The Recovery Illusion: What Is Delaying the Rescue of Imperiled Species?

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With unprecedented losses in biodiversity, the need for stronger environmental policy has emerged as a conservation priority. Yet recovery planning for imperiled species remains a cumbersome, slow legislative process. In the present article, we examine features of recovery planning for species listed under Canada's Species at Risk Act to determine those influencing recovery planning duration. We found that the time to completion of recovery strategies increases with the number of jurisdictions concurrently listing the species, greater land tenure diversity, species population size, and road density. Species at risk in Canada with no listing status in the United States also suffered longer delays. To achieve a more efficient, timely, and defensible implementation of recovery planning, we recommend that governments prioritize recovery planning on the basis of risk level, promote transjurisdictional collaboration among listing agencies, anticipate and mitigate conservation challenges associated with multitenured and developed landscapes, and adopt procedures that enhance compliance with legislated timelines for recovery planning.

Keywords: conservation policy, recovery plan completion lag, transboundary cooperation, multi-stakeholder involvement, Canada

Global biodiversity is declining at an unprecedented rate (Brondizio et al. 2019). Despite increasing efforts to address this crisis, at least 31% of all species are considered globally threatened, and within the next decades, climate change is projected to increase extinction risk for an additional 15%–37% of species (Thomas et al. 2004, Brondizio et al. 2019). More than 30 countries have regulatory policies to prevent biodiversity loss (Mooers et al. 2010), including the United States (the Endangered Species Act of 1973; ESA), the United Kingdom (the Biodiversity Action Plan of 1994), Australia (the Environment Protection and Biodiversity Conservation Act of 1999; EPBCA), and Canada (the Species at Risk Act of 2002; SARA). Although the basic rationale for such legislation is to identify species at risk of extinction and to steer human activity to mitigate harm or encourage species recovery, our ability to effectively manage a growing number of imperiled species is now in question (Ceballos et al. 2017).

Prospects for species recovery should improve with gains in planning efficiency and the effectiveness of implementation (e.g., Martin et al. 2012). Around the world, these two elements (i.e., planning and implementation) are approached differently by policy. For example, the United States' ESA and Australia's EPBCA refer broadly to recovery plans that encompass both stages by including available research, recovery goals, and schedules (planning), as well as the management actions necessary to stop declines and support recovery (implementation; e.g., Doak et al. 2015). In contrast, Canada's SARA explicitly partitions the recovery process into planning and implementation by mandating the production of separate documents. Irrespective of specific policy detail, the planning stage is a universal and critical first step in the recovery process (Taylor et al. 2005), and swift recovery planning is essential to the overall success of protection and potential restoration of imperiled species.

Protracted species recovery planning as an impediment to recovery success has been recognized in the conservation literature (e.g., Tear et al. 1995, Schwartz 2008, Martin et al. 2016, Malcom and Li 2018). Although the factors involved in such delays have not been assessed quantitatively, taxonomic bias (e.g., Walsh et al. 2012), bureaucratic complexity, and unaligned priorities across levels of governance (Hermoso et al. 2016) have been identified. Recovery planning can also be cumbersome for species whose range spans multiple jurisdictions, especially given discrepancies in protection conferred by different legal instruments (Foley

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et al. 2017). Additional delays may arise when recovery planning involves multiple land tenures (i.e., private and public ownership; Raymond and Brown 2011) or when competing interests, such as urban and industrial development and the associated expansion of roads (McCune et al. 2013), obstruct the identification of critical habitat (e.g., Favaro et al. 2014).

Quantifying predictors of recovery planning delays

The performance of SARA has been previously scrutinized by academics (e.g., Mooers et al. 2007, 2010, McCune et al. 2013, Favaro et al. 2014, Bird and Hodges 2017), conservation organizations (WWF-Canada 2017), and the government (Auditor General of Canada 2013). Under SARA, a Recovery Strategy (RS) identifies critical habitat, as well as the goals and objectives for species recovery, and is followed by an Action Plan (AP) outlining the activities required to meet the recovery goals and objectives (SARA 2002; for an overview, see the supplemental material). Long delays in the publication of RS jeopardize the initiation of timely conservation efforts and thereby compromise national and international commitments (Auditor General of Canada 2018). Indeed, a previous analysis of SARA suggested that the required postlisting steps were not being implemented effectively (Environment Canada 2012). Concurrently, populations of SARA-listed species have experienced a 28% decline during the postlegislation period (WWF-Canada 2017), underscoring the need to identify and address the drivers of delay in recovery planning and implementation. More broadly, Canada's SARA provides an appropriate model for such an analysis because planning and implementation are partitioned within the existing policy framework and are bound to legislated timeframes (see the supplemental material for details). This permits the evaluation of factors influencing species recovery planning in isolation from those that delay listing or implementation.

In the present article, we used the recovery planning process in Canada (SARA 2002) to evaluate how a suite of biological and sociopolitical predictors can affect the duration of recovery planning. Our analyses were focused on the time from a species's listing to the publication of a RS (i.e., time-to-RS), given that RS development is the initial planning step and that conservation action is limited until RS completion. Our unit of measurement was the individual RS (n = 327), whereby approximately 400 species were listed as Extirpated, Endangered, or Threatened under schedule 1 of SARA, and of these, 75% had a published RS (www.registrelep-sararegistry.gc.ca). Any time beyond the federally legislated deadline for RS publication (i.e., recovery plan completion lag) indicates delays in recovery planning (see the supplemental material for details).

For each species, we collated data from published RS, amendments, orders, and Committee on the Status of Endangered Wildlife in Canada reports (see www.sararegistry.gc.ca); our cut-off date was 25 March 2016. Road density was calculated in ArcGIS 10.3.3 by overlapping species ranges with a 1 square kilometer kernel density raster built from the National Road Networks layers available at Statistics Canada (www12.statcan.gc.ca/census-recensement/2011/geo/RNF-FRR/index-eng.cfm). Ranges were obtained for most of the species analyzed through the IUCN Spatial Data Resources (www.iucnredlist.org/technical-documents/spatial-data) or Environment and Climate Change Canada. Supplemental table S1 provides a full list and description of the predictors used in the analysis.

To determine which factors influenced the time to RS, we fit Cox proportional hazard models (Cox 1972) using the survival package in R version 3.2.4 (R Development Core Team 2016). The models were stratified by taxon, because our preliminary analyses revealed that survival functions differed among the taxa (log-rank $\chi^2(7) = 38.5$, $p < .001$; see table 1). The relative importance of each predictor was evaluated using Akaike's information criterion corrected for small sample size (AICc) and multimodel inference (Burnham and Anderson 2002) via the dredge and model.avg functions in the MuMIn package (Bartoń 2016). The models within 2 AICc units of the top model were considered highly supported (Burnham and Anderson 2002). Collinearity between predictors was examined (all retained predictors $r < .7$), and hazard proportionality was assessed on the basis of the scaled Schoenfeld residuals.

Overall, the median time to publication of recovery strategies was approximately 5 years (interquartile range = 6 years; table 1), with herpetofauna experiencing the longest time to RS, followed by vascular plants, mammals, fishes, arthropods, birds, mollusks, and lichens and mosses (table 1, figure 1). The mean (M) recovery plan completion lag for all taxa was $M = 3.99$ (standard error [SE] = 1.29 years, $n = 327$), and the greatest delays were found in herpetofauna, vascular plants, mammals, and birds (table 1, figure 2). Endangered species of arthropods and herpetofauna experienced greater lags in recovery planning than their Threatened counterparts (figure 2).

The most important predictors explaining the time to RS were the number of provinces involved in recovery planning (No. provinces SAR), species conservation status in the United States (Species Status USA), the estimated population size (Population Size), the number of land tenure types in the species current range (Land Tenure), and road density in the species's current range (Road Density) (table 2, table S2). Each additional jurisdiction (i.e., provinces or territories) listing the species within their concurrent wildlife act increased the time to RS by around 87%. Canadian species that also occurred in the United States had a shorter time to RS if they were listed under the ESA as Endangered or Threatened, had their status under review, or were candidates for listing. On the other hand, species with no status in the United States showed a longer time to RS under SARA (table 2), and species with larger populations experienced a longer time to RS (table 2). On average, the time to RS increased by 76% with each additional type of land tenure within a species's range, as well as with higher road density

Table 1. Absolute time from species listing to publication of respective recovery strategy and of overdue planning for at-risk species in Canada. N = sample size.

	Time to recovery strategy (in years)					Recovery plan completion lag			
Taxon	*N*	Median	Interquartile range (IQR)	Mean	Standard error (SE)	Median	IQR	Mean	SE
Arthropods	23	5.00	3.00	5.27	0.54	3.00	3.50	3.70	0.58
Birds	47	5.00	6.00	6.35	0.53	2.00	6.00	4.00	0.49
Fishes	37	5.00	3.00	5.90	0.48	1.00	4.00	3.11	0.43
Herpetofauna	24	8.50	6.25	9.15	0.71	5.00	6.00	6.38	0.63
Lichens and mosses	15	3.00	5.00	4.89	0.89	2.00	3.50	3.20	0.72
Mammals	31	6.00	5.00	6.23	0.64	3.00	4.50	4.52	0.49
Mollusks	16	4.00	0.25	4.05	0.54	1.00	1.00	2.13	0.56
Vascular plants	134	7.00	6.00	6.94	0.31	4.00	6.00	4.87	0.29
All	327	5.00	6.00	6.10	0.58	3.00	5.00	3.99	0.52

in the species's current range (table 2). The following predictors did not significantly influence time to RS: the number of governmental agencies involved in recovery planning, the number of provinces (and territories) where the species occurred in Canada, the inclusion of traditional ecological knowledge in recovery planning, the distribution of the species in Canada (peripheral or core), the number of industries identified as threats in the RS, and the feasibility of recovery. For more extensive results see the supplemental material.

Improving species recovery planning processes

Prolonged inaction plagues imperiled species worldwide and increases extinction risk (Martin et al. 2012, Woinarski 2016). The consequences of lengthy recovery planning include outdated science, staff turnover, process fatigue, outdated recovery planning documents, delayed implementation of recovery actions, and, potentially, an irreversible loss of species and their habitats (Schwartz 2008, NOAA Fisheries 2016, Malcom and Li 2018). Confronting weaknesses in recovery planning can therefore improve the efficiency and expediency of conservation actions. For example, in the face of criticism of the ESA, US agencies reviewed species recovery programs, both in 2002 within the US Fish and Wildlife Service (Hoekstra et al. 2002) and in 2016 for the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries 2016). Despite the slow uptake of recommendations, there is consensus that many issues identified by the 2002 review were addressed, which has led to improved recovery plans (Troyer and Gerber 2015). To this end, it is necessary to identify factors that prolong planning and estimate the magnitude of their effect.

Our findings that the publication of RS can take up to 13 years (figure 1), that only 21% of the RS (n = 69) were produced within the expected timeframe, 6% of which (n = 18) had action plans, highlight the defective application of SARA, which compromises the recovery of many species by allowing continued loss in numbers or critical habitat. Our analyses revealed that the duration of recovery planning is strongly influenced by biological factors (i.e., species taxonomy, conservation status, and population size) and sociopolitical factors (i.e., disparate transjurisdictional levels of protection, diversity in land tenure, and road density). Recovery planning inherently signals an urgency for action and requires both resources and efficient procedures to avert delays (Martin et al. 2012, Woinarski 2016). When delays are identified, clear prioritization criteria (e.g., species status, species ecological value, taxonomic uniqueness) are necessary to ensure that excessive bureaucratic timelines do not exacerbate extinction risk.

Taxonomic bias in recovery planning and the lack of prioritization according to conservation status are concerning. Notably, the time to RS was greatest for Endangered reptiles and amphibians, which are already among the most threatened taxa in Canada and worldwide (figure S1; Stuart et al. 2004, Böhm et al. 2013). Walls and colleagues (2017) reported a comparable situation for amphibians in the United States, such that the time between listing and recovery plan development ranged from 2 to 29 years. Arthropods, vascular plants, and mammals also appear to experience taxonomically related delays (figure 2). Unfortunately, this trend is consistent with previous findings (Tear et al. 1995, Campbell et al. 2002, Crouse et al. 2002). Species with larger population sizes also had an extended time to RS completion, perhaps because of challenges associated with compiling data for abundant species or because of the perception that such species do not require quick action. Alternatively, delays associated with population size could reflect the notion that less-abundant species require faster action (Gaston 2010). However, prioritizing conservation efforts based primarily on current abundance is problematic because a species's rate of decline may outweigh its abundance as a predictor of extinction risk (IUCN 2012) and because abundant species are fundamental to the structure of most ecological communities, and their decline comes with concomitant effects on ecosystem services (Gaston 2010). An explicit and transparent prioritization system for species recovery planning is

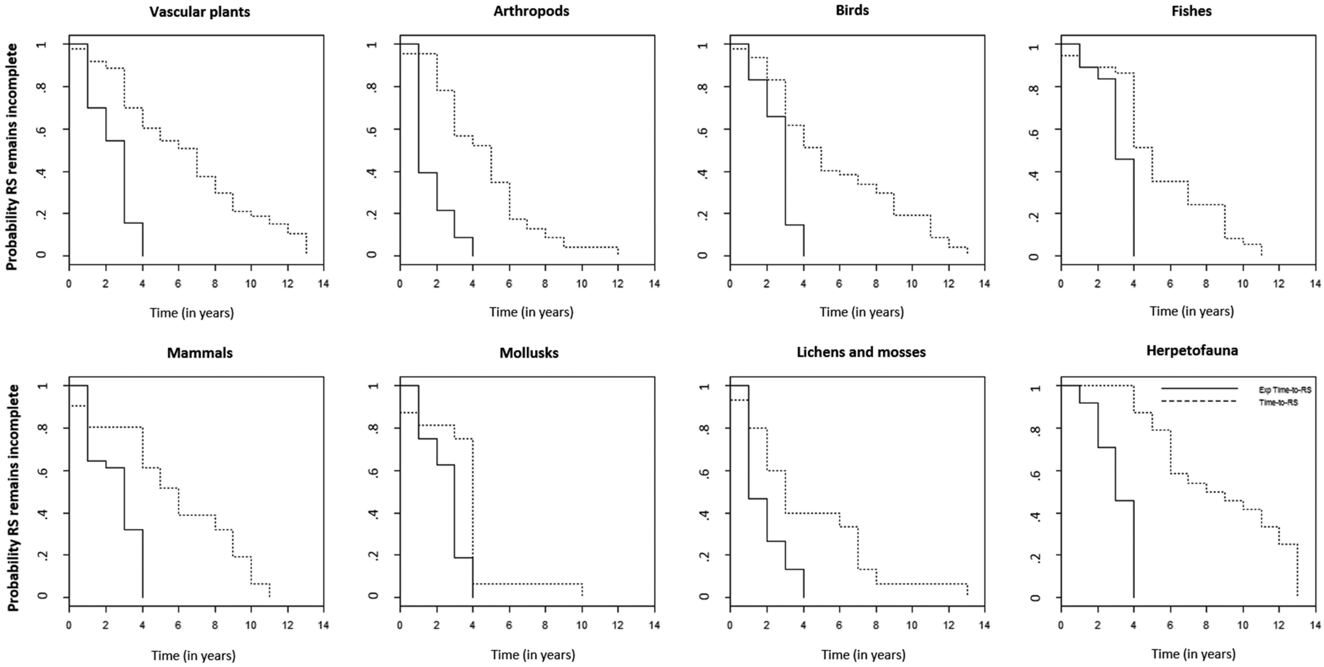

Figure 1. Probability of a recovery strategy (RS) remaining incomplete for an at-risk species in Canada each year following species listing, separated by taxonomic group. Abbreviations: Exp time-to-RS, expected time (as defined in the Species at Risk Act) to the publication of the species recovery strategy; time-to-RS, the observed time to the publication of the species recovery strategy.

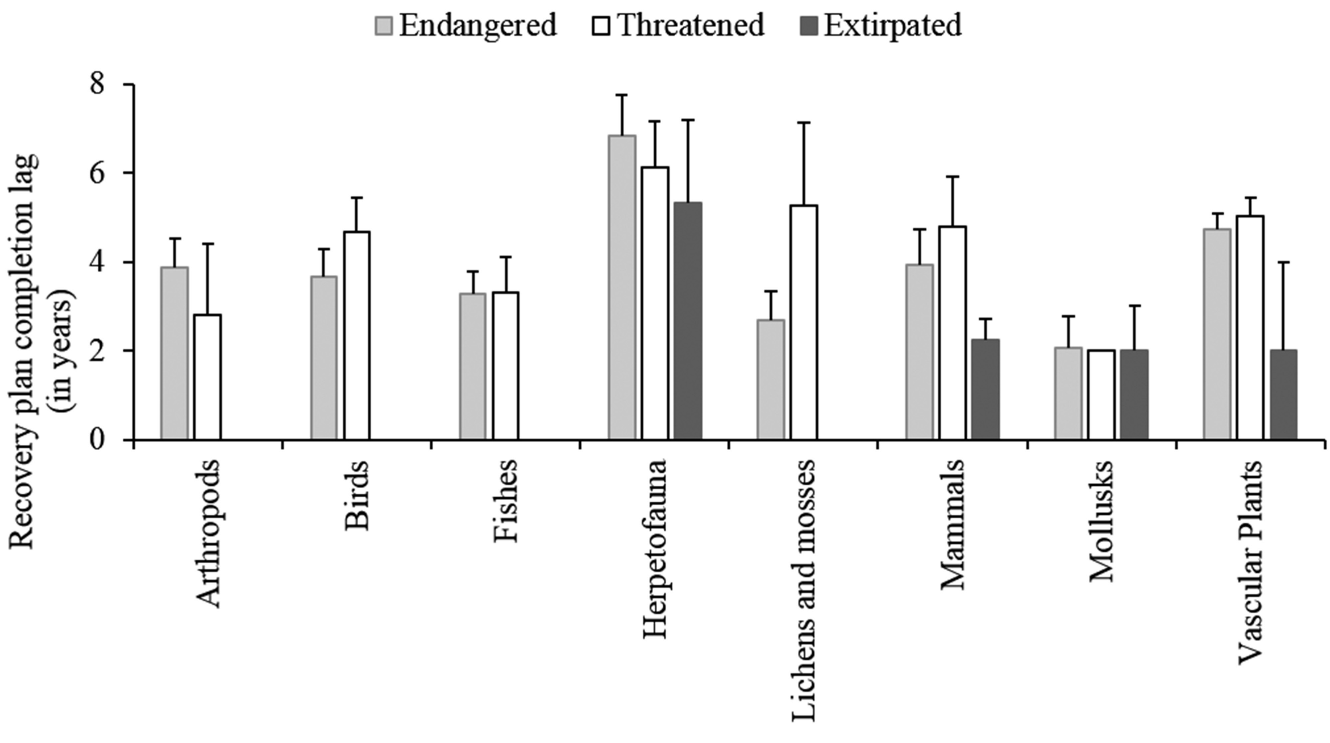

Figure 2. Mean time lag in recovery strategy publication (recovery plan completion lag) of at-risk species in Canada, per taxon and per current species listing status under the Species at Risk Act. The error bars represent the standard error.

Table 2. Model averaged coefficients from Cox proportional hazards models relating complexity of the consultation process, landscape development, and land ownership in at-risk species recovery planning in Canada.

	Time to RS				
Variables	Hazard ratio	Change in risk (percentage)	Standard error coefficient	95% confidence interval	Importance
Land tenure	0.76*	–24.0*	.10*	–0.48, –0.07*	0.87*
Road density	0.16*	–84.0*	.82*	–3.44, –0.23*	0.75*
Species status USA					0.60*
Endangered	3.64*	264.5*	.41*	0.50, 2.09*	
Threatened	2.56	155.6	.52	–0.08, 1.96	
Under Review	1.53	52.6	.81	–1.16, 2.00	
Candidate	1.21	20.9	.89	–1,93, 1.55	
Population size	0.99	–0.4	.002	–0.008, 0.001	0.59
Number of provinces SAR	0.87	–13.3	.08	–0.31, 0.02	0.55
TEK	0.45	–55.2	.52	–1.83, 0.22	0.46
Number of agencies	1.36	36.2	.25	–0.18, 0.79	0.41
Feasibility					0.41
Feasible	0.98	–2.0	.61	–1.22, 1.18	
Unknown	0.55	–44.5	.62	–1.81, 0.63	
Number of provinces occurrence	1.08	8.4	.07	–0.06, 0.22	0.29
Peripheral	–		–	–	0.29
Number of industries	–		–	–	0.26

Note: A positive value for change in risk indicates a shortening of the time from listing to publication of a recovery strategy. *significantly different from 0 at $\alpha = .05$.

necessary to ensure efficient implementation of urgent conservation actions and effective allocation of limited planning resources.

The more the merrier in recovery planning? The involvement of multiple jurisdictions had contrasting effects on the duration of recovery planning. Although more participating within-nation jurisdictions slowed RS completion at the national level, sharing an at-risk status at the international level accelerated these timelines. Within national boundaries, interjurisdictional recovery planning for wide-ranging taxa andtheir habitats may be inefficient because of differential political leverage (e.g., "rigidity traps" sensu Allison and Hobbes 2004), overlapping duties, ill-defined jurisdictional responsibilities (Wojciechowski et al. 2011), and differences in the capacity of provincial or territorial partners. Conversely, greater information sharing between Canada and United States or added pressure from foreign conservation authorities may shorten recovery planning (as is suggested by shorter delays in species with listing status in the United States), reinforcing the potential benefits of cross-border collaboration (e.g., Olive 2014, Foley et al. 2017). Additional delays likely arise from the expanding array of potential stakeholders and landownership regimes when species span intranational jurisdictions (Camaclang et al. 2015). Private and crown lands comprise roughly 60% of Canada's land area and approximately 60% and 77% of the land area in the United States and Australia, respectively (Raymond and Brown 2011), and the success of recovery actions is often contingent on effective engagement with diverse stakeholders (McDonald et al. 2015). Therefore, fostering multistakeholder cooperation under a framework that ensures time-efficient and robust recovery planning processes, on private and public lands alike, should remain a priority. Initiatives such as the Australian Land Conservation Alliance (www.alca.org.au) provide a solid framework for successful private–public partnerships that contribute to local, national, and global biodiversity goals.

Competing interests with human activities. Human disturbance, which is associated with road network expansion (e.g., habitat loss to development), is among the greatest threats to at-risk species (e.g., McCune et al. 2013). Our analysis indicates that road density within the species's range correlates strongly with lags in recovery planning. Areas with high road density are generally associated with high human population density, which may prolong the consultation process because of diverging resident interests. Roads also facilitate landscape disturbance (e.g., forest harvest) and promote habitat loss and fragmentation (Schaefer 2003, Ibisch et al. 2016), potentially adding difficulties to the designation or protection of critical habitat (e.g., Trombulak and Frissell 2000).

Other drivers of recovery plan completion lags. A primary critique of recovery planning policies worldwide is the lack of long-term government funding (e.g., Evans et al. 2013). Unfortunately, specific data were not readily available, so a direct causal relationship should be drawn with caution. However, meaningful investment is necessary to turn legislation into tangible on-the-ground protection, and the recent (2018) $1.3 billion investment by the Canadian government in nature and conservation reflects that legislators recognize how species recovery and habitat protection are simply not possible without significant financial investment. Presumably, higher budget allocations toward recovery planning would also be beneficial, as was shown for the listing stage in other jurisdictions (Puckett et al. 2016). However, it is uncertain how much of this funding was allocated to the recovery planning stage. Concomitantly, biodiversity in Canada continues to decline, and species rarely truly recover (Favaro et al. 2014, Auditor General of Canada 2018). This could indicate that financial investments into the recovery process for at-risk species in Canada to date have been insufficient or poorly managed, an aspect that should be further scrutinized.

Conclusions

Protracted recovery planning can exacerbate threats to at-risk populations or their habitat and accelerate species loss (Schwartz 2008). Despite somewhat distinct species recovery planning policies worldwide, several lessons can be taken from Canada's SARA recovery planning stage that should be widely transferrable. Broadly, the more substantive consequences of delayed species recovery planning are avoidable if the process can be refined to effectively prioritize recovery planning on the basis of clear criteria, anticipate and mitigate complexities associated with multitenured and developed landscapes, limit interjurisdictional discrepancy in recovery planning by facilitating institutional collaboration, and renew government leadership that guarantees compliance with legislated timelines. Current trends in land degradation (Scholes et al. 2018) and climate change (IPCC 2018), in combination with mounting declines in flora and fauna (Grooten and Almond 2018), underscore the requirement for swift and decisive action. Ultimately, our analysis highlights the importance of *timeliness* in the establishment of an efficient and effective species recovery process.

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Supplemental material

Supplemental data are available at *BIOSCI* online.

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