiology, this means interacting continually with conservation practitioners and policy makers. Undertaking physiological research and then trying to 'feed it' to conservation practitioners is a recipe for failure but remains far too common. In this book, we highlighted numerous examples where co-production was clearly in practice (e.g. Chapter 3, Chapter 6, Chapter 8, Chapter 18). The concept of co-production is particularly important for conservation physiology given the common disconnect between knowledge generators and knowledge users, and should be of paramount importance heading into the future.

19.2.11 Shout from the rooftops—share our successes

Sharing successes contributes to solution-oriented narratives and offers positive outlooks to often complex and dreary conservation challenges. Focusing attention on success stories or 'bright-spots' builds conservation optimism, which has been shown to underpin effective collaboration, drive creativity and innovation, and promote positive public perceptions—all of which are critical in mobilizing conservation research, education, and actions (Beever 2000; Bennett et al. 2016; Cvitanovic and Hobday 2018). Examples of successes in conservation physiology include identifying impacts of disturbance or environmental change, implementing disease control, and allowing managers to delineate and prioritize mitigation strategies because physiology offers mechanistic insights into the causes of change (Madliger et al. 2016). In a time of despair, where we as scientists and global citizens are seemingly constantly bombarded with dramatic and negative messages such as how the world is warming, how we are heading to the sixth mass extinction event, and that the biodiversity crisis is worse than climate change, we need optimism (Swaisgood and Sheppard 2010). We need to share success stories, not only to offer hope, but to communicate and share best practices so that these successes can rapidly spread across the globe in a time of urgency.

19.2.12 Don't be 'old school' when communicating your findings

Today's communication landscape is diverse in form (e.g. print media, online news sources, social media), highly fragmented (Bubela et al. 2009; Nisbet and Scheufele 2009), and requires the modern-day scientist to be flexible and creative if they are to be a successful communicator (Chapter 18). Furthermore, communication—like knowledge co-production—requires two-way dialogue (i.e. the 'dialogue model') as opposed to one-way information transfer from experts to non-experts (i.e. the 'deficit model'). It is also important to stay abreast of new developments in communication tools, many of which tap into more informal learning styles (National Research Council 2009). For example, social media is increasingly favoured by scientists as a method to disseminate information (e.g. Côté and Darling 2018), though successful implementation requires interaction among users (e.g. Bortree and Seltzer 2009; McClain 2017). Storytelling—and indeed conservation storytelling—is also being recognized for its ability to efficiently transfer information and its ease of implementation (Leslie et al. 2013; Dahlstrom 2014; Veríssimo and Pais 2014; Green et al. 2018). Additionally, visual communication tools, such as graphic design (e.g. Rodriguez Estrada and Davis 2015) and videography/photography (e.g. Monroe et al. 2009), play critical roles in the modern-day science communicator's toolbox. Ultimately, effective communication strategies will require conservationists to use a blend of approaches, think outside the box, embrace dialogue, and be willing to 'adapt' to changing technologies.

19.3 Overcoming challenges that limit capacity for conservation physiology

Conservation physiology, although not new in terms of application (e.g. see discussion of *Silent Spring* by Rachel Carson; Wikelski and Cooke 2006), is still a relatively new discipline (i.e. first defined in detail by Wikelski and Cooke 2006; redefined by Cooke et al. 2013). As with all new and emerging disciplines, there are inherent challenges, especially when the goal is to deliver applied science to solve conservation problems. Doing the science alone is not enough for conservation physiology to succeed and evolve—if the science is ignored by practitioners and policy makers, conservation physiology will fail (Cooke and O'Connor 2010). Here, we discuss challenges that impede the development of the conservation physiologist as a valued team member, the training of the next generation of conservation physiologists, and the application of physiological knowledge to conservation problems by practitioners and policy makers.

If a scientist is so bold as to self-identify as a 'conservation physiologist', that scientist may face challenges. For example, institutions (i.e. especially universities) may fail to recognize conservation physiology as a valid research domain, which could impede the ability to secure tenure or promotion. Relatedly, there may be challenges with obtaining funding, if funding bodies are focused on resourcing more established disciplines. Fortunately, there are now a number of scholars around the globe who proudly identify as being conservation physiologists and an increasing number of success stories where entire research programmes, including long-term ones, have focused on conservation physiology.

Moreover, with an established journal (i.e. *Conservation Physiology*) there is further legitimacy to the field. Clearly there are links between conservation physiology being relevant to practitioners and policy makers (i.e. helping to solve problems) and the growing recognition of the value that conservation physiologists bring to a team. Nonetheless, as described above, it is important to continue to share success stories.

Another key challenge impeding conservation physiology is the development of effective training programmes. All too often, conservation scientists are not trained in physiology, and physiologists are not trained in conservation. Fortunately, there are a growing number of examples focusing on how this barrier is being surmounted (e.g. entire courses on conservation physiology; lectures on conservation physiology within conservation science, ecology, and physiology courses; development of texts such as this one). Other subdisciplines, such as conservation genetics and conservation behaviour, have benefited from the development of training frameworks that incorporate those subdisciplines into their core (e.g. Jacobson 1990). To date, we are unaware of any training frameworks that explicitly incorporate conservation physiology. We do not anticipate a time where there would be entire university programmes in the realm of conservation physiology, but rather, we hope that conservation physiology will be recognized as a valid and important aspect of conservation science and incorporated into broader training programmes. Beyond training the next generation, there are also opportunities to train and retrain conservation practitioners (e.g. through professional development courses at conferences) to understand what conservation physiology has to offer.

The final, and perhaps biggest, challenge facing conservation physiology is to have it embraced by practitioners and policy makers. This is not trivial (Cooke and O'Connor 2010). There are many complex reasons why practitioners may ignore science and perhaps especially novel information (Young et al. 2016). For example, it is well known that new knowledge is judged based on its legitimacy and relevance. Conservation physiology has struggled to demonstrate both. One of the biggest issues is that conservation physiology tends to focus on molecules, cells, organs, and individuals, while conservation practitioners tend to care about populations, species, and ecosystems. This 'scalar' disconnect has been central to conservation physiology, with our findings therefore being regarded as 'interesting but not essential'. Conservation biology textbooks rarely cover and detail any physiology. Another key issue is that conservation practitioners and conservation physiologists rarely connect in formal settings such as conferences (Madliger et al. 2017a). Knowledge users and knowledge generators are rarely in the same space. This can be, of course, overcome with a co-production model, but that still requires knowledge generators and knowledge users to connect in some way. Fortunately, there is a growing number of examples where successes in conservation physiology have arisen because of meaningful partnerships with stakeholders. And, we anticipate this to become the norm over the next decade.

19.4 Conclusions

Conservation physiology is about generating an evidence base so that decisions can have meaningful impacts that benefit conservation. Doing so is an admirable task and one that is urgent, given the biodiversity crisis that exists today. Conservation physiology is increasingly being recognized for its ability to generate cause-and-effect relationships and understand mechanisms, which are essential for informing evidence-based conservation actions. The chapters in this book exemplify the many ways in which conservation physiology is relevant to stakeholders. We identified a number of themes that highlight both the challenges and opportunities in conservation physiology. For conservation physiology to continue to evolve and deliver on its promise requires concerted efforts from conservation physiologists, trainees, practitioners, policy makers, and other allies. Considering that conservation physiology is still a nascent discipline (Cooke et al. 2013), all of those working in this realm should be very proud of what they have collectively accomplished and be optimistic for the future (Cooke et al. 2020). Nonetheless, there is more work to do, and we hope that this chapter and this book in general will inspire others to rise to the challenge. There is no shortage of conservation problems that require the skills (see Cooke and O'Connor 2010) that well-trained conservation physiologists can bring to the table when partnered with those that will ensure that their research activities are relevant. Then, positive change can happen.

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