


# Conservation decisions under pressure: Lessons from an exercise in rapid response to wildlife disease

Stefano Canessa<sup>1</sup>  | Annemarieke Spitzen-van der Sluijs<sup>2</sup> | Tariq Stark<sup>2</sup> |  
 Bryony E. Allen<sup>3,4</sup> | Phillip J. Bishop<sup>5,6</sup> | Molly Bletz<sup>7</sup> | Cheryl J. Briggs<sup>8</sup> |  
 David R. Daversa<sup>3,4</sup> | Matthew J. Gray<sup>9</sup> | Richard A. Griffiths<sup>10</sup> |  
 Reid N. Harris<sup>6,11</sup> | Xavier A. Harrison<sup>12</sup> | Jason T. Hoverman<sup>13</sup> |  
 Phillip Jervis<sup>3,14</sup> | Erin Muths<sup>15</sup> | Deanna H. Olson<sup>16</sup> | Stephen J. Price<sup>17</sup> |  
 Corinne L. Richards-Zawacki<sup>18</sup> | Jacques Robert<sup>19</sup> | Gonçalo M. Rosa<sup>3,20</sup> |  
 Ben C. Scheele<sup>21</sup> | Benedikt R. Schmidt<sup>22,23</sup>  | Trenton W. J. Garner<sup>3</sup>

<sup>1</sup>Wildlife Health Ghent, Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium

<sup>2</sup>Reptile, Amphibian & Fish Conservation Netherlands (RAVON), Nijmegen, The Netherlands

<sup>3</sup>Institute of Zoology, Zoological Society of London, Regents Park, London, UK

<sup>4</sup>Institute for Integrative Biology, University of Liverpool, Liverpool, UK

<sup>5</sup>Department of Zoology, University of Otago, Dunedin, New Zealand

<sup>6</sup>Amphibian Survival Alliance, London, UK

<sup>7</sup>Biology Department, University of Massachusetts, Boston, Massachusetts

<sup>8</sup>Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, California

<sup>9</sup>Center for Wildlife Health, University of Tennessee Institute of Agriculture, Knoxville, Tennessee

<sup>10</sup>Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, Kent, UK

<sup>11</sup>Department of Biology, James Madison University, Harrisonburg, Virginia

<sup>12</sup>Centre for Ecology & Conservation, University of Exeter, Exeter, UK

<sup>13</sup>Department of Forestry and Natural Resources, Purdue University, West Lafayette, Indiana

<sup>14</sup>Faculty of Medicine, School of Public Health, Imperial College, London, UK

<sup>15</sup>United States Geological Survey, Fort Collins, Colorado

<sup>16</sup>Pacific Northwest Research Station, US Forest Service, Corvallis, Oregon

<sup>17</sup>UCL Genetics Institute, University College London, London, UK

<sup>18</sup>Department of Biological Sciences, University of Pittsburgh, Pittsburgh, Pennsylvania

<sup>19</sup>Department of Microbiology & Immunology, University of Rochester, Rochester, New York

<sup>20</sup>Centre for Ecology, Evolution and Environmental Changes (CE3C), Faculdade de Ciências da Universidade de Lisboa, Lisbon, Portugal

<sup>21</sup>Fenner School of Environment and Society, The Australian National University, Canberra, Australian Capital Territory, Australia

<sup>22</sup>Institut für Evolutionsbiologie und Umweltwissenschaften, Universität Zürich, Zürich, Switzerland

<sup>23</sup>Info Fauna Karch, Neuchâtel, Switzerland

Target audience: Managers and scientists seeking to mitigate impacts of emerging wildlife diseases, particularly those facing a novel pathogen invasion to which they wish to respond quickly.

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2019 The Authors. Conservation Science and Practice published by Wiley Periodicals, Inc. on behalf of Society for Conservation Biology

**Correspondence**

Stefano Canessa, Wildlife Health Ghent,  
Faculty of Veterinary Medicine, Ghent  
University, Merelbeke, Belgium.  
Email: canessa.stefano@ugent.be

**Funding information**

Fonds Wetenschappelijk Onderzoek,  
Grant/Award Number: FWO16/PDO/019;  
Natural Environment Research Council,  
Grant/Award Numbers: NE/N009967/1,  
NE/S000992/1; Zoological Society of  
London

**Abstract**

Novel outbreaks of emerging pathogens require rapid responses to enable successful mitigation. We simulated a 1-day emergency meeting where experts were engaged to recommend mitigation strategies for a new outbreak of the amphibian fungal pathogen *Batrachochytrium salamandrivorans*. Despite the inevitable uncertainty, experts suggested and discussed several possible strategies. However, their recommendations were undermined by imperfect initial definitions of the objectives and scope of management. This problem is likely to arise in most real-world emergency situations. The exercise thus highlighted the importance of clearly defining the context, objectives, and spatial–temporal scale of mitigation decisions. Managers are commonly under pressure to act immediately. However, an iterative process in which experts and managers cooperate to clarify objectives and uncertainties, while collecting more information and devising mitigation strategies, may be slightly more time consuming but ultimately lead to better outcomes.

**KEYWORDS**

amphibians, chytridiomycosis, containment, detection, early warning, epizootic, expert elicitation, mitigation, objectives, workshop

**1 | INTRODUCTION**

Of all major causes of biodiversity loss, emerging infectious diseases of wildlife remain one of the most challenging to address. Once a pathogen invades a new area, eradication is typically impossible (e.g., Canessa et al., 2018; Carter et al., 2009; Hallam & McCracken, 2011). However, greater awareness of disease impacts is opening new possibilities for rapid response. For example, when the fungus *Batrachochytrium dendrobatidis* (Bd) was described in 1998 as causing amphibian chytridiomycosis, it had already been driving widespread species losses since the 1970s (Scheele et al., 2019). When a second related pathogen emerged in the early 2010s (*B. salamandrivorans*, Bsal; Martel et al., 2013), its threat was recognized more quickly than for Bd, prompting the development of strategic plans for prevention and reaction in Europe ([www.bsaleurope.com](http://www.bsaleurope.com)) and North America ([www.salamanderfungus.org/resources/](http://www.salamanderfungus.org/resources/)). Framing such strategic plans as decision problems can assist their development and implementation (Bernard & Grant, 2019). Grant et al. (2017) developed a decision-support analysis for proactive Bsal management, and Hopkins et al. (2018) used scenario-building to prepare response frameworks for Bsal detection on public lands in the United States. However, these general plans and frameworks remain to be tested and a true emergency response has rarely been implemented for a wildlife disease

(Mysterud & Rolandsen, 2018). For chytridiomycosis, several Panamanian species were brought into captivity ahead of the expected wave of Bd invasion (Gratwicke et al., 2016). Yet even this action did not seek to actively respond to the pathogen's arrival, instead aiming to mitigate its long-term impacts through development of assurance colonies and reintroductions.

**2 | CASE STUDY: A SIMULATED EMERGENCY MEETING TO INFORM RESPONSE TO DISEASE DETECTION**

In April 2019, we simulated an emergency meeting in which a panel of experts was asked to recommend a rapid response to Bsal detection. The 1-day workshop was organized jointly with the international symposium “Mitigating single pathogen and co-infections threatening amphibian biodiversity” hosted by the Zoological Society London (UK). Attendees signed up voluntarily for the workshop, without prior knowledge of the specific topic or structure, although a focus on mitigating chytridiomycosis was anticipated. To give experts a practical context for the exercise, organizers presented a realistic case study, based on a real case of Bsal detection in 2018 in the Netherlands, 200 km from the closest known Bsal location in Europe. Two professionals from

RAVON (Reptile, Amphibian, and Fish Conservation the Netherlands), a nongovernmental organization that routinely advises Dutch authorities on herpetological conservation planning, attended the workshop and acted as decision-makers in the simulation (A.S. and T.S.; S.C. facilitated). All other 24 attendees were scientists with expertise in amphibian diseases or conservation attending the above-mentioned international symposium (hereafter “the experts”).

For realism, experts were given no case-specific information before the workshop. At the beginning of the exercise, they were provided limited information available about the hypothetical Bsal detection: a brief summary of species, focal area, and Bsal detection history at the site. The detection site was a single 235-m<sup>2</sup> pond in a multiple-pond system within the agricultural landscape (Figure 1), where two dead crested newts (*Triturus cristatus*) were found by volunteers during routine monitoring and subsequently confirmed as Bsal-positive by laboratory testing (personal communication by co-authors A.S. and T.S.).

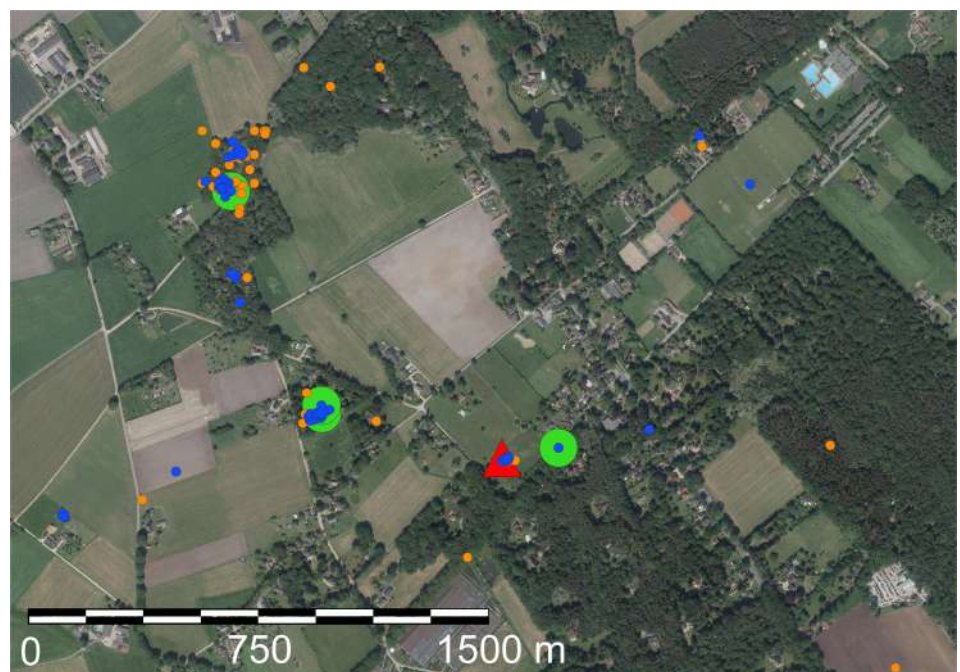
Experts were given three management objectives, agreed upon the previous day by the acting decision-makers and facilitator: (a) minimize the probability of Bsal spread from the detection site to neighboring sites, (b) minimize collateral damage to the amphibian community, and (c) minimize collateral damage to nontarget species and the environment.

Participants then articulated the uncertainty that influenced their recommendations about mitigation actions. The question of whether Bsal was present, but undetected, at sites adjacent to the detection site was

perceived as particularly important for recommending management actions. The only relevant information available was that a limited number of newts sampled across the neighboring ponds shortly after the initial diagnosis ( $n = 37$ ) all tested negative for Bsal. This information was considered insufficient to infer Bsal presence or absence (results of additional surveys in spring 2019 were not yet available at the time of our workshop). Uncertainty was therefore further articulated into three hypotheses: (a) Bsal is currently present only at the detection site; (b) Bsal is present at neighboring ponds (i.e., within amphibian dispersal distance from the detection site—hundreds of meters); and (c) Bsal is present in the surrounding landscape (>1 km from the detection site).

Participants then developed a set of mitigation actions of different intensity. The group agreed upon five alternative actions: (a) implement basic biosecurity (Phillott et al., 2010) when entering or leaving the detection site; (b) prevent amphibian movement into or out of the site by fencing and limit other wildlife movements into the detection site (e.g., overhead netting to prevent bird entry), and capture amphibians around the fence and release them inside to reduce pathogen spread; (c) in addition to the actions in 2, treat captured amphibians with heat to clear putative Bsal infection (Bloom et al., 2015) before release inside the fence; (d) install a fence impermeable to most potential Bsal hosts and vectors at the detection site, remove all animals from the detection site and treat the site with chemicals using Virkon Aquatic<sup>®</sup> (sensu Bosch et al., 2015)—the captured individuals could be euthanized, or quarantined and tested

**FIGURE 1** Aerial image of the case study landscape where Bsal was detected. The green circles are locations where newts were tested for Bsal in 2018 (light green;  $n = 37$  all negative). The red triangle is the confirmed Bsal positive site in 2019. Small circles indicate known presence of *Triturus cristatus* (orange) and *Lissotriton vulgaris* (blue) at ponds between 2009 and 2019. Map orientation and coordinates not provided



for Bsal then disinfected; and (e) in addition to the actions in (d), completely dry the waterbody at the detection site and return the captured and treated amphibians to the site after water was again present.

We then used a modified Delphi process with four-point elicitation (Hemming, Burgman, Hanea, McBride, & Wintle, 2018) to obtain quantitative estimates of the expected outcomes of actions under the different hypotheses. In other words, experts were asked to estimate the probability that each action would succeed in containing Bsal spread if Bsal were present only at the detection site *or* if it were present in neighboring water bodies *or* if it were present across the adjacent landscape (three estimates per action, each with the associated uncertainty). Experts provided initial estimates individually; these were summarized and displayed to the group using bar plots, to allow opinions and information to be shared among experts.

The ensuing discussion soon highlighted discrepancies among experts about the decision context, particularly about whether eradication or containment were sought only from the detection site, from the broader landscape, or from the province/region/country, and about the size of the area that could be directly managed. There was a wide array of implicit assumptions among experts, fueled in part by the imprecise definition of objectives against the three hypotheses about the current spread of the Bsal outbreak. For example, if Bsal were already present across the landscape, would action focusing at one pond contribute at all to preventing its spread? Would uncertainty about the broader presence of Bsal in the surrounding landscape truly affect the decision to manage the focal pond, or would pond-level actions be undertaken regardless? These and other components of the problem had been, to this point, interpreted in substantially different ways by different experts, which meant that a comparison of individual estimates was not meaningful. Further discussion failed to resolve these issues, and the acting decision-makers were unable to provide definitive responses about the objectives. A complete revision of the decision problem appeared necessary, but time did not allow it. Rather than pushing through an artificially simplified solution, we chose to terminate the exercise and focus the final discussion on the difficulties encountered and lessons learned.

### 3 | DISCUSSION

Our workshop failed to solve our simulated decision problem, but it succeeded in its primary aim of highlighting some key challenges likely to arise in emergency responses to pathogen detection. Here we convert these challenges

into lessons learned. We identify stall-points that could easily arise in a real emergency wildlife-disease event with elevated emotions and a broader set of stakeholders. Resolving known stall-points ahead of a crisis can facilitate and accelerate rapid responses when it really matters.

#### 3.1 | Poorly defined objectives make decisions difficult

Our workshop focused exclusively on engaging experts to provide recommendations about which actions to implement. The workshop was free from many complexities that are likely to arise in real emergency situations: Experts had engaged voluntarily in the exercise, had no personal stakes in its outcome, and there were no obvious conflicts among scientists. Potentially challenging interactions among decision makers and stakeholders, such as obtaining access to private properties, were also not represented in the exercise. Experts generally felt comfortable discussing actions and providing scores, even without elicitation training or experience, and interacted well in small and large groups. While knowledge of chytridiomycosis is still incomplete, it is probably sufficient to devise an emergency mitigation plan. Despite these favorable conditions, issues emerged that proved insurmountable within the time available. Those problems did not arise from scientific disagreements about disease dynamics and management actions but from the unclear definition of the initial decision context (the objectives, scope, and spatial scale of mitigation). The importance of context and objectives is a central principle of decision-making theory (Gregory et al., 2012) and a recognized challenge to Bsal mitigation (Bernard & Grant, 2019). We observed this challenge develop firsthand, which could severely impede a real emergency response where there is little room for error and delay. Decision-makers should prepare for such an emergency by clarifying the decision context as much as possible before a real crisis occurs. A clear context, including objectives, scale, and scope of the decision, will allow experts to be more efficient and provide more informed advice.

In the absence of clearly stated objectives and context, experts will use their own experience to construct the context from which they then advise decisions. During our workshop, uncertainty about Bsal epidemiology and the state of the outbreak in the wild highlighted our lack of clarity in defining objectives. For example, the optimal spatial scale at which to manage an outbreak is related to its rate of spread across a landscape, but the scope of our decision (whether objectives were at the local, regional, or national level, and what time frame was being

considered) was unclear, so experts struggled to provide their estimates or based them on their own assumptions about the spatial scale.

Objectives may need to be updated quickly to reflect the current state of knowledge. In some cases, local information may be accessed for additional information and surveillance could be initiated that might yield results in time for incorporation into the decision-making process. In our case, if new monitoring confirmed Bsal presence beyond the focal pond, the objective of minimizing spread might change to large-scale eradication, and some actions such as fencing would be inappropriate. If data collection cannot be incorporated into the initial decision, managers might decide to precautionarily implement mitigation over a larger area. Data collection and broader precautionary actions might also be combined, to the extent allowed by the resources available.

### 3.2 | Ask quantitative questions of the right experts

There is still much to be learned about wildlife diseases. Many management decisions will depend on expert opinion, especially in a crisis. Formal methods for expert elicitation may be perceived as time-consuming (even our incomplete Delphi process took over a third of the 1 day workshop). However, the problems in our scenario emerged only when quantitative individual estimates were shared and discussed with the group and divergent assumptions became apparent. More informal, purely verbal assessments might have failed to uncover different personal interpretations, leading to a flawed recommendation and a poor decision. Simply asking experts, or even worse a single expert, for their intuition rather than engaging them formally is likely to exacerbate such problems (Sutherland & Burgman, 2015). We recommend eliciting written quantitative estimates, to facilitate discussion, analysis and reporting.

The composition of the expert panel is also important. Discussions rapidly expanded our decision to include impacts on nonamphibian species and the environment; such multiple objectives are common and should be considered when assembling an expert panel. Our workshop was planned around amphibians and the panel assembled opportunistically, but an ecotoxicologist or a restoration ecologist likely would have contributed to the discussion about the collateral damage of mitigation treatments, improving both the definition of objectives and the elicitation of consequences (Game, Kareiva, & Possingham, 2013). Other types of experts may also be required (e.g., for legal advice); again, decision-makers should anticipate these needs and prepare as much as possible before the

emergency occurs. Finally, cultural and disciplinary diversity is generally advantageous when assembling expert panels (Sutherland & Burgman, 2015). Our exercise involved scientists from Europe, the Americas, and Oceania, allowing us to hear a wide range of views and experiences. However, this also meant there was little time to establish a common knowledge base of the decision context, for example, by clarifying the relevant European, Dutch and local authorities and legislation (such as regulations for accessing private sites, releasing chemicals into the environment or killing nontarget species), or addressing implicit assumptions about resource availability, willingness to act, or species ecology. Preplanning, including a list of experts, their areas of knowledge and contact details is advantageous in reacting to an emergency.

### 3.3 | Iterative processes are necessary but time-consuming

Facilitators of decision-making workshops often repeat the process several times. This approach, known as “rapid prototyping,” initially requires heavy simplification but quickly highlights key problems on which a second iteration can then focus (Gregory et al., 2012). In our workshop, a second iteration might have sought a shared definition of “spread” and “landscape” that satisfied the decision-maker and gave experts a clear scenario for elicitation. This second iteration would have probably been more efficient, as common language and objectives had been developed and clarified in the first one. However, we ran out of time for a second iteration. In comparison, a 3-day scenario planning exercise for Bsal response in the United States provided more information for policy-makers, but it did not include an explicit quantitative assessment of detailed actions (Hopkins et al., 2018). A 4-day workshop in Europe produced a complete quantitative assessment of several Bsal mitigation actions but did not involve a real decision-making context (Canessa et al., 2018). Gerber et al. (2018) developed a full mathematical model and decision process for landscape-scale management of enzootic chytridiomycosis in boreal toads (*Anaxyrus boreas*) over several months, including two multiday workshops and iterated remote elicitation. Such complex tools are obviously difficult to develop in emergency situations; if possible, they should be prepared in advance.

Disease outbreaks typically leave little time for response, but also little room for error. Even 1–2 extra days might allow a more informed decision, although longer delays are obviously riskier (Scudamore & Harris, 2002). How long is too long depends on the local policy context and on the characteristics of the disease: for

example, Bsal might disperse slowly (Spitzen-van der Sluijs et al., 2018), allowing managers more time—possibly weeks—than in the case of pathogens spread by more mobile hosts (e.g., *Pseudogymnoascus destructans* causing white-nose syndrome in bats; Foley, Clifford, Castle, Cryan, & Ostfeld, 2011). Again, such characteristics may be unknown in the case of novel emerging pathogens and diseases, forcing decision-makers to rely on expert elicitation and making uncertainty inevitable.

### 3.4 | Drills are not reality, for better or worse

In a real emergency, urgency could give the decision-maker a stronger resolve to act, but might also rush decisions. For simplicity, we did not explicitly represent such time and social pressures in our 1-day workshop. For *P. destructans*, a similar recent workshop was successful in reaching a decision for pathogen control (Bernard et al., 2019). We did not provide information to experts before the workshop, but the logistics of larger, international meetings might allow some time for preparation. Preselecting panels could make emergency meetings more efficient when they are eventually called.

### 3.5 | Policy directions

Based on our experience, we suggest the following for engaging scientists to define a rapid response plan for pathogen invasions.

- Clarify the decision context as much as possible: identify the decision-maker and the spatial and temporal scope.
- Assemble a mid-sized group (10–15) including managers and experts, not limited to specialists of the focal hosts and pathogen.
- Engage experts with clear questions but be prepared to incorporate feedback and go back to clarify policy aspects as needed. Presence of decision-makers at the meeting should facilitate this process.
- Formal expert elicitation requires more preparation than informal discussions, but is more effective and transparent for identifying misunderstandings and presenting results. Trained facilitators can assist.
- Take extra time as necessary without rushing to action. Plan for multiple iterations of the decision-making process, even if it means simplifying at the beginning.

Decisions made in the first days after disease detection can be crucial for mitigation success (Keeling &

Rohani, 2008). Effective collaboration between managers and scientists before and after detection is the key to that success.

### ACKNOWLEDGEMENTS

S.C. was supported by the Research Foundation Flanders (FWO16/PDO/019); T.W.J.G., D.R.D., and G.M.R. by NERC (NE/S000992/1, NE/N009967/1). The workshop was funded by the Zoological Society of London. We thank D. Carter and A. Fenton for attending. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government. This is publication number #716 of the Amphibian Research and Monitoring Initiative (ARMI) of the U.S. Geological Survey.

### CONFLICT OF INTEREST

The authors declare there are no conflicts of interest associated with this publication.



### AUTHOR CONTRIBUTIONS

S.C., A.S., T.S. and T.W.J.G. conceived the idea and organized the workshop; all authors attended the workshop and contributed to the elicitation and discussions; S.C. wrote the manuscript with input from all other authors.

### ETHICS STATEMENT

The research did not require ethics approval.

### ORCID

Stefano Canessa  <https://orcid.org/0000-0002-0932-826X>  
Benedikt R. Schmidt  <https://orcid.org/0000-0002-4023-1001>

### REFERENCES

- Bernard, R. F., Evans, J., Fuller, N. W., Reichard, J. D., Coleman, J. T., Kocer, C. J., & Grant, E. H. C. (2019). Different management strategies are optimal for combating disease in East Texas cave versus culvert hibernating bat populations. *Conservation Science and Practice*, *1*, e106.
- Bernard, R. F., & Grant, E. H. C. (2019). Identifying Common Decision Problem Elements for the Management of Emerging Fungal Diseases of Wildlife. *Society & Natural Resources*, *32*, 1040–1055.
- Blooi, M., Martel, A., Haesebrouck, F., Vercammen, F., Bonte, D., & Pasmans, F. (2015). Treatment of urodelans based on temperature dependent infection dynamics of *Batrachochytrium salamandrivorans*. *Scientific Reports*, *5*, 8037.
- Bosch, J., Sanchez-Tomé, E., Fernández-Loras, A., Oliver, J. A., Fisher, M. C., & Garner, T. W. (2015). Successful elimination of a lethal wildlife infectious disease in nature. *Biology Letters*, *11*, 20150874.
- Canessa, S., Bozzuto, C., Grant, E. H. C., Cruickshank, S. S., Fisher, M. C., Koella, J. C., ... Schmidt, B. R. (2018). Decision making for mitigating wildlife diseases: from theory to practice

- for an emerging fungal pathogen of amphibians. *Journal of Applied Ecology*, 55, 1987–1996.
- Carter, S. P., Roy, S. S., Cowan, D. P., Massei, G., Smith, G. C., Ji, W., ... Delahay, R. J. (2009). Options for the Control of Disease 2: Targeting Hosts. In R. J. Delahay, G. C. Smith, & M. R. Hutchings (Eds.), *Management of Disease in Wild Mammals* (pp. 121–146). Tokyo: Springer Japan.
- Foley, J., Clifford, D., Castle, K., Cryan, P., & Ostfeld, R. S. (2011). Investigating and managing the rapid emergence of white-nose syndrome, a novel, fatal, infectious disease of hibernating bats. *Conservation Biology*, 25, 223–231.
- Game, E. T., Kareiva, P., & Possingham, H. P. (2013). Six common mistakes in conservation priority setting. *Conservation Biology*, 27, 480–485.
- Gerber, B. D., Converse, S. J., Muths, E., Crockett, H. J., Mosher, B. A., & Bailey, L. L. (2018). Identifying species conservation strategies to reduce disease-associated declines. *Conservation Letters*, 11, e12393.
- Grant, E. H. C., Muths, E., Katz, R. A., Canessa, S., Adams, M. J., Ballard, J. R., ... White, C. L. A. (2017). Using decision analysis to support proactive management of emerging infectious wildlife diseases. *Frontiers in Ecology and the Environment*, 15, 214–221.
- Gratwicke, B., Ross, H., Batista, A., Chaves, G., Crawford, A., Elizondo, L., ... Guerrel, J. (2016). Evaluating the probability of avoiding disease-related extinctions of Panamanian amphibians through captive breeding programs. *Animal Conservation*, 19, 324–336.
- Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T., & Ohlson, D. (2012). *Structured decision making: a practical guide to environmental management choices*. Hoboken, NJ: Wiley.
- Hallam, T. G., & McCracken, G. F. (2011). Management of the panzootic white-nose syndrome through culling of bats. *Conservation Biology*, 25, 189–194.
- Hemming, V., Burgman, M. A., Hanea, A. M., McBride, M. F., & Wintle, B. C. (2018). A practical guide to structured expert elicitation using the IDEA protocol. *Methods in Ecology and Evolution*, 9, 169–180.
- Hopkins, M. C., Adams, M. J., Super, P. E., Olson, D. H., Hickman, C. R., English, P., ... Ludwig, K. A. (2018). *Batrachochytrium salamandrivorans* (Bsal) in Appalachia—Using scenario building to proactively prepare for a wildlife disease outbreak caused by an invasive amphibian chytrid fungus [Report]. Reston, VA: US Geological Survey.
- Keeling, M. J., & Rohani, P. (2008). *Modeling infectious diseases in humans and animals*. Princeton, NJ: Princeton University Press.
- Martel, A., Spitzen-van der Sluijs, A., Blooi, M., Bert, W., Ducatelle, R., Fisher, M. C., ... Bossuyt, F. (2013). *Batrachochytrium salamandrivorans* sp. nov. causes lethal chytridiomycosis in amphibians. *Proceedings of the National Academy of Sciences of the United States of America*, 110, 15325–15329.
- Mysterud, A., & Rolandsen, C. M. (2018). A reindeer cull to prevent chronic wasting disease in Europe. *Nature Ecology & Evolution*, 2, 1343–1345.
- Phyllott, A., Speare, R., Hines, H., Skerratt, L., Meyer, E., McDonald, K., ... Berger, L. (2010). Minimising exposure of amphibians to pathogens during field studies. *Diseases of Aquatic Organisms*, 92, 175–185.
- Scheele, B. C., Pasmans, F., Skerratt, L. F., Berger, L., Martel, A., Beukema, W., ... Canessa, S. (2019). Amphibian fungal panzootic causes catastrophic and ongoing loss of biodiversity. *Science*, 363, 1459–1463.
- Scudamore, J., & Harris, D. (2002). Control of foot and mouth disease: lessons from the experience of the outbreak in Great Britain in 2001. *Revue scientifique et technique-Office international des épizooties*, 21, 699–707.
- Spitzen-van der Sluijs, A., Stegen, G., Bogaerts, S., Canessa, S., Steinfartz, S., Janssen, N., ... Martel, A. (2018). Post-epizootic salamander persistence in a disease-free refugium suggests poor dispersal ability of *Batrachochytrium salamandrivorans*. *Scientific Reports*, 8, 3800.
- Sutherland, W. J., & Burgman, M. (2015). Policy advice: use experts wisely. *Nature*, 526, 317–318.

**How to cite this article:** Canessa S, Spitzen-van der Sluijs A, Stark T, et al. Conservation decisions under pressure: Lessons from an exercise in rapid response to wildlife disease. *Conservation Science and Practice*. 2020;2:e141. <https://doi.org/10.1111/csp2.141>