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1 **How to ensure threatened species monitoring leads to threatened species conservation**

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26 **Summary**

27 Monitoring is essential for effective conservation and management of threatened species and
28 ecological communities. However, more often than not, threatened species monitoring is poorly
29 implemented, meaning that conservation decisions are not informed by the best available
30 knowledge. We outline challenges and provide best-practice guidelines for threatened species
31 monitoring, informed by the diverse perspectives of 26 conservation managers and scientists from a
32 range of organisations with expertise across Australian species and ecosystems. Our collective
33 expertise synthesised five key principles that aim to enhance the design, implementation and
34 outcomes of threatened species monitoring. These principles are: 1) Integrate monitoring with
35 management; 2) Design fit-for-purpose monitoring programs; 3) Engage a diverse range of
36 stakeholders; 4) Ensure good data management; and 5) Communicate the value of monitoring. We
37 describe how to incorporate these principles into existing frameworks to improve current and future
38 monitoring programs. Effective monitoring is essential to inform appropriate management and
39 enable better conservation outcomes for our most vulnerable species and ecological communities.

40

41 **Key words:** adaptive management; conservation management; knowledge transfer; management
42 cycle; monitoring and evaluation; threatened species, populations & communities; translating
43 science

44 **Introduction**

45 The world is losing species at an alarming rate (Butchart et al. 2010, Waldron et al. 2017), far higher
46 than background rates through geological time (Ceballos et al. 2017). Australia, especially, is
47 contributing to ongoing species declines and extinctions (Cresswell and Murphy 2017, Waldron et al.
48 2017). Many extinctions may have been avoided if adequate knowledge of declines existed, and if
49 this knowledge triggered actions to halt declining species trajectories (Martin et al. 2012,
50 Lindenmayer et al. 2013, Woinarski et al. 2016). In this regard, the application of effective
51 monitoring is central to preventing species extinctions (Martin et al. 2007). Monitoring is the process
52 of collecting and analysing repeated observations or measurements to identify changes and evaluate
53 progress of management towards a stated aim. In the context of threatened species conservation,
54 monitoring is essential to detect trends in abundance and distribution through time, measure the
55 impacts of threatening processes, and evaluate the effectiveness of management responses (Legge
56 et al. 2018). It is also important for informing legislative protection and securing investment in
57 management, and is a powerful communication tool that allows for meaningful engagement with a
58 broad range of stakeholders. Despite these important values, the current contribution of monitoring
59 to the conservation and management of threatened biodiversity in Australia is severely deficient
60 (Legge et al. 2018).

61 Threatened species monitoring and management in Australia is not of a standard and
62 comprehensiveness commensurate with the nation's wealth, scientific capacity and stable
63 governance structure (McDonald et al. 2015, Waldron et al. 2017, Legge et al. 2018). A recent
64 assessment of Australia's threatened species and ecological communities has revealed inadequacies
65 in the quantity and quality of monitoring, with a lack of monitoring for many threatened species and
66 communities (Legge et al. 2018). An estimated 24 – 46% of threatened vertebrate species receive no
67 monitoring at all, and a high proportion of monitoring programs that do exist are poorly designed
68 with not enough statistical power to detect changes in population trends. More worryingly, Legge et
69 al. (2018) also identified poor coordination between monitoring programs, inadequate data
70 management and reporting, and limited integration between monitoring and management. These
71 issues are not unique to Australia, with inadequacies in monitoring being documented globally (Legg
72 and Nagy 2006, Lindenmayer and Likens 2010).

73 Resource constraints are often cited as a fundamental reason for not being able to monitor
74 effectively (Lindenmayer et al. 2012, Environment and Communications References Committee
75 2013). Indeed, the Australian Government falls short on delivering adequate resources for

76 biodiversity by both national (Cresswell and Murphy 2017) and international standards (Waldron et
77 al. 2013). This is despite threatened biodiversity facing increasing pressures, and despite the
78 inclusion of an explicit target to develop a national monitoring program in Australia's Biodiversity
79 Conservation Strategy (2010–30) (Natural Resource Management Ministerial Council 2010). We note
80 that, at present, monitoring is not mandatory even for critically endangered species. We advocate
81 that adequately resourced monitoring programs be developed for priority threatened species, in line
82 with nations such as United States of America, where biennial monitoring of threatened species
83 population trend is mandated via funded recovery plans (U.S. Endangered Species Act of 1973).
84 Further improvements in monitoring can be made through enhancing existing capacity such as
85 through greater engagement, effective partnerships, and increased coordination and integration of
86 programs.

87 Other reasons for inadequate monitoring, however, are more concerning than resource limitations.
88 These include a growing disregard for science (Lindenmayer et al. 2015), scientific elitism against
89 monitoring (Lindenmayer and Likens 2018), de-valuing of evidence-based management (Russell-
90 Smith et al. 2015), competing interests that undervalue biodiversity or erode ecological integrity
91 (Ritchie et al. 2013), wilful obstruction towards receiving bad news (Woinarski et al. 2016), and
92 hesitation to act on information (Martin et al. 2012). Such attitudes and behaviours are attributed to
93 limited understanding of the value of threatened species monitoring by scientists, governments,
94 industry and the broader public, along with a culture of pessimism that considers extinction
95 inevitable (Garnett and Lindenmayer 2011). Under-appreciation of biodiversity values and
96 defeatism, however, can be transformed into empowerment to act, by promoting both intrinsic and
97 extrinsic biodiversity values (Keith et al. 2017), inspiring hope (Garnett and Lindenmayer 2011,
98 Balmford 2012, Garnett et al. 2018), and demonstrating how effective monitoring can inform
99 decision-making and management to enhance threatened species conservation (Lindenmayer et al.
100 2013).

101 Although the overall state of threatened species monitoring in Australia is inadequate, this is not
102 universally the case (e.g. Hansen et al. 2018). Much can be learnt from evaluating good monitoring
103 programs, and using existing frameworks that have been developed to guide monitoring. Here, we
104 collate personal experience in what makes monitoring difficult, learn lessons from good examples
105 and synthesise the academic literature to draw out key principles that lead to better monitoring.

106 ***Essential principles for making the monitoring of threatened biodiversity count***

107 Our principles are the product of a two-day workshop on threatened species monitoring in Australia,
108 involving 26 practitioners from government, non-government organisations, environmental
109 consulting companies and academic institutions. Participants had expertise in monitoring that
110 encompassed threatened flora and fauna across all major Australian biomes; they shared their
111 knowledge and experience in threatened species monitoring via pre-workshop surveys (Robinson et
112 al. 2018), individual presentations and targeted group discussion. The workshop culminated in
113 focused discussion on how to improve threatened species monitoring. Within small groups, ideas
114 and insights were shared then, as a collective, these were collated and distilled into five essential
115 principles for monitoring; these being: 1) Integrate monitoring with management; 2) Design a fit-for-
116 purpose monitoring program; 3) Engage a diverse range of stakeholders; 4) Ensure good data
117 management; and 5) Communicate the value of monitoring. These principles complement existing
118 guidelines for developing monitoring programs (e.g. Reynolds et al. 2016), and monitoring-
119 management frameworks (e.g. Williams 2011, Schwartz et al. 2012). Central to all these frameworks
120 is a holistic and cyclical view of improving monitoring and management through learning, evaluating
121 and applying new knowledge. We outline how our principles fit with such frameworks with the
122 specific aim of improving conservation actions for threatened species (Fig. 1). Our principles,
123 although designed to address monitoring of threatened species, are equally applicable to the
124 monitoring of threatened ecological communities.

125 *Principle 1. Integrate monitoring with management*

126 Threatened species monitoring is often poorly integrated with management, even for species with
127 dedicated monitoring programs (Legge et al. 2018). Failing to explicitly link the two limits the
128 potential to positively influence conservation outcomes and document the effectiveness of actions
129 (Martin et al. 2012). A threatened species monitoring program should complement a recovery plan
130 (or analogous process) with clearly articulated management responsibilities and accountabilities.
131 These monitoring and management plans should be publicly available (e.g. online reports, published
132 management plans) to ensure transparency in process and accountability for actions, and be
133 regularly reviewed and updated.

134 Many monitoring-management frameworks have been devised to help plan, design and implement
135 an integrated monitoring-management plan (e.g. Schwartz et al. 2012, Reynolds et al. 2016). These
136 frameworks vary, but all begin by defining and scoping the problem (or problems) affecting a species
137 (Fig. 1). These initial steps focus on developing compatible conservation monitoring and
138 management aims and outlining existing and potential management actions and strategies.

139 Collaboration and integration at this early stage facilitates greater uptake and implementation of
140 new knowledge by managers later in the management cycle (Nichols and Williams 2006). An
141 understanding of the management context further helps to identify priority areas for monitoring
142 based on management needs and knowledge gaps (Nichols and Williams 2006). Clarifying
143 relationships between threats, actions and species persistence helps to prioritise management
144 actions and refine what monitoring is required to improve our understanding and management. For
145 example, Bode et al (2017) used expert elicitation along with ecosystem modelling to illustrate the
146 links between threats to malleefowl (*Leipoa ocellata*) and effective management action; this process
147 has subsequently helped guide management and monitoring needs.

148 Integration with management is also important during the monitoring design phase. To encourage
149 management accountability and action, the monitoring design should outline decision triggers
150 (Lindenmayer et al. 2013) and identify who is responsible for management intervention. Decision
151 triggers indicate critical stages along a species' population trajectory, or a level of impact from
152 threatening process, where an action is required (Lindenmayer et al. 2013). Often, immediate and
153 decisive action is necessary to avert negative outcomes or prevent extinction (Martin et al 2012). For
154 example, decisive action by the orange-bellied parrot (*Neophema chrysogaster*) recovery team in
155 response to critically low numbers of wild individuals triggered a captive breeding program that
156 averted extinction of the wild population (Martin et al 2012). Conversely, indecision and opaque
157 accountability meant that the Christmas Island pipistrelle (*Pipistrellus murrayi*) was monitored to
158 extinction (Martin et al 2012). Decision triggers should be identified early to minimise indecision,
159 and enforce action and accountability in a timely fashion (Martin et al. 2012), yet such triggers are
160 rarely defined during the design phase of monitoring programs.

161 The next two phases of the monitoring-management cycle focus on evaluating monitoring data (i.e.
162 learning) and improving future management decisions (Fig. 1). Evaluation and reporting ensures that
163 monitoring results inform management and other stakeholders, enabling responsive action (e.g. via
164 decision triggers) and adjustments to ongoing monitoring and management action. Evaluation
165 should occur at multiple levels. At the species or population level, analysing monitoring data can
166 quantify trends in distribution and abundance, which can inform future projections of species or
167 population trends, and be used to review listing status under threatened species legislation. For
168 example, ongoing monitoring of woylies (*Bettongia penicillata*) tracked initial population increases
169 followed by subsequent unexpected declines which prompted a re-listing of the species (Groom
170 2010). At the program level, evaluation reveals the effectiveness of management actions, suitability
171 of methodological approach, efficiency of resource allocation, and explains how well the program is

172 meeting conservation objectives. For example, review of a long-running vertebrate monitoring
173 program in Northern Australia revealed that statistical power to detect further declines in occupancy
174 was low. This prompted a re-design of the program and changes to the location, timing and
175 frequency of monitoring (Einoder et al. 2018). Evaluation, and subsequent program improvement,
176 ensures effective and efficient threatened species monitoring and management.

177 *Principle 2: Design a fit-for-purpose program*

178 Threatened species monitoring can rarely be a by-product of generic biodiversity monitoring (i.e.
179 'surveillance' monitoring). It needs to be targeted, question-driven and scientifically robust, to be
180 able to detect and quantify causes of decline and evaluate management effectiveness (Lindenmayer
181 and Likens 2018). The design of a threatened species monitoring program (i.e. where, when, what
182 and how to survey) must address the monitoring objectives and questions, be tailored to suit the
183 specific attributes of the target species and have adequate statistical rigour with respect to the
184 monitoring objective (Lindenmayer and Likens 2018). Failure to consider these design issues could
185 result in a costly data collection exercise that is unable to detect causes and effects, and ultimately a
186 waste of resources that could otherwise be spent on management (Legg and Nagy 2006).

187 The design of a monitoring program for threatened species is usually more challenging than for non-
188 threatened taxa. Species rarity can invoke particular sampling and detection challenges. For
189 example, the regent honeyeater (*Anthochaera Phrygia*) is rare and highly mobile (Crates et al. 2017),
190 making it difficult to know where to locate monitoring sites to confidently detect population changes
191 given low and variable occupancy over time. Monitoring design should be informed by the type and
192 quantity of data required, what analyses are to be conducted, the variability in the dynamics of the
193 species or system (e.g. spatial coverage, irruptive species), and the probability of detection (Block et
194 al. 2001, Martin et al. 2007). Power analysis is a particularly important tool to ensure that sufficient
195 effort is allocated towards monitoring to detect variation in populations should a change occur (e.g.
196 Einoder et al. 2018). At the most basic design level, sampling methods must be able to adequately
197 represent the abundance of target species or life history stages (e.g. new recruits, Lintermans 2016).
198 Monitoring-program design should also consider the level of skill or training needed, timing and
199 duration of data collection, and opportunities for new technologies. Design and methodology need
200 to also consider cost-effectiveness, ethics, longevity and feasibility of the monitoring program.

201 To meet rigorous design criteria, threatened species monitoring programs can be at risk of becoming
202 extremely expensive and / or logistically unfeasible. Innovative approaches could be investigated
203 that enable more cost-effective and or data-specific methods. For example, advancements in drone

204 technology can facilitate greater precision in data capture (Hodgson et al. 2016) and eDNA has
205 proven to be an effective tool in monitoring some endangered species or threats (Thomsen et al.
206 2012); both techniques promise benefits in cost effectiveness. Similarly, citizen science projects such
207 as the web-based Wildlife Spotter (www.wildlifespotter.net.au) have increased data processing
208 capacity of camera trap images with high accuracy of species identification (Koleck 2018).

209 *Principle 3. Engage people and organisations*

210 Successful engagement ensures that a monitoring program is valued, integrated in decision making,
211 and has financial and popular support from institutions, partner agencies and across the broader
212 community (Dickman 2013). Effectively engaging with people and organisations means that all
213 relevant stakeholders are involved or consulted appropriately throughout the monitoring process
214 (Burbidge et al. 2011, Ens et al. 2012, Ives and Kendal 2014). Engagement can promote knowledge
215 exchange, develop common or compatible goals, raise awareness, generate political support and
216 create change.

217 Identifying stakeholders and the significance of their role to the success of the monitoring is
218 important at the outset (Fig. 1). Similar to managers of threatened species, there may be
219 stakeholders whose involvement or activities may significantly affect the monitoring and / or the
220 threatened species or ecosystems of interest. These may include users of the threatened species or
221 their habitat (e.g. recreational users and extractors / harvesters of water, minerals, timber, flowers,
222 food, etc.) and adjacent land users whose activities may impact the threatened species (e.g. source
223 of invasive species such as introduced predators). Such stakeholders may be better identified as
224 integrated partners in the monitoring program, because if they 'own it' they are more likely to be
225 part of the solutions and remedial actions if they are required. Other stakeholders whose roles may
226 be more supportive than integral, remain important but may be better engaged differently (e.g.
227 consultation or participation as assistants more so than partners). In the case of the Lord Howe
228 Island stick insect (*Dryococelus australis*), early engagement with the local community meant that
229 the recovery of the species was supported from the outset. Soon after its rediscovery, it was listed
230 and a recovery plan that involved the community was produced (Carlile et al. 2009). Recovery of the
231 species has subsequently inspired an ambitious black rat (*Rattus rattus*) eradication program that
232 was possible only with strong community support (Carlile et al. 2009). Without some level of
233 consensus between stakeholders on issues of management and recovery approach, monitoring
234 efforts may be hampered.

235 During the design and implementation stages, people with expertise or those closely involved with
236 or conducting the monitoring should be consulted (Fig. 1). Researchers and statisticians are
237 particularly valuable in the design stage to draw out key monitoring questions, highlight limitations
238 in monitoring approaches, and give advice on appropriate methods, data requirements, and data
239 analysis (Lindenmayer et al. 2012). Conversely, field staff and land managers can provide valuable
240 insights to what is happening on the ground, and outline constraints to implementation (Burbidge et
241 al. 2011). Engagement across jurisdictional boundaries (regions, states) facilitates coordinated 'big
242 picture' management and monitoring approaches and multijurisdictional recovery teams play a key
243 role (Lintermans 2013). Regular interaction with those implementing the monitoring (e.g. via training
244 and project updates) ensures problems are quickly resolved, maintains consistent application of
245 methods and data collection, improves morale, and, in the case of volunteers, can lead to greater
246 commitment to the project (Koleck 2018).

247 Inadequate acknowledgement and involvement of stakeholders throughout the monitoring process
248 can, conversely, undermine the capacity of the program to properly address monitoring objectives,
249 and exclude potential supporters. In the case of the nationally vulnerable Baudin's cockatoo
250 (*Calyptorhynchus baudinii*), limited representation and ad hoc engagement with the fruit growing
251 and timber industries effectively ignored links between these industries and the primary threats (e.g.
252 illegal shooting, insufficient tree hollows) (Holmes et al. 2017). Consideration of additional
253 stakeholder values, beyond that of monitoring threatened species, may further require development
254 of compatible goals, or the design of multi-objective programs. For example, monitoring programs
255 on Indigenous lands should be developed in partnership with Indigenous communities and aim to
256 integrate values and objectives from both Indigenous and non-Indigenous perspectives (Ens et al.
257 2012). Indigenous groups often place importance on integration of environmental outcomes with
258 cultural, social and economic outcomes, and aim to bring together Indigenous knowledge (in
259 culturally-appropriate ways) with western science, which influences both the design and execution
260 of monitoring and management programs (Bohensky et al. 2013, Ens et al. 2015). In North America,
261 the incorporation of Indigenous ecological knowledge is often required in threatened species
262 recovery planning, adding value and improving knowledge outcomes (Polfus et al. 2014). In cross-
263 cultural collaborations, ample time should be provided to understand perspectives, develop trust
264 and build relationships, define the governance structure, and establish intellectual property
265 agreements (Ens et al. 2012, Bohensky et al. 2013). Investing time and energy to develop good
266 stakeholder relationships and develop compatible objectives early in the process can provide long-
267 term benefits such as financial support (Bush Heritage Australia 2017), community advocacy
268 (Ainsworth et al. 2016) and institutional commitment to projects (Burbidge et al. 2011).

269 *Principle 4. Ensure good data management*

270 Data management is an essential component of developing and maintaining effective monitoring
271 programs. Good data management will identify data needs, maintain data integrity, and enable early
272 detection of species trends allowing managers to act quickly (e.g. Groom 2010). However, data
273 management is often neglected and its value apparent only when it fails (Caughlan and Oakley
274 2001). For example, if data analysis requirements are poorly estimated during program design, there
275 may be a failure to make reliable inferences about threatened species (Houston and Hiederer 2009).
276 Similarly, budget blow-outs resulting from a lack of accounting for the cost of data management
277 (Caughlan and Oakley 2001), or data loss resulting from insufficient data security (Whitlock 2011)
278 highlight the need for good data management practices. Data management should be considered
279 throughout the life of a monitoring program and be properly costed at the start of the project. Data
280 management plans assist by outlining how data will be organised, stored, processed and analysed.
281 Such plans further detail responsibilities for who maintains the database, and who can use the data
282 (Vos et al. 2000).

283 An example of a well maintained database for a single species is the National Malleefowl Monitoring
284 Database (Benshemesh et al. 2018). This central data repository was custom designed to enable
285 consistent data collection, accessibility to users, stakeholders and contributors, and facilitate regular
286 reporting. Not all monitoring programs, however, are as well coordinated or their data as accessible.
287 Monitoring data from small scale or short term projects are largely unavailable, or difficult to access.
288 A national review of conservation activities for threatened freshwater fish reported that >80% of
289 onground actions had associated monitoring, but there were no national databases to store and
290 curate such datasets (Lintermans 2013), making learning from previous monitoring approaches
291 problematic.

292 During initial problem framing, it is important to consider what data are required and already
293 available (Fig. 1). Australia's Long Term Ecological Research Network (<http://www.ltern.org.au>), until
294 recently, maintained a large database of species observation records that was available for broader
295 use. Unfortunately, its recent decommission now jeopardises the future of associated monitoring
296 and reporting (Lindenmayer 2017). Other data requirements may be met by collaborating with
297 related monitoring projects to integrate and share data. The development of Australia's first
298 threatened species index relies on collating data from multiple sources
299 ([http://www.nespthreatenedspecies.edu.au/projects/national-and-regional-monitoring-for-](http://www.nespthreatenedspecies.edu.au/projects/national-and-regional-monitoring-for-threatened-species)
300 [threatened-species](http://www.nespthreatenedspecies.edu.au/projects/national-and-regional-monitoring-for-threatened-species)). Data sharing arrangements can minimise unnecessary monitoring, reduce

301 costs, and value-add to existing data. However, the sensitive nature of threatened species data and
302 the concern for abuse of knowledge (e.g. poaching, interference of habitat) will require that certain
303 data restrictions be considered to protect sensitive species location data (Lindenmayer and Scheele
304 2017).

305 *Principle 5. Communicate the value of monitoring*

306 Multiple values are inherent in threatened species monitoring, including tracking changes in
307 populations, evaluating management performance and effectiveness, and contributing to improved
308 biodiversity conservation. Extrinsic values, such as empowering local communities (Ens et al. 2012),
309 creating social connections between diverse people and groups (Holmes et al. 2017), and
310 highlighting health, economic and societal benefits (Keith et al. 2017), may not be the primary
311 reason to monitor but can be important for other parts of society and contribute to conservation
312 initiatives (Ives and Kendal 2014). These diverse values are often lost in the overwhelming tide of
313 negative stories about the future of threatened species and ongoing extinctions. Continuous
314 reminders of dire situations can lead to a sense of hopelessness and inevitability, and a lack of
315 motivation to work towards solutions; this only serves to reinforce undesirable outcomes (Garnett
316 and Lindenmayer 2011). Instead, messages need to be framed around solutions to the threatened
317 species crisis, and examples of how monitoring has improved conservation trajectories. These
318 messages need to be communicated broadly and creatively to inspire participation and support of
319 threatened species monitoring (Fig. 1).

320 The telling of success stories is an important tool in inspiring activism and engagement, and
321 promoting the value of monitoring. Several authors have done this eloquently, compiling a list of
322 conservation success stories to inspire optimism (Balmford 2012, Garnett et al. 2018). Support,
323 especially in the form of funding, can be further encouraged by spruiking novel and unusual
324 elements of a species' biology, and innovative monitoring methods or management approaches. For
325 example, the Lord Howe Island stick insect has achieved widespread fame and support, a rare feat
326 for an insect, due to a creative campaign capitalising on quirky aspects of the species biology (large
327 size), the charm of its rediscovery (an adventurous tale of rock climbing on an isolated sea spire),
328 and the diverse use of media and educational tools (e.g. books, film, school programs) (Carlile et al.
329 2009). Similarly, the Difficult Birds Research Group (<https://www.difficultbirds.com/>) have used
330 original messaging (e.g. cartoons) to communicate their innovative management approaches and
331 successfully attract crowd funding for several threatened bird species.

332 Conservation success stories and messages of hope may, however, not appeal to all members of
333 society due to different underlying values. In such circumstances, messaging that speaks to different
334 values can be more useful. For example, the old growth forests of mountain ash (*Eucalyptus*
335 *regnans*) in the Central Victorian highlands are home to a range of species, including the critically
336 endangered Leadbeater's possum (*Gymnobelideus leadbeateri*), and vulnerable greater glider
337 (*Petauroides volans*). The forest ecosystem is also listed as critically endangered by the IUCN (Burns
338 et al. 2015). Despite clear and longstanding promotion of these conservation values, one of the main
339 threatening processes (clear-fell timber harvesting) continues (Burns et al. 2015). This has prompted
340 researchers and advocates to diversify their messaging. Environmental accounting is being used to
341 put an economic value on the range of natural values of these forests (e.g. water provisioning,
342 carbon sequestration, cultural and recreational services) (Keith et al. 2017). This message draws in
343 other elements of society, such as those interested in employment, health benefits and economic
344 growth. Communicating the value of monitoring through creative messaging can foster broad(er)
345 support among stakeholders, secure funding and facilitate uptake and integration of monitoring into
346 management (Ives and Kendal 2014, Lindenmayer and Likens 2018).

347 The value of threatened species monitoring can be further communicated through education and
348 engaging conservation champions to teach people of all ages about the value of threatened species
349 and the role of monitoring. Mulligan's Flat, a conservation reserve in the Australian Capital Territory,
350 has successfully motivated people to be interested in the conservation of several threatened
351 species, through visits to schools and community events, showcasing animals such as the eastern
352 bettong (*Bettongia gaimardi*). Conservation champions can influence and strengthen values, and
353 drive species recovery. Local champions, in particular, can lend credibility to conservation initiatives,
354 and mobilise action, exemplified by the conservation trajectories of two almost morphologically
355 identical, equally threatened birds (Ainsworth et al. 2016). In the first instance, local advocacy led to
356 strong emotional attachment to the Capricorn chat (*Epthianura crocea macgregori*), resulting in
357 increased awareness, government funding and effective conservation actions. In contrast, the
358 Alligator River chat (*Epthianura crocea tunneyi*) had no local support; it subsequently received no
359 dedicated funding, was infrequently monitored, and no recovery program was implemented. Social
360 values are influential in determining conservation effort, thus it is important to understand what
361 motivates people in order to effectively engage and promote positive action.

362 **Conclusion**

363 Effective threatened species monitoring can make an important contribution to improved
364 conservation outcomes. We outline five principles designed to improve threatened species
365 monitoring. They serve as a reminder of key elements to consider when planning, designing,
366 implementing and reviewing monitoring programs. First, monitoring must be integrated with
367 management with clear objectives, transparency and accountability. Second, a fit-for-purpose
368 monitoring design is required to address specific monitoring questions. Third, inclusive, respectful
369 engagement with a broad range of stakeholders is necessary for shaping monitoring objectives and
370 securing the future of the program. Fourth, data management needs to be comprehensive and
371 considered early in the design phase. Lastly, the value of monitoring must be enthusiastically and
372 creatively communicated to ensure that its contribution to threatened species conservation, and
373 broader societal values, is understood and supported. Implementation of these principles will not
374 prevent species extinctions. However, when conservation actions and decisions are underpinned by
375 good processes and knowledge, declines due to inaccurate or irrelevant data, inefficient or
376 ineffective management actions, poor knowledge transfer and communication, and lack of support
377 or awareness can be avoided. As practitioners in this space, we need to promote the value of
378 monitoring and increase its efficacy to enable informed management and enhanced conservation of
379 our threatened biodiversity.

380

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Figures

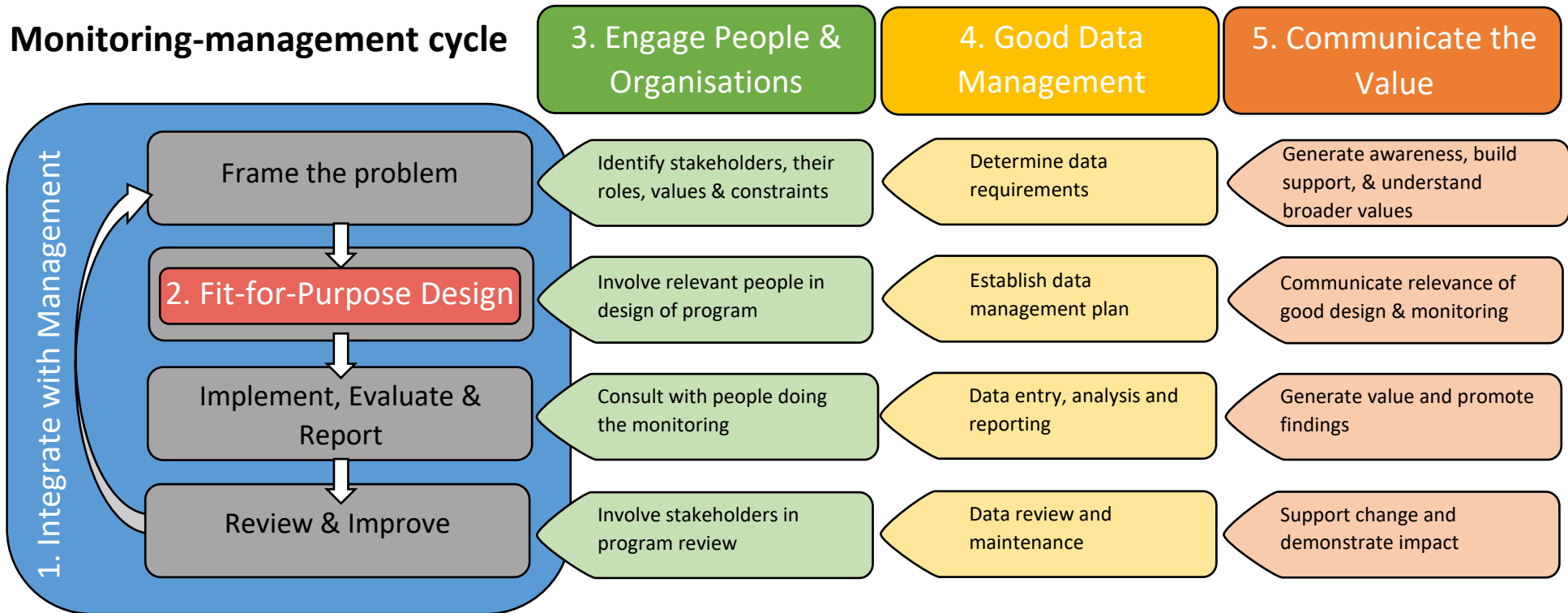


Fig. 1. The five essential monitoring principles (numbered) and how they fit within a four stage monitoring-management cycle (grey boxes).