Recovery planning under Canada's Species at Risk Act

Christopher Brassard

Thesis submitted to the Faculty of Graduate and Postdoctoral Studies
in partial fulfillment of the requirements for the degree of
Master of Science

Department of Biology

University of Ottawa

Acknowledgements

Sincere thanks to my supervisor, Dr. C. Scott Findlay, without whom this project would not have been possible. Your expertise and patience have made this experience an enjoyable one. Thanks also to my committee members, Drs. David Currie and Lenore Fahrig, whose advice was always valuable, and to Sue McKee for infectious enthusiasm for her work. A final thanks to the friends and family who enrich my life on a daily basis. Your impact is immeasurable. You know who you are.

Abstract

One of the integral components of Canada's Species at Risk Act (SARA) is recovery planning for threatened, endangered, or extirpated species in Canada. The recovery planning process is guided by recovery strategies, to be published within one year of listing for endangered species and within two years of listing for threatened or extirpated species, though publication has rarely met statutory timelines. Here I investigate factors associated with recovery strategy completion as well as factors associated with strategy content, specifically recovery feasibility, information gaps, and critical habitat identification. Despite significant delays in strategy publication, I find no evidence of internal prioritization of species for strategy completion, with only administrative factors retained in predictive models; species listed on Schedule 1, for which the Department of Fisheries and Oceans (DFO) or Parks Canada Agency (PCA) is the Responsible Authority, or which there was a smaller backlog of due strategies one year after listing were more likely to have recovery strategies submitted on time. Analysis of factors associated with recovery feasibility show a higher likelihood of feasible recovery for species for which critical habitat is identified, the DFO or PCA is the Responsible Authority, there are more identified information gaps, or for which the recovery strategy contains a section on potential socioeconomic conflict. There were fewer identified information gaps in recovery strategies for those species for which recovery strategies were published after the judgments of the Nooksack Dace (ND) and Greater Sage-Grouse (SG) court proceedings, there was a greater time elapsed between strategy due date and date of draft publication, or whose range does not fall on a provincial or federal protected area.

Pre-ND and SG court judgements, critical habitat was less likely to be identified for species with a lower threat status, species included in multi-species or ecosystem plans, or species not found within provincial or federal protected areas. None of these biases were detected post-judgement, however, as rates of identification increased significantly and only recovery feasibility was associated with CH identification. These results point to some potential problems in the recovery planning process as currently implemented under SARA, and inform recommendations as to how these might be addressed.

Résumé

La planification du rétablissement des espèces menacées, en voie de disparition, ou disparues au Canada est une des composantes intégrales de la Loi sur les espèces en péril du Canada (LEP). Le processus de planification du rétablissement est guidé par des stratégies de rétablissement. Ces stratégies de rétablissement doivent être publiées, au plus, un an après la parution dans la liste des espèces en voie de disparition et, au plus, deux ans après la parution de la liste des espèces menacées ou disparues du pays. Ces publications ont rarement respecté les délais prescrits. Dans cette étude, j'examine les facteurs associés avec la publication des stratégies de rétablissement ainsi qu'aux facteurs associés au contenu de la stratégie, plus particulièrement la faisabilité du rétablissement, les lacunes relatives aux informations ainsi que l'identification de l'habitat essentiel. Malgré d'importants retards dans la publication de la stratégie, je n'ai trouvé aucune preuve de hiérarchisation interne des espèces afin de compléter la stratégie; seuls des facteurs administratifs ont été retenus dans les modèles de prévision. Les espèces indiquées à l'annexe 1, pour lesquelles le ministère des Pêches et des Océans (MPO) ou l'Agence Parcs Canada (APC) est l'autorité responsable et pour lesquelles il y a eu un retard moindre des stratégies demandées, étaient plus susceptibles de voir leur stratégie de rétablissement soumise à temps. L'analyse des facteurs associés à la faisabilité du rétablissement montre une plus forte probabilité de récupération possible pour les espèces pour lesquelles l'habitat essentiel est identifié, le MPO ou l'APC étant par ailleurs l'autorité responsable et des lacunes relatives aux informations ont été identifiées, ou pour les espèces pour lesquelles la stratégie de récupération identifie une section quant à

un sur conflit socio-économique potentiel. Pour les espèces pour lesquelles des stratégies de rétablissement ont été publiées après les arrêts des procédures judiciaires de Nooksack Dace (ND) et de Tétras des armoises (TA), le délai entre la date d'échéance de la stratégie et de la date était plus grand. Pour les espèces pour lesquelles l'habitat ne correspond pas à des zones protégées par le provincial ou le fédéral, moins de lacunes relatives aux informations ont été identifiées dans les stratégies de récupération. Avant les jugements de ND et TA, l'habitat essentiel était moins susceptible d'être identifié pour les espèces ayant un statut de menace inférieure, les espèces appartenant à des multiespèces ou des plans d'écosystèmes ou les espèces introuvables dans les zones protégées par le provincial ou fédéral. Toutefois, aucun de ces préjugés n'a été détecté après le jugement, les taux d'identification ayant augmenté de manière significative et seule la faisabilité du rétablissement a été associée à l'identification de l'habitat essentiel. Ces résultats indiquent ainsi des problèmes potentiels dans le processus de planification du rétablissement actuellement appliqué au sein de la LEP ainsi que des recommandations quant à la façon d'aborder ces problèmes potentiels.

Table of Contents

List of Tables

List of Figures

List of Appendices

General Introduction

Recovery plans or strategies are a key element of most national endangered species legislation. They are an integral component of species protection under the American Endangered Species Act (ESA) which apparently has had some success: only 35% of species listed under the ESA remained in decline after 13 years of listing (Male & Bean 2005), and, while 80% of listed species have not yet reached their projected recovery year, 90% of species advancing towards recovery are on track to meet delisting deadlines (Suckling et al. 2012). ESA-listed species with dedicated recovery plans are more likely to have improving status trends than those without recovery plans or part of multi-species or ecosystem plans (Taylor et al. 2005), and a number of different studies have presented evidence that that the ESA has prevented extinctions (Schwartz 1999, Schwartz 2008, Solomon 1998, Suckling et al. 2004) and promoted species recovery. Australia's Environmental Protection and Biodiversity Conservation Act (EPBCA) also makes use of recovery plans as tools of species conservation. Though questions have been raised concerning the effectiveness of recovery plans under the EPBCA (Bottrill et al. 2011), it is difficult to measure the effectiveness of endangered species legislation introduced only recently (the EPBCA was introduced in 1999) because imperilled populations have not had sufficient opportunity to respond to recovery efforts.

An important element of recovery planning in most jurisdictions is the identification and/or designation of critical habitat. This is considered an integral element of recovery planning because it is widely believed that for many species, habitat loss and degradation has been a major contributing factor to population species decline (e.g.

Venter et al. 2006). This belief notwithstanding, the existing evidence on the importance of critical habitat identification is rather mixed. Multiple studies have linked critical habitat identification to favourable status trends under the ESA (Taylor et al. 2005, Rachlinski 1997, Schwartz 2008 etc…) but a subsequent study (Kerkvliet and Langpap 2007) found no effect of critical habitat on status trends once funding is controlled for, and Gibbs and Currie (2012) found no evidence of a relationship between recovery and critical habitat designation.

Recovery planning under Canada's Species At Risk Act (SARA)

Since coming into force in June 2003, the Species at Risk Act (SARA) has been the primary means of protection of imperiled species on Canadian federal lands. Under SARA, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is responsible for assessing the status of any species thought to be at-risk (SARA s. 16). Assessments are performed by sub-committees of relevant specialists and are based on status reports either prepared by COSEWIC or received by COSEWIC in an application (SARA s. 18-21). Assessments are due within one year of receipt/completion of a status report (SARA s. 23), and must be forwarded to the competent minister(s) and the Canadian Endangered Species Conservation Council (CESCC). The minister(s) then has/have 90 days to report to the public registry whether the recommendation will be forwarded to the Governor in Council (GIC) or sent for extended consultation (SARA s. 25). If the decision is to forward the recommendation to the GIC, the GIC has 9 months after receipt of the assessment to either list the species, not list the species, or refer the species back to COSEWIC for more information (SARA s. 27). If the decision is made to not list the species, the rationale must be posted to the public registry.

If a species is listed as threatened, endangered, or extirpated, the competent minister(s) is/are responsible for the preparation of a draft recovery strategy within one year of listing for endangered species and two years of listing for threatened or extirpated species, with the exception of species automatically listed on Schedule 1 when SARA first came into force, in which case recovery strategies were due within three years of listing for endangered species and four years for threatened or extirpated species – see SARA s. 42. After the submission of a draft recovery strategy, 60 days are allotted for public comment and final strategies are to be published within 30 days of the conclusion of this 60-day public comment period (SARA s. 42). In cases where recovery is deemed feasible by recovery strategy authors, strategies are to include:

> a) a description of the species and its needs that is consistent with information provided by COSEWIC;
>
> b) an identification of the threats to the survival of the species and threats to its habitat that is consistent with information provided by COSEWIC and a broad strategy to be taken to address those threats;
>
> c) an identification of the species' critical habitat, to the extent possible, including the information provided by COSEWIC, and examples of activities that are likely to result in its destruction;
>
> c.1) a schedule of studies to identify critical habitat, where available information is inadequate;
>
> d) a statement of the population and distribution objectives that will assist the recovery and survival of the species, and a general description of the research and management activities needed to meet those objectives;
>
> e) any other matters that are prescribed by the regulations;

f) a statement about whether additional information is required about the species; and

g) a statement of when one or more action plans in relation to the recovery strategy will be completed (SARA s. 41)

In cases where recovery is not feasible, the requirements are much more modest, and include a description of the species, identification of its needs and critical habitat, and a rationale for the assessment that recovery is not feasible (SARA s. 41).

Following finalization of the recovery strategy, competent ministers are responsible for completing one or more action plans as outlined in the recovery strategy (SARA s. 47-49). As with recovery strategies, 60 days are allotted for public comment on proposed action plans, and final plans are to be published within 30 days of the conclusion of this 60-day public comment period (SARA s. 50). If action plans are not finalized in the timeframe proposed in the recovery strategy, a summary of completed work must be published to the public registry (SARA s. 50).

Critical Habitat identification under SARA

Under SARA, critical habitat is defined as “habitat that is necessary for the survival or recovery of a listed wildlife species” (SARA s. 2) and is to be identified in recovery strategies “to the extent possible, based on the best available information” (SARA s. 41 (1)). Yet critical habitat is not identified in recovery strategies for many species, which has led to several court challenges to the government’s implementation of SARA (see Campbell 2009, Zinn 2009, Russell 2010). Judgements in favour of the Alberta Wilderness Association in a case against the Minister of Environment regarding critical habitat identification for the Greater Sage-Grouse (Zinn 2009) and in favour of Environmental

Defense Canada in a case against the Minister of Fisheries and Oceans regarding critical habitat identification for the Nooksack Dace (Campbell 2009) in 2009 have profoundly influenced the identification of critical habitat in recovery strategies under SARA. Taylor and Pinkus (2012) identified a 50% increase in critical habitat designation in recovery strategies following these court judgements. Indeed, critical habitat was at least partially identified for only 23 of 98 species included in recovery strategies published before the court judgements (23%), but for 93 of 113 after (87%). Taylor and Pinkus also found an effect of lead government agency on critical habitat completion, finding that species under authority of the Department of Fisheries and Oceans (DFO) were much less likely to have critical habitat identified than species under authority of Environment Canada (EC).

Study objectives

Despite the important role of recovery strategies under SARA, completion has rarely met timelines mandated by SARA. Here I make use of the University of Ottawa's Species at Risk database to investigate factors associated with recovery strategy completion times, with particular attention to possible prioritization criteria (Chapter 1). I then investigate factors associated with strategy content, specifically recovery feasibility and identified information gaps (Chapter 2) and critical habitat identification (Chapter 3).

The University of Ottawa Species At Risk Database

Over the past 10 years, an extensive database on Canadian Species at Risk Canada has been developed and maintained at the University of Ottawa. As part of an ongoing evaluation of SARA's effectiveness, a set of measurable performance indicators were developed that relate directly to one or more SARA benchmarks using goals and expected outcomes derived from SARA itself, background legislative documents, witness testimony delivered during SARA review hearings, policy statements and departmental information. Relevant data have been extracted from published documents (e.g. recovery strategies, COSEWIC status reports) that were accessed from the Species at Risk public registry. Documents that were not online (e.g. older status reports) were obtained directly from COSEWIC.

The database is populated using a validated set of protocols that allow undergraduate student volunteers to harvest data from specific documents. Each volunteer was given a training session in which the study objectives, metadata and data extraction protocols were described. Following training, each volunteer was provided with a small set of documents, with documents being independently assessed by two evaluators. Using the provided metadata and protocols, students extracted information from the documents assigned to them, entered these data into a personal copy of the database, and submitted the completed file to the database manager. For each document, the multiple data submissions from independent evaluators were then compared, and any discrepancies resolved by the manager through direct reference to the document in question.

References

Bottrill, M.C., J.C. Walsh, J.E.M. Watson, L.N. Joseph, A. Ortega-Argueta & H.P. Possingham. 2011. Does Recovery Planning Improve the Status of Threatened Species? Biological Conservation 144: 1596 - 1601.

Campbell, J. 2009. Environmental Defence Fund et al. vs. the Minister of Fisheries and Oceans. Docket T-1529-07, 2009 FC 878. Available from http://reports.fja.gc.ca/eng/2009/2009fc878.html (Accessed April 2014).

EPBCA (Environmental Protection and Biodiversity Conservation Act). 1999. Available from http://www.comlaw.gov.au/Details/C2013C00301 accessed July 2013).

ESA (Endangered Species Act). 1973. Available from http://www.fws.gov/endangered/esa-library/pdf/ESAall.pdf (accessed April 2014).

Kerkvliet, J. & C. Langpap. 2007. Learning from endangered and threatened species recovery programs: A case study using U.S. Endangered Species Act recovery scores. Ecological Economics 63 (2-3): 499 - 510.

Male, T.D. & M.J. Bean. 2005. Measuring progress in US endangered species conservation. Ecology Letters 8: 986 - 992.

Rachlinski, J. J., 1997. Noah by the numbers: an empirical evaluation of the Endangered Species Act. Cornell Law Review. 82: 356 - 389.

Russell, J. 2010. David Suzuki Foundation et al. vs. the Minister of Fisheries and Oceans and Environment Canada. Docket T-541-09, 2010 FC 1233. Available from http://reports.fja.gc.ca/eng/2012/2010fc1233.html (Accessed April 2014)

SARA (Species at Risk Act). 2002. Available from http://laws-lois.justice.gc.ca/PDF/S-15.3.pdf (accessed April 2014).

Schwartz, M.W.. 2009. Choosing the appropriate scale of reserves for conservation. Annual Review of Ecology and Systematics 30: 83 - 108.

Schwartz, M.W.. 2008. The Performance of the Endangered Species Act. Annual Review of Ecology, Evolution, and Systematics 39: 279 - 299.

Solomon, B.D..1998. Impending recovery of Kirtland's warbler: Case study in the effectiveness of the Endangered Species Act. Environmental Management 22 (1):9 - 17.

Suckling, K.F., R. Slack & B. Nowicki. 2004. Extinction and the Endangered Species Act. Center for Biological Diversity report.

Suckling, K.F., N. Greenwald & T. Curry. 2012. On time, on target: How the Endangered Species Act is saving America's wildlife. Center for Biological Diversity report.

Taylor, E.B. and S. Pinkus. 2013. The effects of lead agency, non-governmental organizations, and recovery team membership on the identification of critical habitat for species at risk: insights from the Canadian experience. Environmental Reviews 21 (3): 93 - 102.

Taylor, M.F.J., K.F. Suckling & J.J. Rachlinski. 2005. The effectiveness of the Endangered Species Act: a quantitative analysis. BioScience 55 (4): 360 – 367

Venter, O., N.N. Brodeur, L. Nemiroff, B. Belland, I.J. Dolinsek & J.W.A. Grant. 2006. Threats to Endangered Species in Canada. Bioscience 56 (11): 903 - 910.

Zinn, J. 2009. Alberta Wilderness Association et al. vs. Minister of Environment. Docket T-241-08 2009 FC 710. Available from http://reports.fja.gc.ca/eng/2009/2009fc710.html (Accessed April 2014)

Chapter 1 – Recovery Strategy Completion

Introduction

Recovery strategies are, as the name implies, intended to recover species by mitigating extinction threats and/or implementing actions to increase population abundance and/or distribution (see ESA (s. 4[f][1], SARA s. 37, Schwartz (2008)). Especially for species teetering on the brink of extinction, one might expect that delays in recovery planning increase the risk of decline, and decrease the chances of successful recovery, and there is some evidence to suggest this is the case under the ESA. Lundquist et al. (2002) discuss the importance of recovery plan implementation in preventing species extinction, and numerous other studies identify the importance of more prompt implementation of recovery plans (e.g. Boersma et al. 2001, Hoekstra et al. 2002 etc…).

Under SARA, critical habitat is typically not identified until the drafting of a Recovery Strategy or Action Plan. Protection of critical habitat under SARA cannot occur until it has been identified. This is a crucial step in the recovery process, as more than 80% of species with at least a special concern status from COSEWIC are suffering from habitat loss (Venter et al. 2006). For these species it is critical to identify critical habitat so that work can be done to prevent further habitat loss, and under SARA, this identification occurs at the recovery strategy or action plan stage. Thus, the longer recovery planning is delayed, the longer the interval during which degradation and/or loss of critical habitat can occur, with an associated reduced likelihood of species recovery.

As of September 20, 2013, there were 383 species listed under SARA for which recovery strategies were due (SARA public registry). Of these 383 species, only 229 (60%)

have draft recovery strategies. Given that (a) the critical habitat provisions of SARA do not come into force until critical habitat has been identified; (b) critical habitat must be identified either in recovery strategies or action plans; and (c) habitat loss and degradation is the most prevalent cited factor for species decline in Canada (Venter et al. 2006), delays in recovery strategy publication might be expected to have negative consequences to Canadian species at risk.

That many recovery strategies are not completed on time is clear. What is not clear is why. Here, several hypotheses may be advanced. An obvious one is that delays in recovery strategy production represent mainly resource constraints: given the number of species for which recovery strategies were required upon SARA coming into force, the resources allocated to the task were simply inadequate. A second - not mutually exclusive - hypothesis is that given resource constraints, choices must be made as to which species to prioritize for recovery planning. Indeed, the idea of prioritizing species for recovery has a long and controversial history in biodiversity conservation, with a number of prioritization schemes and criteria being developed (Marsh et al. 2007, Pimm 2000, Redding & Mooers 2006). Given limited resources, factors that have been identified as potential prioritization criteria include extinction risk (Possingham et al. 2002, Redding & Mooers 2006, Brehm et al 2010), management responsibility (i.e. the extent to which a jurisdiction is, at least in principle, responsible for the species in question, usually operationalized as the proportion of the species' range within the jurisdiction (Marsh et al. 2007, Taylor et al. 2011)); evolutionary distinctiveness (Redding & Mooers 2006, Goldstein et al. 2000); recovery feasibility (Marsh et al. 2007, Bunnell et al. 2009) and cost (Brehm et al. 2010, Marsh et al. 2007, Wilson et al. 2011).

In this chapter, I investigate factors associated with delays in recovery planning under SARA. In particular, I investigate whether resource constraints have influenced the ability of responsible authorities under SARA to meet legislated time-lines, and if so, what factors seem to be associated with prioritization of species for completion of recovery plans.

Methods

Data Selection and Analysis

As of September 20th, 2013, there were 383 SARA-listed species for which the statutory deadline for final recovery strategy completion had passed. The entire group was considered in the analysis, with on-time publication of a draft recovery strategy (with a 3-month grace period allotted, N = 62) treated as a binary response to a constrained set of 24 candidate independent variables (Table 1.1., see also Appendix 1) which might be expected to be associated with recovery strategy completion time (e.g. are measures of administrative constraints or potential recovery prioritization criteria), or for which previous work has identified as factors associated with elements of the recovery planning process, either under SARA or in other jurisdictions.

Potential explanatory variables can be grouped into two general classes. Administrative variables are those which are, in some sense, independent of the biological or ecological attributes of the species in question, and concern rather administrative or management factors that might be expected to influence the time required to complete recovery plans. These include the Responsible Authority (RA); backlog of due recovery strategies at time of listing, one year after listing, and two years after listing; whether the species has multiple RAs; whether there is any provincial recovery strategies for the species at the time of listing; and whether the species was a Schedule 1 species, that is, a species that was automatically listed when SARA came into force. The second set of variables are those which might be employed by managers in prioritizing species for recovery, including; taxon; whether the species is at the edge of its range in Canada; whether the species' extent of occurrence and area of occupancy are in decline; whether at least some part of the species' range occurs in a provincial or federal protected area; whether the various UCN-CMP Unified Classification Threats are considered threats; threat status; whether the species' population is in decline (see Table 1 and Appendix I for more information on all variables used in the analysis).

I employed an information-theoretic approach to model selection, with both the residual deviance and AIC_c values (AIC corrected for small sample size) used to guide model selection (see Burnham and Anderson 2002, Burnham et al. 2010). Beginning with a null model, terms were added individually and retained if they resulted in a substantial improvement in AICc (i.e., reduced AICc by more than 7). Where there was evidentiary support for multiple models, Akaike weights were calculated for each retained model, variable importance calculated for each variable, and parameter estimates based on multi-model weighting.

Results

As of September 20th, 2013, 229 of 383 (60%) species for which recovery strategies were due have published draft or final strategies, with 62 (16%) being completed within 3 months of their statutory time-lines. Species under authority of the Department of Fisheries and Oceans ($\beta = 2.06 \pm 0.37$) or the Parks Canada Agency ($\beta = 1.89 \pm 0.38$) were more likely than species under authority of Environment Canada to have recovery strategies published on-time (see Table 1.3, Figure 1.1), though there was evidence that much of this was a backlog effect; Environment Canada acts as lead agency for 241 of the 383 species included in the study, and backlog sizes were, in general, much larger for species under authority of EC. There was, in fact, more support for models that included backlog size than for models that included Responsible Authority (see Table 1.2), with larger backlogs one year after listing associated with increased completion times ($\beta = -0.02 \pm <0.01$). There was also evidence that Schedule 1 species ($\beta = 0.92 \pm <0.33$) were more likely to have recovery strategies published on-time than species listed more recently. No other candidate predictor was retained in the final set of models. There was, therefore, no evidence that recovery planning prioritization is associated with extinction risk, management responsibility, or recovery feasibility.

Discussion

While Responsible Authorities have clearly struggled to publish recovery strategies at the rate mandated by SARA, my results suggest that this prioritization does not appear to have been based on many of the criteria that have been proposed, including extinction risk (here, operationalized as listing status, population decline, and area of occupancy/extent of occurrence decline – see e.g. Possingham et al. 2002, Redding & Mooers 2006, Brehm et al 2010 etc…); management responsibility (edge of range species – see Marsh et al. 2007, Taylor et al. 2011); and recovery feasibility (IUCN threat criteria – see Marsh et al. 2007, Bunnell et al. 2009). This is interesting given that there is at least some mention of species prioritization in Environment Canada's most recent Report on Plans and Priorities (see: Environment Canada 2013). All variables retained in final models were associated with administrative factors - including the backlog of species requiring recovery strategies one year after listing, Responsible Authority, and whether or not the species was listed in Schedule 1 - rather than factors typical of prioritization.

My results provide some support for the hypothesis that, at least in part, the failure to produce recovery strategies according to the timelines specified in SARA is a consequence of insufficient resources. This evidence is of two sorts: (1) backlog one year after listing was an informative negative predictor of recovery strategy completion; and (2) Schedule 1 was a significant positive predictor of recovery strategy completion. Under SARA s. 2(1), 42(2), and 68(2), Responsible Authorities were allotted additional time for recovery strategy completion for species automatically listed at SARA's inception (3 years from listing date for endangered species and 4 years for threatened or extirpated species, while species not listed in Schedule 1 were allotted 2 and 3 years, respectively – see SARA s. 42). This reflects largely the feeling of parliamentarians that it was unreasonable to expect Responsible Authorities to deliver quality recovery strategies for all 201 species added to Schedule 1 when SARA came into force, given the initial funding allocated to

SARA. But this initial leniency notwithstanding, the persistent backlog effect suggests that resource limitations continue to impede the ability of RAs to deliver on statutory timelines This finding could potentially be useful in future discussions about relaxing mandated RS completion times, as under the ESA (see Chapter 2 for more on this). An obvious reason for strictly-mandated completion times is a concern that without them, strategies will lag indefinitely but, as yet, there is no evidence of this under SARA.

In light of the observed Schedule 1 and backlog effects, it is curious that RAs were reluctant to suggest resource limitation as a mitigating factor in a recent judicial review of SARA. In her recent decision concerning the failure of the Department of Fisheries and Oceans and Environment Canada to publish recovery strategies for four species (Nechako White Sturgeon, Pacific Humpback Whale, Marbeled Murrelet and Southern Mountain Caribou), Federal Court Judge Madam Mactavish noted:

> "Secondly, several of the respondents' affiants attribute at least some of the delays in producing recovery strategies to "organizational capacity issues", including staff turnover. Delays were also attributed to the need to manage competing legal duties, including the need to consult with stakeholders including provincial governments, First Nations, landowners and industry representatives.
>
> It should, however, be noted that although a lack of resources was a recurring theme in the respondents' evidence, counsel for the respondents advised the Court that he had been specifically instructed not to raise a lack of resources as a justification for the delay in posting proposed recovery strategies for the four species." (Mactavish, 2014, s[51, 52]).

Moreover:

> "While the cause of much of the delay described by Dr. Smith in his affidavit ultimately boils down to a question of resources, it bears repeating that the Ministers expressly do not rely on a lack of resources as a justification for the delay in relation to the species at issue in these applications." (Mactavish, 2014, s[83]).

So despite affidavits deposed by witnesses for the respondents (DFO & EC), counsel refused to use lack of resources as a justification – and potentially mitigating factor – for recovery strategy delay. Several explanations might be advanced: for example, it is difficult to, one the one hand, admit that insufficient resources have prevented a government department from discharging a statutory duty while simultaneously claiming that ongoing budget reductions to the same institutions will not compromise their capacity to discharge their fiduciary – let alone statutory – responsibilities.

I also found that the Department of Fisheries and Oceans (DFO) and Parks Canada Agency (PCA) were more likely than Environment Canada (EC) to publish recovery strategies on time. One explanation for this is that EC was responsible for 241 species while DFO and PCA were each responsible for 71. This unequal resource strain on Responsible Authorities, with EC responsible for just under two thirds of species with due recovery strategies, is likely a significant factor in explaining why EC struggles more than DFO or PCA to publish strategies on time. Worth noting is that there was no statistical support for models that included both RA and backlog size one year after listing. If unequal resource strain were solely responsible for the RA effect, one would expect that backlog size, as a proxy for resource strain at the time of listing (and one year after listing) for a given species, would not be retained in models that also included an RA effect. That this was indeed the case allows for no evidence of an RA effect independent of backlog size, though such a finding would not be without precedent. Findlay et al. (2009) discuss a reduced probability of listing for species under authority of the DFO, and Taylor and Pinkus (2012) provide evidence for a Lead Agency bias in critical habitat identification, with EC having a significantly higher rate of identification than the DFO (though I suggest in Chapter 3 that this might indeed be an effect of multi-species/ecosystem plans doing a comparatively poorer job of identifying critical habitat).

At issue here are the reasons why EC species have longer RS completion times, if indeed there are underlying reasons that go beyond the additional demand on resources. Taylor and Pinkus (2012) suggest that differences among agencies in culture, policy, or management might be at least partially responsible for their reported effect of Lead Agency on CH identification. One specific hypothesis concerns the critical role of consultation with aboriginal communities and wildlife management boards. Under SARA s. 39:

> (1) To the extent possible, the recovery strategy must be prepared in cooperation with
> (*a*) the appropriate provincial and territorial minister for each province and territory in which the listed wildlife species is found;
> (*b*) every minister of the Government of Canada who has authority over federal land or other areas on which the species is found;
> (*c*) if the species is found in an area in respect of which a wildlife management board is authorized by a land claims agreement to perform functions in respect of wildlife species, the wildlife management board;
> (*d*) every aboriginal organization that the competent minister considers will be directly affected by the recovery strategy; and
> (*e*) any other person or organization that the competent minister considers appropriate.
> (2) If the listed wildlife species is found in an area in respect of which a wildlife management board is authorized by a land claims agreement to perform functions in respect of wildlife species, the recovery strategy must be prepared, to the extent that it will apply to that area, in accordance with the provisions of the agreement.
> (3) To the extent possible, the recovery strategy must be prepared in consultation with any landowners and other persons whom the competent minister considers to be directly affected by the strategy, including the government of any other country in which the species is found.

Parks Canada's authority extends to federal lands in national parks or heritage sites. As such, recovery strategies for which PCA is the Responsible Authority might be expected to involve a much smaller group of stakeholders, especially landowners and those with (possibly) competing interests. Similarly, many of the species for which DFO is the Responsible Authority are marine and, in all marine waters outside of Canada's territorial zone (roughly 12 nautical miles from shoreline high water), the federal government has jurisdiction in respect to environmental protection. Consequently, one might expect that insofar as in marine areas provinces have minimal constitutional jurisdiction, and there is, in any event, no land to own, consultations will involve a limited number of stakeholders. By contrast, south of 60, provinces have exclusive jurisdiction over land and wildlife that is not held by the federal Crown, and given the "safety net" provisions of SARA, will necessarily be heavily involved in stakeholder consultation (SARA s. 39 (1)(a), as will aboriginal communities/First Nations (SARA s. 39(1)(d)). It is also worth noting that EC likely has less power than DFO or PCA to control factors associated with recovery of species for which they act as responsible authority. This is because, unlike EC, DFO and PCA are associated primarily with federally-owned land.

Overall, is seems as though Responsible Authorities are simply struggling to meet the demand imposed by large backlogs of due strategies. I expected to find evidence of internal prioritization in ranking species for recovery strategy completion, but was unable to detect any, at least with respect to the comparatively restricted set of variables examined. While SARA does not allow for prioritization of species for recovery strategy completion, it might make sense to take a more pragmatic approach. If deadlines are not being met (and they are not), perhaps species should be ranked according to priority until the backlog of due strategies has been cleared. Barring a temporary increase in resources to RAs to facilitate prompt completion of due strategies, the next-best alternative might be transparent prioritization, especially in cases where extinction risk might be directly tied to delays in RS publication and subsequent protection. There is some evidence for prioritization under the ESA, as Taylor et al. (2005) found that endangered species had higher rates of recovery plan completion than threatened species. As Taylor et al. point out, under the ESA species with dedicated recovery plans are more likely than species without to have improving status trends, and there is little reason to expect differently under SARA, especially given that CH identification occurs at the recovery strategy stage.

References

Boersma, P.D., P. Kareiva, W.F. Fagan, J.A. Clark & J.M. Hoekstra. 2001. How good are endangered species recovery plans? Bioscience 51: 643 - 649.

Brehm, J.M., N. Maxted, J. Magos Brehm, N. Maxted, M.A. Martins-Loução, and B.V. Ford-Lloyd. 2010. New approaches for establishing conservation priorities for socio-economically important plant species. Biodiversity Conservation. 19: 2715 – 2740.

Bunnell, F., D. Fraser and A.P. Harcombe. 2009. Increasing effectiveness of conservation decisions: a system and its application. Natural Areas Journal 29: 79 - 90.

Bottrill, M.C., J.C. Walsh, J.E.M. Watson, L.N. Joseph, A. Ortega-Argueta & H.P. Possingham. 2011. Does Recovery Planning Improve the Status of Threatened Species? Biological Conservation 144: 1596 - 1601.

Campbell, S. P., J. A. Clark, L. H. Crampton, A. D. Guerry, L. T. Hatch, P. R. Hosseini, J. J. Lawler & R. J. O'Connor. 2002. An assessment of monitoring efforts in endangered species recovery plans. Ecological Applications 12 (3): 674 - 681.

Environment Canada. 2013. 2013-14 Report on Plans and Priorities. Available from https://ec.gc.ca/default.asp?lang=En&n=09DD7F56-1 accessed October 2014).

EPBCA (Environmental Protection and Biodiversity Conservation Act). 1999. Available from http://www.comlaw.gov.au/Details/C2013C00301 accessed July 2013).

ESA (Endangered Species Act). 1973. Available from http://www.fws.gov/endangered/esa-library/pdf/ESAall.pdf (accessed April 2014).

Findlay, C.S., S. Elgie, B. Giles & L. Burr. 2009. Species listing under Canada's Species at Risk Act. Conservation Biology 23: 1609 - 1617.

Gerber, L.R. & C.B. Schultz. 2001. Authorship and the use of biological information in endangered species recovery plans. Conservation Biology 15 (5): 1308 - 1314.

Goldstein, P.Z., R. DeSalle, G. Amato & A.P. Vogler. 2000. Conservation genetics at the species boundary. Conservation Biology 14 (1): 120 - 131.

Hoekstra, J.M., W.F. Fagan & J.E. Bradley. 2002b. A critical role for critical habitat in the recovery planning process? Not yet. Ecological Applications 12 (3): 701 - 707.

IUCN-CMP. IUCN-CMP Unified Classification of Direct Threats. IUCN Red List. Accessed April 2014 from http://www.iucnredlist.org/documents/Dec_2012_Guidance_ Threats_Classificati on_Scheme.pdf.

Lundqvist, C.L., J.M. Diehl, E. Harvey & L.W. Botsford. 2002. Factors affecting implementation of recovery plans. Ecological Applications 12 (3): 713 - 718.

Mactavish, A. 2014. Western Canada Wilderness Committee et al. vs. Environment Canada and Department of Fisheries and Oceans. Docket. T-1777-12 Available from http://cas-ncr-nter03.cas-satj.gc.ca/rss/T-1777-12%20SARA%20decision%2014-02-2014%20ENG.pdf (Accessed April 2014).

Male, T.D. & M.J. Bean. 2005. Measuring progress in US endangered species conservation. Ecology Letters 8: 986 - 992.

Marsh, H., D. Andrew, H. Hines, A. Kutt, K. McDonald, E. Weber, S. Williams, and J. Winter. 2007. Optimizing allocation of management resources for wildlife. Conservation Biology 21: 387 - 399.

Mooers, A.O., L.R. Prugh, M. Festa-Bianchet & J.A. Hutchings. 2007. Biases in legal listing under Canadian endangered species legislation. Conservation Biology 21: 572 - 575.

Pimm, S. L.. 2000. Against triage. Science 289:2289.

Possingham, H.P., S.J. Andelman, M.A. Burgman, R.A. Medellin, L.L. Master & D.A. Keith. 2002. Limits to the use of threatened species lists. Trends in Ecology and Evolution 17: 503 - 507.

Redding, D.W. & A. O. Mooers. 2006. Incorporating evolutionary measures into conservation prioritization. Conservation Biology 20: 1670 – 1678.

SARA (Species at Risk Act). 2002. Available from http://laws-lois.justice.gc.ca/PDF/S-15.3.pdf (accessed April 2014).

Schwartz, M.W.. 2009. Choosing the appropriate scale of reserves for conservation. Annual Review of Ecology and Systematics 30: 83 - 108.

Schwartz, M.W.. 2008. The Performance of the Endangered Species Act. Annual Review of Ecology, Evolution, and Systematics 39: 279 - 299.

Solomon, B.D..1998. Impending recovery of Kirtland's warbler: Case study in the effectiveness of the Endangered Species Act. Environmental Management 22 (1):9 - 17.

Suckling, K.F., R. Slack & B. Nowicki. 2004. Extinction and the Endangered Species Act. Center for Biological Diversity report.

Suckling, K.F., N. Greenwald & T. Curry. 2012. On time, on target: How the Endangered Species Act is saving America's wildlife. Center for Biological Diversity report.

Taylor, E.B. and S. Pinkus. 2013. The effects of lead agency, non-governmental organizations, and recovery team membership on the identification of critical habitat for species at risk: insights from the Canadian experience. Environmental Reviews 21 (3): 93 - 102.

Taylor, M.F.J., K.F. Suckling & J.J. Rachlinski. 2005. The effectiveness of the Endangered Species Act: a quantitative analysis. BioScience 55 (4): 360 – 367

Venter, O., N.N. Brodeur, L. Nemiroff, B. Belland, I.J. Dolinsek & J.W.A. Grant. 2006. Threats to Endangered Species in Canada. Bioscience 56 (11): 903 - 910.

Wilson, K., M.C. Evans, M. Di Marco, D.C. Green, L. Boitani, H. Possingham, F. Chioza, and C. Rondinini. 2011. Prioritizing conservation investments for mammal species globally. Philosophical Transactions of the Royal Society B 366: 2670 - 2680.

Tables

Table 1.1. Candidate predictor variables included in analysis of recovery strategy completion.

Variable	Rationale	Reference(s)
Backlog (at listing, one year after listing, two years after listing)	A larger backlog would increase resource strain on RAs, thereby increasing RS completion times	
Edge of range	Canada might be considered to have low management responsibility for edge of range species, resulting in lower prioritization in recovery planning and increasing RS completion times..	Marsh et al. 2007, Taylor et al. 2011
Extent of occurrence (EO)/area of occupancy (AO) decline	Species with EO or AO decline considered to be at greater extinction risk, and hence, higher recovery planning priority, resulting in shorter RS completion times.	Possingham et al. 2002, Redding & Mooers 2006, Brehm et al 2010
Formal Conservation Area	At least some portion of a species' range occurring on a federal or provincial protected area might expedite recovery strategy completion, as in such areas identified critical habitat is already protected.	
IUCN-CMP threats (see Appendix I for information on the 11 distinct threat categories)	Certain types of threats may be considered easier to mitigate than others and, as a result, might be expected to influence assessments of recovery feasibility, with species for which recovery is considered infeasible being assigned lower priority.	Marsh et al. 2007, Bunnell et al. 2009

Listing status	If extinction risk is a criterion for prioritization, species with a higher threat status have higher priority and hence, shorter delays.	Possingham et al. 2002, Redding & Mooers 2006, Brehm et al 2010 etc…
Multiple Competent Ministers	The requirement for coordination among multiple RAs in production of a recovery strategy might be expected to increase delays, all else being equal.	Possingham et al. 2002, Redding & Mooers 2006, Brehm et al 2010 etc…
Population decline	If extinction risk is a criterion for prioritization, species undergoing population declines would be expected to have higher priority and hence, shorter delays.	Possingham et al. 2002, Redding & Mooers 2006, Brehm et al 2010 etc…
Provincial RS at time of listing	If there already exists a provincial recovery strategy that can be comparatively easily adapted to fulfill SARA's requirements, this might be expected to reduce recovery planning delays.	SARA s. 44
Responsible Authority	Effect of RA reported in species listing and critical habitat identification under SARA.	Findlay et al. (2009); Taylor and Pinkus (2013)
Schedule 1	Species automatically listed in Schedule 1 were allotted additional time for RS completion.	SARA s. 42
Taxon	Taxonomic bias reported for listing under SARA and in recovery planning under the ESA	Mooers 2008; Campbell et al. 2002; Hoekstra et al. 2002b; and Gerber & Schultz 2001

Table 1.2. Log Likelihoods, AICc, Akaike Weights, and null and residual deviances of the two best logistic regression models for completion of recovery strategies.

Model	logLik	AICc	∆ AICc	Akaike Weight	N. Deviance	R. Deviance
BL1Y + S1	-142.37	290.79	0	0.64	339.16	284.73
RA + S1	-141.94	291.99	1.19	0.36	339.16	283.88

Variables include the backlog of recovery strategies due for a given Responsible Authority one year after listing (BL1Y) of the target species; Responsible Authority (RA); whether or not the species was a Schedule 1 species automatically listed when SARA came into force (S1).

Table 1.3. Weighted estimated coefficients, 95% confidence intervals, and standard errors, based on multi-model weighing of logistic regression models for completion of recovery strategies.

Variable	**Value**	**B (upper, lower 95% CI)**	**SE**
RA	DFO	2.06 (1.34, 2.78)	0.37
RA	PCA	1.89 (1.15, 2.63)	0.38
BL1Y		-0.02 (-0.03, -0.01)	< 0.01
S1	yes	0.92 (0.26, 1.57)	0.33

Variables include the backlog of recovery strategies due for a given Responsible Authority one year after listing (BL1Y) of the target species; Responsible Authority (RA); whether or not the species was a Schedule 1 species automatically listed when SARA came into force (S1).

Figures

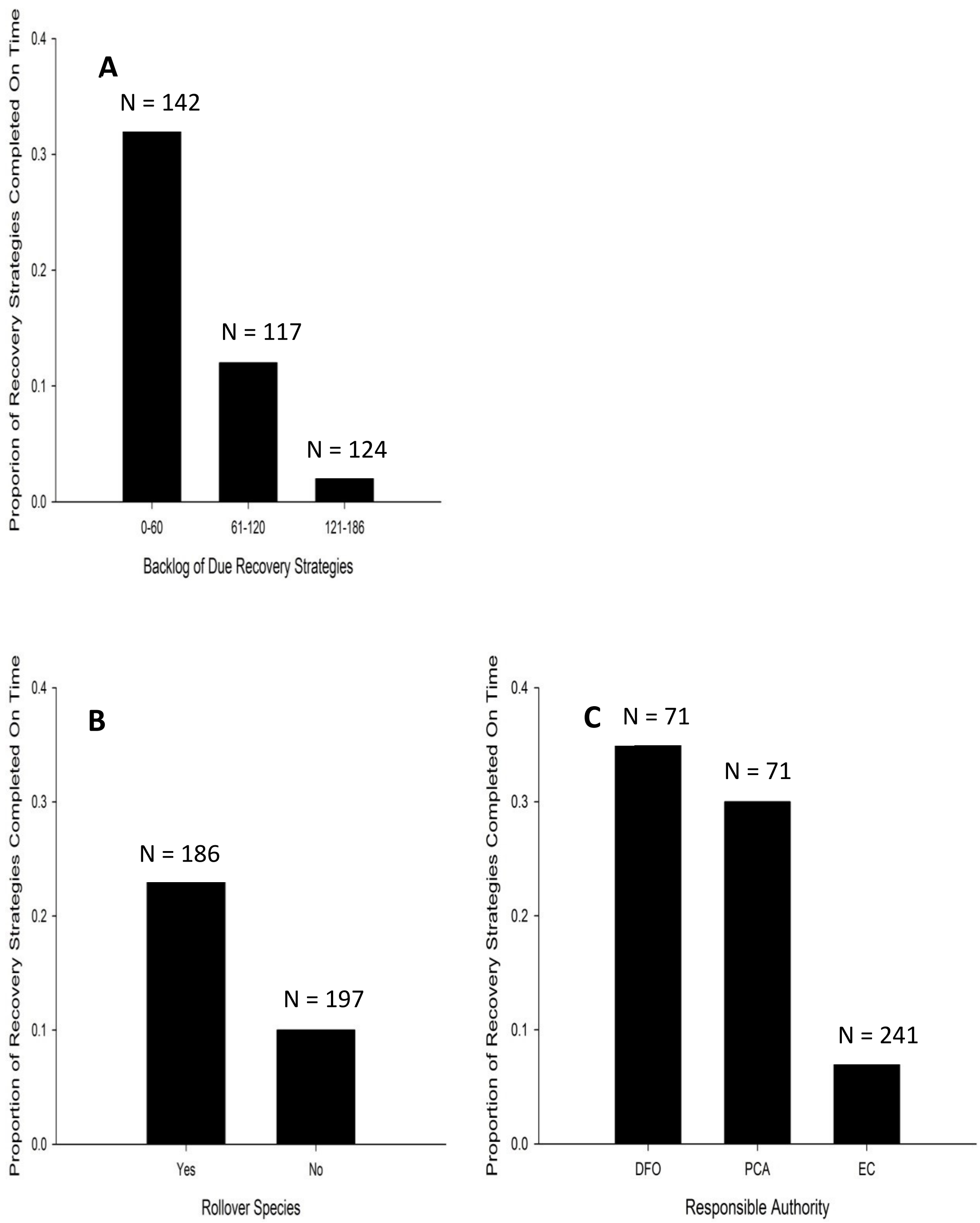

Figure 1.1. Factors associated with on-time completion of N = 383 due draft recovery strategies, including backlog of due strategies for a given Responsible Authority one year after listing (A), whether or not the species was a rollover species automatically listed at SARA's inception (B) and Responsible Authority (C).

Appendix I: Candidate Predictor Variables Chapter 1

Backlog (at listing, one year after listing, and two years after listing)
variable type: continuous
The number of species listed without a complete draft strategy at the time a given species is listed, for a given Responsible Authority.

Edge of Range
variable type: categorical
Whether the species is at the edge of its range in Canada (most of the populations are found elsewhere but there may be small or scattered populations in Canada).

Edge of range
No
Yes
Extirpated

Extent of Occurrence (EO)/Area of Occupancy (AO) Decline
variable type: categorical
Whether the species' population is said in the most recent COSEWIC status report to be in decline.

EO/AO Decline
neither in decline
at least one in decline
both unknown

Formal Conservation Area
variable type: binary
Whether or not at least some part of the species' range occurs in federal or provincial protected area.

Formal Conservation Area
Yes
No

IUCN IUCN-CMP Unified Classifications of Direct Threats

Threats identified in the most recent COSEWIC status report, using IUCN-CMP threat classification

variable type: binary for each threat

Threat Type
Residential and Commercial Development
Agriculture and Aquaculture
Energy Production and Mining
Transportation and Service Corridors
Biological Resource Use
Human Intrusions and Disturbance
Natural Systems Modification
Invasive and Other Problematic Species, Genes, and Diseases
Pollution
Geological Events
Climate Change and Severe Eeather

Listing Status

The status assigned to the species when it was listed under SARA.

variable type: categorical

Status
Endangered
Threatened
Extirpated

Multiple Competent Ministers

variable type: binary

Whether or not there are multiple federal agencies responsible for the species' recovery.

Multiple CM
Yes
No

Population Decline

variable type: categorical

Whether the species' population is said in the most recent COSEWIC status report to be in decline.

Population Decline
No
Yes
Unknown

Provincial RS at Time of Listing
variable type: binary
Whether or not the species had an operational provincial RS at the time it was listed under SARA.

Provincial RS
Yes
No

Responsible Authority
variable type: categorical
The federal authority responsible for protection of the species.

Responsible Authority/Authorities
Environment Canada
Department of Fisheries and Oceans
Parks Canada Agency

Schedule 1 Species
variable type: binary
Whether the species was a Schedule 1 species listed automatically when SARA came into force.

Rollover Species
Yes
No

Taxon
variable type: categorical

Taxon
vascular plants
birds
fishes
terrestrial mammals
lichens and mosses
herptiles
arthropods
molluscs
marine mammals

Chapter 2 – Recovery Feasibility and Information Gaps

Introduction

Evaluation of recovery efforts is accomplished in very different ways depending on the amount of time that has passed since the recovery process began. For older legislation such as the United States' Endangered Species Act (ESA), which was signed into law in 1973, effectiveness of protection can in principle be evaluated using changes in population size or distributions, or some surrogate thereof (e.g. listing status). Indeed, many studies have relied at least in part on such responses to evaluate recovery under the ESA; Boersma et al. 2001, Clark et al. 2002, Gerber & Hatch 2002, Kerkvliet & Langpap 2007 etc. For comparatively recent legislation, such as Australia's Environmental Protection and Biodiversity Conservation Act (EPBCA, 1999) or Canada's Species at Risk Act (SARA, 2002) evaluation of the effectiveness of recovery efforts must be done indirectly, simply because insufficient time has elapsed to evaluate population response. For example, under SARA, final recovery strategies have been published for only 211 species, with the earliest plans being published in 2006.

Research on species protection under SARA has thus focused more on the various steps in the listing and recovery planning processes. Mooers at al. (2007) found taxonomic variation in listing probability, with freshwater fishes, marine fishes, marine mammals, and terrestrial mammals having a reduced probability of listing. Further research suggested that these taxonomic effects were largely due to decreased probability of listing for northern species, harvested species, and species for which the Department of Fisheries and Oceans is the responsible authority (Findlay et al. 2009). Chapter 1 of this thesis took a similar approach, looking at factors associated with recovery plan completion.

Under SARA, concrete conservation and recovery actions are implemented in an Action Plan (SARA s. 47) that are based directly on information provided in the recovery strategy (SARA s. 49), including the determination of threats to the species as well as recommended threat mitigation actions. Thus, the content of a recovery strategy is likely to have a substantial impact on the success – or lack thereof – of recovery efforts. The presumed importance of recovery plan content is reflected in the efforts devoted to the analysis thereof. While some preliminary work has been done on recovery strategy content under SARA (e.g. threat designations (McCune et al. 2013) and critical habitat identification (Taylor and Pinkus (2013)), the most extensive analysis undertaken to date concerns the ESA as a result of the recovery plan review project (RPRP), initiated by P. Dee Boersma in 1998 and supported by the Society for Conservation Biology (SCB), the United States Fish and Wildlife Service (USFWS) and the National Center for Ecological Analysis and Synthesis (NCEAS) (Boersma 1999, Clark et al. 2002, Hoekstra 2002a). The project, described in detail by Hoekstra et al. (2002a), was a large-scale collaborative effort among 19 universities and more than 325 researchers to create a quantitative database detailing content of recovery strategies under the ESA. The project provided great insight into ESA recovery plan content and quality, yielding more than 15 peer-reviewed papers (Clark et al. 2002).

Included in these findings were a number of important associations between recovery plan content and species status trends as documented in the USFWS biennial reports to Congress (U.S. Fish and Wildlife Service 1994-2010). Boersma et al. (2001) attempted to link recovery plan attributes to species status trends (improving, stable, declining, extinct, or unknown) assigned by the USFWS in biennial reports submitted to Congress. They found evidence that species included in multi-species recovery plans are much less than likely than species with dedicated plans to exhibit improving status trends. They also found that non-federal input on recovery plan authorship is associated with improving status trends. This final finding was supported by Gerber and Schultz (2001) who also found that plans without non-federal input tend to have insufficient attention to species biology. Multi-species plans were the focus of a separate study (Clark & Harvey 2002), that found that on a per-species level they enumerated fewer recovery tasks than dedicated plans. There was also evidence for taxonomic and geographical bias in determination of plan type for individual species (Clark & Harvey 2002). Finally, taxonomic bias in recovery plan content was reported by Campbell et al. (2002), Hoekstra et al. (2002b), and Gerber & Schultz (2001).

In a similar vein, and building on initial work on recovery strategy content under SARA by McCune (2013), Taylor and Pinkus (2013) I here consider the determination of recovery feasibility as well as the specification of information gaps in recovery strategies. Under SARA (s. 40) feasibility of recovery, both biological and technical, is to be outlined in recovery strategies based on the best available information. This designation is important because it determines recovery strategy content (SARA s. 41-42). When recovery is considered to be infeasible, the recovery strategy need not include information on threats to the species, a schedule of studies for complete identification of critical habitat in cases where it could not be identified in the recovery strategy, nor an estimate of the expected time to completion of an action plan.

It is also likely that feasibility of recovery, or likelihood of management success, is considered when prioritizing species for conservation efforts (see, for example, Joseph et al. 2008, Marsh et al. 2007, Bunnell et al. 2009), and Bottrill et al. (2011) suggest that management feasibility is likely associated with the amount of resources/attention a particular species receives in the conservation process. Analysis of recovery objectives under the EPBCA suggests that they are associated with the feasibility of recovery, with more optimistic recovery goals set out for species with more feasible recovery (Ortega-Argueta 2008). At present, there has been no analysis of recovery feasibility under SARA and, given the potential consequences of a determination of "unfeasible", an understanding of the factors that affect this determination is one of the foci of this chapter: what factors, if any, are associated with the determination of recovery feasibility in recovery strategies?

Recovery strategies and plans must also identify gaps in knowledge and prescribe monitoring efforts and/or a schedule of future studies that improves the quality of information used in the recovery planning process (Campbell et. al 2002, Ortega-Argueta 2008, Pullin and Knight 2003, Pullin et al. 2003). Under the EPBCA, inadequate compliance with recovery planning requirements is linked primarily to gaps in scientific information (Ortega-Argueta 2008, Ortega-Argueta et al. 2011), though recovery strategies have a high degree of consistency in providing research prescriptions to address these gaps (Ortega-Argueta 2008). Similarly, identified information gaps are well-addressed in the planning process under the ESA (Brigham et al. 2002). There has, as yet, been no work done on the treatment of information gaps in recovery strategies under SARA, and here I investigate two related questions: what information gaps are most frequently identified in recovery strategies? What factors, if any, are associated with the number of information gaps identified for a given species?

Methods

Data Selection and Analysis

As of September 20th, 2013, there were 211 species with final recovery strategies posted to the SARA online registry. Recovery feasibility was treated as a binary response, with species for which recovery was considered to be infeasible (N = 9) pooled with those for which feasibility of recovery was considered unknown (N = 25). For the remaining 177 species recovery was considered to be feasible.

Information gaps (IGs) were categorized into six different commonly-recurring categories; population abundance and spatial distribution; statistical modelling of population or distributional changes, including population viability analysis; recovery targets; habitat use; risk factors and threats to recovery; land ownership. Each of the six categories was treated as a binary variable, with 1 indicating that the IG in question was explicitly identified, and 0 indicating that it was not (i.e. was absent). The total number of information gaps thus ranged from 0-6.

In both analyses I investigated a constrained set of 15 independent variables (see Appendix 1) which might be expected to be associated with recovery feasibility or information gaps, or for which previous work has identified as factors associated with elements of the recovery planning process, either under SARA or in other jurisdictions (Table I).

I employed an information-theoretic approach to model selection, with both the residual deviance and AIC_c values (AIC corrected for small sample size) used to guide model selection (see Burnham and Anderson 2002, Burnham et al. 2010). Beginning with a null model, terms were added individually and retained if they resulted in a substantial improvement in AICc (i.e., reduced AICc by more than 7). Where there was evidentiary support for multiple models, Akaike weights were calculated for each retained model, variable importance calculated for each variable, and parameter estimates based on multi-model weighting.

Results

Information pertaining to population abundance and spatial distribution was the most commonly identified information gap (N = 188 (89%)), followed by habitat use (N = 164 (78%)) and risk factors/threats impacting recovery (N = 158 (75%)). Information gaps regarding statistical modelling (N = 86 (41%)), recovery targets (N = 48 (23%)) and land ownership (N = 42 (20%)) were less prevalent.

Species under authority of the Parks Canada Agency ($\beta = 3.31 \pm 1.1$) or DFO ($\beta = 2.05 \pm 0.72$), species for which critical habitat was at least partially identified ($\beta = 2.07 \pm 0.57$) and species for which potential socioeconomic conflicts were discussed ($\beta = 2.33 \pm 1.09$) had an increased likelihood of having recovery considered to be feasible (See Tables

2.2, 2.3, Figure 2.1). Also, a greater number of identified information gaps was associated with increased recovery feasibility (β = 0.77 ± 0.18).

Species included in recovery strategies published after the Nooksack Dace and Sage-Grouse court judgements (β = -1.13 ± 0.19) or for which recovery was considered not feasible or of unknown feasibility (β = -1.16 ± 0.25) had a reduced number of identified information gaps. The number of information gaps was also negatively associated with the length of the recovery strategy delay (β = -0.02 ± <0.01). There was also some evidence that species found in federal or provincial protected areas had an increased number of identified information gaps (β = 0.54 ± 0.19) (Tables 2.4 and 2.5, Figure 2.2). I was unable to detect evidence that information gaps or recovery feasibility are associated with the size of the backlog of due strategies, degree of endemism, threat status, whether or not the species is listed provincially, whether or not the species has multiple Competent Ministers, the number of provinces/territories in which the species is found, plan type, or taxon.

Discussion

Overall, this analysis shed some light on factors associated with treatment of recovery feasibility and information gaps in recovery strategies. Given that resources for species recovery are limited, feasibility and cost-effectiveness of recovery is regarded as an important prioritization criterion (Marsh et al. 2007, Bunnell et al. 2009 etc…). Moreover, insofar as 80% of species with at least Special Concern status are apparently experiencing habitat loss or degradation (Venter et al. 2006), one might expect that identification of critical habitat - and presumably the resulting protection - would be an important step towards recovery for many species. In particular, the feasibility of recovery would seem to depend on having sufficient habitat of sufficient quality to maintain a viable population of the species in question (e.g. Christianen et al. 2014, Mullen et al. 2013). Although there are important questions concerning the effect of critical habitat identification on species recovery under the ESA (see, for example, Suckling and Taylor 2006, Taylor et al. 2005, Rachlinski 1997, Kerkvliet and Langpap 2007, Gibbs and Currie 2012) and of potentially problematic effects on private landowners (Brook et al. 2003, Mir and Dick 2012, Quigley and Swoboda 2007, Wilcove and Lee 2004, Zabel and Paterson 2006 etc…), it is nonetheless a truism that a species at risk cannot recover (in the wild at least) without sufficient habitat of sufficient quality. This belief is explicitly represented in the Canadian Wildlife Service's 2005 policy on recovery feasibility, which identifies as its second criterion: "Is sufficient suitable habitat available to support the species or could it be made available through habitat management or restoration?" Certainly there is evidence that for many at risk species, recovery depends on quality and quantity of habitat and there is evidence that under the US ESA, habitat conservation plans promote species recovery (e.g. Langpap and Kerkvliet 2012).

The negative relationship between recovery feasibility and number of information gaps is intriguing. My expectation was that a large number of information gaps would be a significant hurdle to the determination of recovery feasibility. Indeed, the Canadian Wildlife Service Policy on Recovery Feasibility hints that lack of information may be a legitimate reason for the conclusion that recovery is not feasible, rather than of unknown feasibility:

> "If a species' recovery is determined to be not feasible, the recovery strategy should include a statement of whether research would be appropriate to address the reasons for the not feasible determination" (Government of Canada 2005)

However, with respect to recovery planning, SARA is explicit in stating that a precautionary approach must be adopted: section 38 states that:

> "In preparing a recovery strategy, action plan or management plan, the competent minister must consider the commitment of the Government of Canada to conserving biological diversity and to the principle that, if there are threats of serious or irreversible damage to the listed wildlife species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty."

The interpretation of the precautionary principle incorporates the idea of reverse onus (see Briand 2010). In the case of recovery feasibility, the strong interpretation would imply that recovery strategy authors ought to consider that indeed, recovery is technically and biologically feasible unless there is compelling evidence to the contrary. In other words, the presumption is that recovery is feasible, and sufficient evidence must be presented before this presumption is overcome. By contrast, one might adopt the presumption that recovery is not feasible, unless there is compelling evidence to the contrary. My results are consistent with the former, and inconsistent with the latter. If indeed the presumption is, generally, that recovery is not feasible unless demonstrated otherwise, then one would expect that the fewer the information gaps, the greater the probability of a feasible determination. This prediction is not supported. By contrast, if authors were generally of the view that lack of information was not a sufficient reason for a designation of infeasible (or unknown feasibility), and that a determination of infeasible was only appropriate when there was sufficient information in hand to demonstrate that recovery was very likely to be infeasible, then one would predict the observed negative relationship between the probability of a feasible determination and number of information gaps. This problem may be confounded by SARA's provisions. There is no characterization of "unknown feasibility" in SARA: under the Act, feasibility must be determined as either: (a) feasible; (b) not feasible (SARA s. 40, 41). If the determination is (b), then there is no legal requirement for an Action Plan (AP) nor a Management Plan (MP). Thus, it is entirely possible (indeed, very likely) that a finding of infeasible not only will result in a reduction of resources for information gathering, but no critical habitat protection deriving from SARA. On the other hand, a finding of feasible imposes a statutory duty to develop and implement either an AP or MP (SARA s. 47) and it is here that critical habitat must be identified and, within 180 days of being identified, protected if it has not been identified in the Recovery Strategy (SARA s. 41, 58). Moreover, a determination of feasible allows the specification of further required studies in the recovery strategy (SARA s. 41.1: no such requirement exists for the recovery strategies of species whose recovery is deemed infeasible (SARA s. 41.2).

I was also surprised to detect a strong effect of Responsible Authority (RA), with species for whom DFO or PCA is the responsible authority more likely to have recovery considered feasible than those for whom Environment Canada is the RA. This finding is particularly surprising given the recent finding by Taylor and Pinkus (2012) that species under authority Environment Canada are more likely than species under authority of the

DFO to have critical habitat identified in recovery strategies. Taylor and Pinkus suggest that differences among agencies in culture, management and policy might explain why they differ in rates of critical habitat identification, and this might also explain differences in determination of recovery feasibility. It would be useful to explore the relationship further and determine the reasons for it, as the effect might simply be a result of species under control of different agencies tending to have different attributes, another possibility suggested by Taylor and Pinkus. As I discuss in Chapter 3,there is some evidence that this is indeed the case for critical habitat listing.

The final factor associated with recovery feasibility was mention of potential socioeconomic conflicts, which was associated with increased likelihood of recovery being considered feasible. On the one hand, this finding is encouraging: the Policy on Recovery Feasibility (GOC 2005) states that:

> "Feasibility in this document means technical and biological feasibility. Other considerations such as aesthetic, economic or other social values shall *not* be considered when making a determination on recovery feasibility. These other considerations will be taken into account later in the recovery process if recovery is deemed to be feasible.

If socioeconomic values were being considered, one might expect that species for which a potential socioeconomic conflict had been identified would be less likely to receive a feasible designation, but my results indicate the opposite. On the other hand, this result is perplexing, as it is difficult to conceive of why having potential socioeconomic conflicts would increase the likelihood of a feasible designation. One possibility is that, insofar as the determination of recovery feasibility under the Policy also requires that "the necessary recovery techniques exist and have been demonstrated to be effective?" (GOC,

2005) , it is possible that species which have no potential socioeconomic conflicts have a greater probability of not satisfying this criterion. This hypothesis remains to be explored.

Of the factors for which I could not detect an association with recovery feasibility, the most surprising was listing status. Species with a higher threat status (i.e., endangered or extirpated rather than threatened) are, at least in principle, more imminently facing extinction, and should thus be expected to have a lower feasibility of recovery. This was not the case, however, as there was very little statistical support for models containing listing status as an explanatory variable. It was also somewhat surprising to find no evidence of taxonomic bias, for both recovery feasibility and the number of information gaps. Conservation research is littered with evidence of taxonomic bias at nearly every stage (see Mooers et al. 2007 and Findlay et al. 2009 for discussion of taxonomic bias in listing under SARA, for example), and it is encouraging that I was unable to detect it in an evaluation of recovery strategy content under SARA.

Judgements in favour of the Alberta Wilderness Association in a case against the Minister of Environment regarding critical habitat identification for the Greater Sage-Grouse (Zinn 2009) and in favour of Environmental Defense Canada in a case against the Minister of Fisheries and Oceans regarding critical habitat identification for the Nooksack Dace (Campbell 2009) in 2009 have profoundly affected the rate of critical habitat determination in recovery strategies (Taylor and Pinkus 2012, see also Chapter 3), and seem to also be associated with a reduction in the number of information gaps identified in recovery strategies. This finding supports the suggestion by Taylor and Pinkus that scientific information included in post-judgement recovery strategies is more rigorous and complete, shedding further light on the positive impact the court challenges seem to have had on SARA's implementation, particularly as far as recovery strategies are concerned.

It is also interesting, and not particularly surprising, that greater time elapsed between a strategy's due date and date of draft publication is associated with a reduced number of information gaps. This finding opens up the question of whether or not strict adherence to statutory dates makes for best conservation practice. If recovery strategies that adhere to due dates, or are submitted only several months late, are rushed and lacking important information, it might make more sense to delay publication until the information acquired is of sufficient enough quality that plan content does not suffer. This is not a problem under legislation such as the ESA and EPBCA, neither of which dictate recovery plan completion times. Exploring a similar approach in cases where information simply is not available might make sense in lieu of rushing plans that contain inadequate information. While it seems obvious that plans with better information will yield better results when put into effect, Boersma et al (2001) noted that under the ESA revised plans, though they contain more information than unrevised plans, have not shown to be more effective at improving status trends. It is critical that any revisiting of mandatory recovery strategy due dates appropriately weigh the costs not only of publishing plans with incomplete information but also of delaying publication of useful information while information gaps are addressed.

An important next step in evaluating recovery planning under SARA is evaluating the consistency with which information gaps are addressed with scheduled studies in recovery plans. Plans under the both the EPBSA (Ortega-Argueta 2008) and ESA (Brigham et al. 2002) have been found to be fairly consistent in addressing identified gaps in the planning process, and similar work should be done on recovery plans under SARA. It is also important that we shed more light on the Responsible Authority biases detected both in this study and in the critical habitat work by Taylor and Pinkus. Consistency among the three lead agencies is important, and we should work to fully understand any institutional biases present in conservation under SARA.

References

Boersma, P. D. 1999. SCB to conduct national review of recovery plans. Society for Conservation Biology Newsletter 6: 12.

Boersma, P.D., P. Kareiva, W.F. Fagan, J.A. Clark & J.M. Hoekstra. 2001. How good are endangered species recovery plans? Bioscience 51: 643 - 649.

Bottrill, M.C., J.C. Walsh, J.E.M. Watson, L.N. Joseph, A. Ortega-Argueta & H.P. Possingham. 2011. Does Recovery Planning Improve the Status of Threatened Species? Biological Conservation 144: 1596 - 1601.

Briand, A. 2010. Reverse onus: An effective and efficient risk management strategy for chemical regulation. Canadian Public Administration 53(4): 489 - 508

Brigham, C.A., A.G. Power & A. Hunter. 2001. Evaluating the internal consistency of recovery plans for federally endangered species. Ecological Applications 12: 3 648 - 654.

Brook, A., M. Zint, & R. De Young. 2003. Landowners' response to an Endangered Species Act listing and implications for encouraging conservation. Conservation Biology 17 (6): 1638 - 1649.

Bunnell, F., D. Fraser and A.P. Harcombe. 2009. Increasing effectiveness of conservation decisions: a system and its application. Natural Areas Journal 29: 79 - 90.

Burnham, K. P. & D. A. Anderson. 2002. Model selection and multimodel inference. 2nd edition. Springer-Verlag, New York.

Burnham, K.P., D.R. Anderson & K.P. Huyvaert. 2010. AIC model selection and multimodel inference in behavioral ecology: some background, observations, and comparisons. Behavioral Ecology and Sociobiology 65: 23 - 35.

Campbell, J. 2009. Environmental Defence Fund et al. vs. the Minister of Fisheries and Oceans. Docket T-1529-07, 2009 FC 878. Available from http://reports.fja.gc.ca/eng/2009/2009fc878.html (Accessed April 2014).

Campbell, S. P., J. A. Clark, L. H. Crampton, A. D. Guerry, L. T. Hatch, P. R. Hosseini, J. J. Lawler & R. J. O'Connor. 2002. An assessment of monitoring efforts in endangered species recovery plans. Ecological Applications 12 (3): 674 - 681.

Christianen, M.J.A., P.M.J. Herman, T.J. Bouma et al. 2014. Habitat collapse due to overgrazing threatens turtle conservation in marine protected areas. Proceedings of the Royal Society B 281 (1777): article number 20132890.

Clark, J.A. & E. Harvey. 2002. Assessing multi-species recovery plans under the Endangered Species Act. Ecological Applications 12 (3): 655 - 662.

Clark, J.A., J.M. Hoekstra, P.D. Boersma, & P. Kareiva. 2002. Improving U.S. Endangered Species Act recovery plans: key findings and recommendations of the SCB Recovery Plan Project. Conservation Biology 16: 1510 - 1519.

EPBCA (Environmental Protection and Biodiversity Conservation Act). 1999. Available from http://www.comlaw.gov.au/Details/C2013C00301 accessed April 2014).

ESA (Endangered Species Act). 1973. Available from http://www.fws.gov/endangered/esa-library/pdf/ESAall.pdf (accessed July 2013).

Findlay, C.S., S. Elgie, B. Giles & L. Burr. 2009. Species listing under Canada's Species at Risk Act. Conservation Biology 23: 1609 - 1617.

Gerber, L.R. & L.T. Hatch. 2002. Are we recovering? An evaluation of recovery criteria under the US Endangered Species Act. Ecological Applications 12: 668 - 673.

Gerber, L.R. & C.B. Schultz. 2001. Authorship and the use of biological information in endangered species recovery plans. Conservation Biology 15 (5): 1308 - 1314.

Gibbs, K.E. & D.J. Currie. 2012. Protecting endangered species: do the main legislative tools work? PLoS ONE 7(5): e35730. doi:10.1371/journal.pone.0035730.

Government of Canada. 2005. Draft Policy on the Feasibility of Recovery. Accessed from ftp://142.36.245.139/.virtual/slk6ftp/pub/outgoing/requests/!white_sturgeon/NTWG%20 INFO/policy%20docs/recovery%20feasibility%20policy%20Jan%2005[2].doc April 2014.

Hoekstra, J.M., J.A. Clark, W.F. Fagan & P.D. Boersma. 2002a. A comprehensive review of Endangered Species Act recovery plans 12 (3): 630 - 640.

Hoekstra, J.M., W.F. Fagan & J.E. Bradley. 2002b. A critical role for critical habitat in the recovery planning process? Not yet. Ecological Applications 12 (3): 701 - 707.

Joseph, L.N., R.F. Maloney & H.P. Possingham. 2008. Optimal allocation of resources among threatened species: a project prioritization protocol. Conservation Biology 23 (2): 328 - 338.

Kerkvliet, J. & C. Langpap. 2007. Learning from endangered and threatened species recovery programs: A case study using U.S. Endangered Species Act recovery scores. Ecological Economics 63 (2-3): 499 - 510.

Langpap, C. & J. Kerkvliet. 2012. Endangered species conservation on private land: assessing the effectiveness of habitat conservation plans. Journal of Environmental Economics and Management 61 (1): 1 - 15.

Lundqvist, C.L., J.M. Diehl, E. Harvey & L.W. Botsford. 2002. Factors affecting implementation of recovery plans. Ecological Applications 12 (3): 713 - 718.

Marsh, H., D. Andrew, H. Hines, A. Kutt, K. McDonald, E. Weber, S. Williams, and J. Winter. 2007. Optimizing allocation of management resources for wildlife. Conservation Biology 21: 387 - 399.

McCune, J.L., W.L. Harrower, S. Avery-Gomm, J.M. Brogan, A.M. Csergo, L.N.K. Davidson, A. Garani, L.R. Halpin, L.P.J. Lipsen, C. Lee, J.C. Nelson, L.R. Prugh, C.M. Stinson, C.K. Whitney & J. Whitton. 2013. Threats to Canadian species at risk: an analysis of finalized recovery strategies. Biological Conservation 166: 254 - 265.

Mir, D.F. & K. Dick. 2012. Conservation Approaches to protecting critical habitats and species on private property. Natural Areas Journal 32 (2): 190 - 198.

Mooers, A.O., L.R. Prugh, M. Festa-Bianchet & J.A. Hutchings. 2007. Biases in legal listing under Canadian endangered species legislation. Conservation Biology 21: 572 - 575.

Mullen, K.A., M.L. Peterson & S.K. Todd. 2013. Has designating and protecting critical habitat had an impact on endangered North Atlantic right whale ship strike mortality? Marine Policy 42: 293 - 304.

Ortega-Argueta, A. 2008. Evaluating recovery planning for threatened species in Australia. PhD Thesis, School of Integrative Systems, The University of Queensland, Australia. http://espace.library.uq.edu.au/view/UQ:178617

Ortega-Argueta, A, G. Baxter & M. Hockings. 2011. Compliance of Australian threatened species recovery plans with legislative requirements. Journal of Environmental Management 92 (2011) 2054 - 2060.

Pullin, A. S. & T. M. Knight. 2003. Support for decision making in conservation practice: An evidence-based approach. Journal for Nature Conservation 11: 83 - 90.

Pullin, A. S., T. M. Knight, D.A. Stone & K. Charman. 2003. Do conservation managers use scientific evidence to support their decision-making? Biological Conservation 119 (2004): 245 - 252.

Quigley, J.M. & A.M. Swoboda. 2007. The urban impacts of the Endangered Species Act: a general equilibrium analysis. Journal of Urban Economics 61 (2): 299 - 318.

Rachlinski, J. J., 1997. Noah by the numbers: an empirical evaluation of the Endangered Species Act. Cornell Law Review. 82: 356 - 389.

Russell, J. 2010. David Suzuki Foundation et al. vs. the Minister of Fisheries and Oceans and Environment Canada. Docket T-541-09, 2010 FC 1233. Available from http://reports.fja.gc.ca/eng/2012/2010fc1233.html (Accessed April 2014)

Sapir, Y., A. Shmida, & O. Fragman. 2003. Constructing Red Numbers for setting conservation priorities of endangered plant species: Israeli flora as a test case. Journal for Nature Conservation 11: 91 - 107.

SARA (Species at Risk Act). 2002. Available from http://laws-lois.justice.gc.ca/PDF/S-15.3.pdf (accessed April 2014).

Suckling, K. F., and M. Taylor. 2006. Critical habitat and recovery. Pages 75-89 in D. Goble, M. J. Scott, and F. W. Davis, editors. The Endangered Species Act at thirty: renewing the conservation commitment. Island Press, Washington DC.

Taylor, M.F.J., K.F. Suckling & J.J. Rachlinski. 2005. The effectiveness of the Endangered Species Act: a quantitative analysis. BioScience 55 (4): 360 - 367.

Taylor, E.B. and S. Pinkus. 2013. The effects of lead agency, non-governmental organizations, and recovery team membership on the identification of critical habitat for species at risk: insights from the Canadian experience. Environmental Reviews 21 (3): 93 - 102.

U.S. Fish and Wildlife Service. (1994-2010). Reports to Congress on the recovery of threatened and endangered species: fiscal years 1994, 1996, 1998-2000, 2001-2002, 2003-2004, 2005-2006, 2007-2008. 2009-2010. Washington (DC): U.S. Fish and Wildlife Service. Available: http://www.fws.gov/endangered/esa-library/index.html#recovery Accessed April 2014.

Venter, O., N.N. Brodeur, L. Nemiroff, B. Belland, I.J. Dolinsek & J.W.A. Grant. 2006. Threats to Endangered Species in Canada. BioScience 56 (11): 903 - 910.

Wilcove, D.S. & J. Lee. 2004. Using economic and regulatory incentives to restore endangered species: lessons learned from three new programs. Conservation Biology 18 639 - 645.

Zabel, J.E. & R.W. Paterson. 2006. The effects of critical habitat designation on housing supply: an analysis of California housing construction activity. Journal of Regional Science 46 (1): 67 - 95.

Zinn, J. 2009. Alberta Wilderness Association et al. vs. Minister of Environment. Docket T-241-08 2009 FC 710. Available from http://reports.fja.gc.ca/eng/2009/2009fc710.html (Accessed April 2014)

Tables

Table 2.1. Candidate predictor variables included in analysis of recovery feasibility and information gaps identified in recovery strategies.

Variable	Rationale	Reference(s)
Backlog Size	As an indicator of resource demand at the time of listing (and one year after listing), larger backlogs might be associated with lower recovery feasibility and increased information gaps.	
Before/After Nooksack Dace and Sage Grouse Court Judgements	Given the increase in CH identification rates post-judgment, feasibility of recovery might be higher for plans published post-judgement, especially if other aspects of plan quality have improved post-judgment (e.g., a reduction in the number of identified information gaps).	Taylor and Pinkus 2012
Critical Habitat Identification	CH is to be identified regardless of recovery feasibility under SARA, but feasible recovery might be more likely if CH identified. CH identification is also likely associated with a reduced number of information gaps.	SARA s. 41, Suckling and Taylor 2006, Taylor et al. 2005, Rachlinski 1997, Schwartz 2008
Degree of Endemism	Canada might be considered to have low management responsibility for species with large populations found elsewhere, and this might impact the willingness of strategy authors to give an 'infeasible' determination, and also result in more information gaps, as resources are allocated elsewhere.	Marsh et al. 2007, Taylor et al. 2011

Formal conservation area	Species located on federal or provincial land likely have fewer hurdles to recovery, and thus likely increased recovery feasibility. They are also likely to have fewer identified information gaps, especially pertaining to land ownership.	
Listed Provincially	Species already protected via provincial legislation might be more likely to have a ‘feasible’ designation, and have fewer information gaps, especially in cases where a provincial RS has been completed.	
Listing status	A higher listing status might be associated with decreased recovery feasibility, as endangered species less likely to recovery under ESA, as well as an increased number of information gaps.	Taylor et al. 2005
Months elapsed between RS due date and date of draft submission	Given that CH identification does not occur until recovery strategy stage, and that recovery strategies guide action plans, delays might negatively affect feasibility of recovery, though they might be associated with a decreased number of information gaps given the additional time spent preparing the strategy.	Suckling and Taylor 2006, Taylor et al. 2005, Rachlinski 1997, Schwartz 2008
Multiple Competent Ministers	Species under authority of Multiple CMs, given additional institutional resources, might have fewer information gaps and increased recovery feasibility	

Number of Information Gaps/Recovery Feasibility	Ability to determine feasibility is likely effected significantly by gaps in information.	
Number of Provinces	Species found in more provinces (i.e., with a larger range) might be more likely to have feasible recovery than species with more localized populations.	e.g. Sapir et al. 2003
Multi-Species/Ecosystem Strategy	Under ESA and EBPCA documented differences in plan quality depending on plan type	Clark and Harvey 2002, Ortega-Argueta 2008
Responsible Authority	Associations with RA reported for species listing and critical habitat identification under SARA	Findlay et al. 2009; Taylor and Pinkus 2013
Socioeconomic conflict discussed	As per SARA, determination of feasibility to be based on technical and biology feasibility, and not influenced by socioeconomic factors, though SEC likely associated with increased information gaps.	SARA s. 40
Taxon	Taxonomic bias reported for listing under SARA and in recovery planning under the ESA	Mooers 2008; Campbell et al. 2002; Hoekstra et al. 2002b; and Gerber & Schultz 2001

Table 2.2. Log Likelihoods, AICc, Akaike Weights, and null and residual deviances of the two best logistic regression models for recovery feasibility (feasible vs. unknown or infeasible) as identified in completed recovery strategies.

Model	logLik	AICc	ΔAICc	Akaike Weight	N. Deviance	R. Deviance
nIG + RA + CH + SEC	-56.07	124.56	0	0.94	186.33	112.15
nIG + RA + CH	-59.92	130.14	5.58	0.06	186.33	119.85

Variables: number of information gaps identified in the recovery strategy (nIG); Responsible Authority (RA); whether or not critical habitat is identified in the recovery strategy (CH); whether or not potential socioeconomic conflicts are discussed in the recovery strategy (SE).

Table 2.3. Weighted estimated coefficients, 95% confidence intervals, and standard errors, based on multi-model weighing of logistic regression models for recovery feasibility (feasible vs. unknown or infeasible) as identified in completed recovery strategies.

Variable	Value	B (upper, lower 95% CI)	SE
nIG		0.77 (1.13, 0.41)	0.18
RA	DFO	2.05 (3.47, 0.64)	0.72
RA	PCA	3.31 (5.46, 1.17)	1.1
CH	yes	2.07 (3.19, 0.95)	0.57
SEC	yes	2.33 (4.46, 0.19)	1.09

Variables: number of information gaps identified in the recovery strategy (nIG); Responsible Authority (RA); whether or not critical habitat is identified in the recovery strategy (CH); whether or not potential socioeconomic conflicts are discussed in the recovery strategy (SE).

Table 2.4. Log Likelihoods, AICc, Akaike Weights, and Multiple R^2 values of the two best multiple regression models for the number of information gaps identified in completed recovery strategies.

Model	**logLik**	**AICc**	**ΔAICc**	**Akaike Weight**	**Multiple R^2**
FCA + RF + Date	-347.88	706.06	0	0.72	0.265
FCA + RF + MDL	-348.81	707.9	1.84	0.28	0.259

Variables; whether at least some part of the species' Canadian range is found in a formal conservation area (FCA); recovery feasibility (RF); the number of number of months elapsed between the recovery strategy's due date and date of draft submission (MDL); whether the species' recovery strategy was submitted before or after the judgements for the Sage Grouse and Nooksack Dace court proceedings (Date).

Table 2.5. Weighted estimated coefficients, 95% confidence intervals, and standard errors, based on multi-model weighing of the two best multiple regression models for the number of information gaps identified in completed recovery strategies.

Variable	**Value**	**B (upper, lower 95% CI)**	**SE**
FCA		0.54 (0.18, 0.91)	0.19
RF	feasible	1.16 (1.65, 0.68)	0.25
Date	After	-1.13 (-1.49, -0.76)	0.19
MDL		-0.02 (-0.03, -0.01)	<0.01

Variables; whether at least some part of the species' Canadian range is found in a formal conservation area (FCA); recovery feasibility (RF); the number of number of months elapsed between the recovery strategy's due date and date of submission (MDL); whether the species' recovery strategy was submitted before or after the judgements for the Sage Grouse and Nooksack Dace court proceedings (Date).

Figures

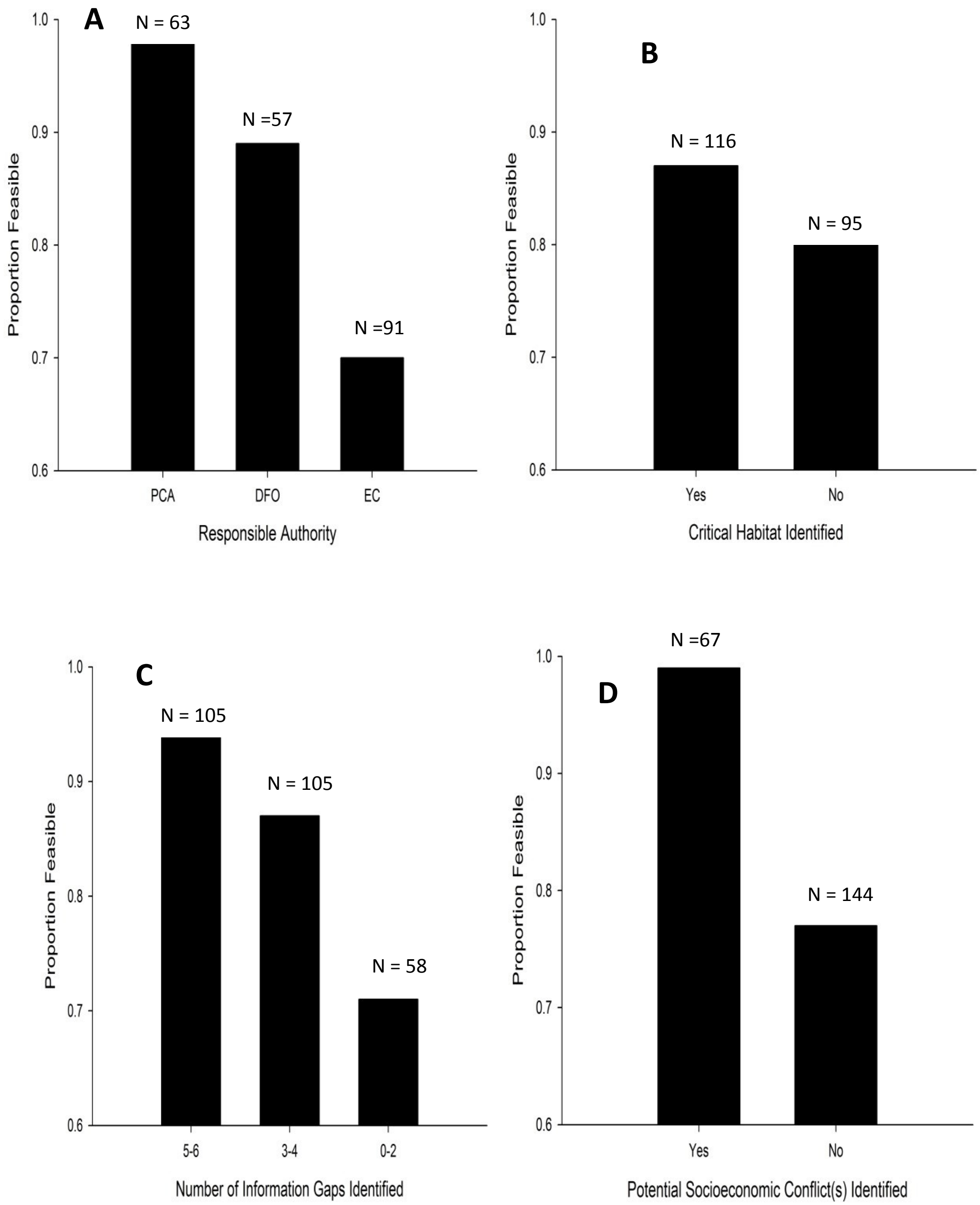

Figure 2.1. Factors associated with recovery feasibility as identified in N = 211 completed recovery strategies, including Responsible Authority (A), critical habitat identification (B), identification of potential socioeconomic conflicts (C) and the number of identified information gaps (D).

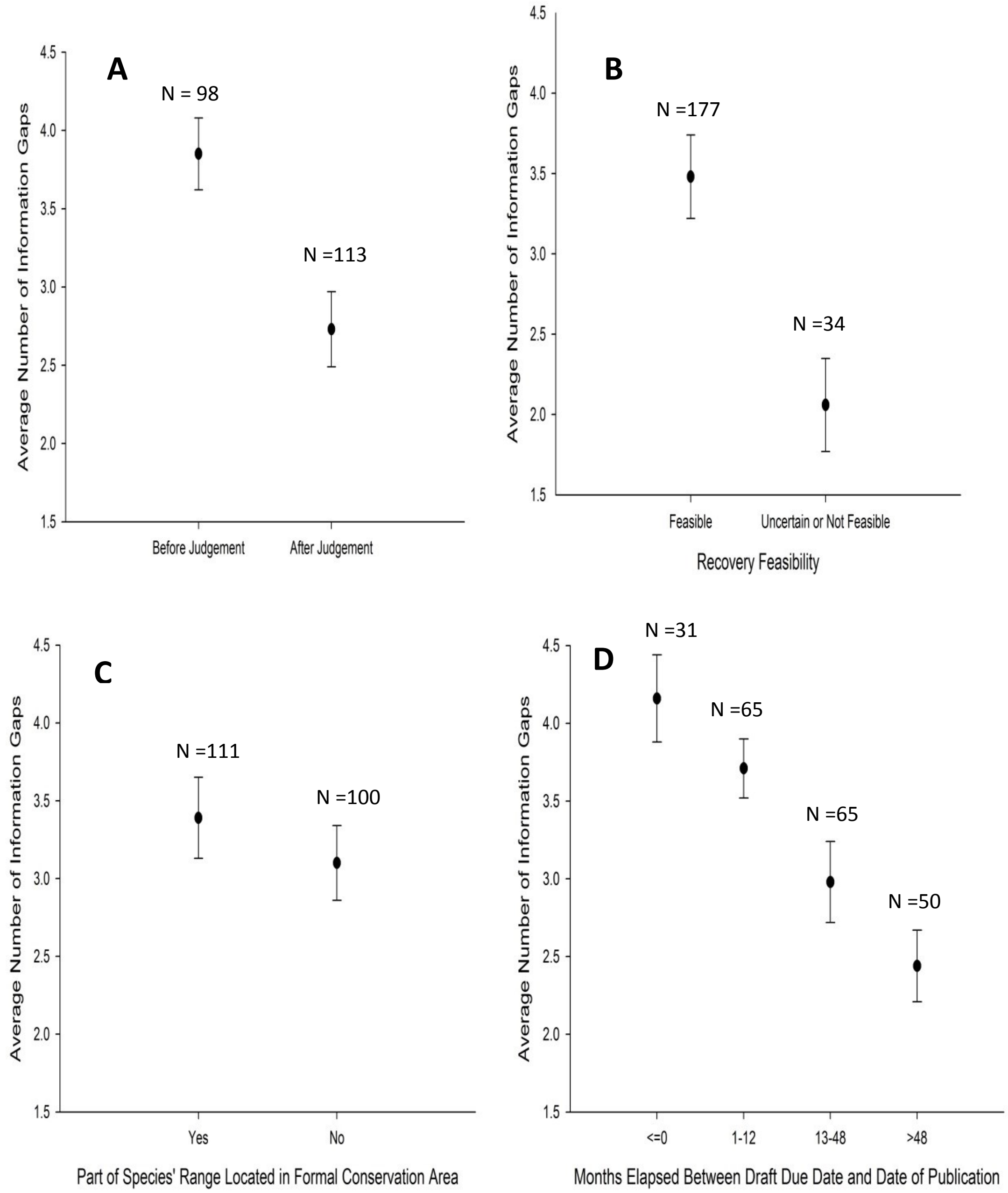

Figure 2.2. Factors associated with the number of information gaps identified in recovery strategies, including whether the recovery strategy for a given species was published before or after the judgements in court cases regarding the Sage-Grouse and Nooksack Dace (A), recovery feasibility (B),whether or not some portion of the species' range is located in a formal conservation area (C) and number of months elapsed between draft due date and date of submission (D). Results based on recovery strategies completed for 211 species. Error bars showing SE.

Appendix II: Candidate Predictor Variables Chapter 2

RF = used in "recovery feasibility" analysis
IG = used in "number of information gaps" analysis

Backlog (RF, IG)
variable type: continuous
The number of species listed without a complete draft strategy at the time a given species is listed, for a given Responsible Authority.

Before/After Sage Grouse and Nooksack Dace court proceedings (RF, IG)
variable type: binary
Whether the final recovery strategy was submitted before or after the conclusion of the Sage Grouse and Nooksack Dace court proceedings.

Final strategy published before/after proceedings
Before
After

Critical Habitat (RF, IG)
variable type: binary
Whether or not critical habitat has been identified at least in part in the Recovery Strategy.

Critical Habitat Identified
No
Yes

Degree of Endemism (RF, IG)
variable type: categorical
The degree to which the species is endemic to Canada.

Degree of endemism
no information
species found only Canada
species found mostly in Canada with edge-of-range populations found elsewhere
species found both in Canada and elsewhere to relatively the same degree
species is at the edge of its range in Canada
species is extirpated in Canada

Formal Conservation Area (RF, IG)
variable type: binary
Whether or not at least some part of the species' range occurs in a provincial or federal protected area.

Formal Conservation Area
Yes
No

Listed Provincially (RF, IG)
variable type: binary
Whether or not the species is listed under at least one provincial/territorial species-at-risk legislation.

Listed Provincially
No
Yes

Listing Status (RF, IG)
The status assigned to the species when it was listed under SARA.
variable type: categorical

Status
endangered
extirpated
threatened

Multiple Competent Ministers (RF, IG)
variable type: binary
Whether or not there are multiple federal agencies responsible for the species' recovery.

Multiple CM
Yes
No

Multi-Species/Ecosystem Strategy (RF, IG)
variable type: binary
Whether the species is included in a dedicated or multi-species/ecosystem recovery strategy.

Species Included in Multi-Species or Ecosystem Recovery Strategy
No
Yes

Number of Information Gaps (RF)
variable type: continuous
The number of information gaps identified in a recovery plan for a given species.

Number of Months Draft Late (RF, IG)
variable type: continuous
The number of months elapsed between the draft due date and draft submission.

Number of Provinces/Territories (RF, IG)
variable type: continuous
The number of provinces/territories in which the species found.

Recovery Feasibility (IG)
variable type: binary
Feasibility of recovery according to the most recent status report.

Recovery Feasibility
Uncertain or Not Feasible
Feasible

Responsible Authority (RF, IG)
variable type: categorical
The federal authority responsible for protection of the species.

Responsible Authority/Authorities
Environment Canada (EC)
Department of Fisheries and Oceans (DFO)
Parks Canada Authority (PCA)

Socioeconomic Conflict (RF, IG)
variable type: binary
The recovery strategy contains a discussion on potential socioeconomic conflicts.

Discussion on socioeconomic conflict
No
Yes

Taxon (RF, IG)
variable type: categorical

Taxon
vascular plants
birds
freshwater fishes
terrestrial mammals
lichens and mosses
herptiles
arthropods
molluscs
marine fishes and mammals

Chapter 3 – Critical Habitat Identification

Introduction

More than 80% of species in Canada with at least a special concern status from COSEWIC are experiencing some form of habitat loss (Venter 2006), while species endangerment in Canada is linked in part to the conversion of land for agricultural purposes (Kerr and Cihlar 2004). This is not unique to Canada. Habitat loss has been cited as the most significant global threat to mammal populations (Schipper et al. 2008) and amphibian populations (Stuart et al. 2004) as well as a significant threat to vertebrate species in China (Yiming & Wilcove 2005) and biodiversity overall in the United States (Czech & Krausman 1997, Flather et al. 1998, Wilcove et al. 1998 etc…) and Australia (Watson et. al 2011, Kingsford et al. 2009).

It is thus not surprising that endangered species legislation has tended to focus at least in part on identification and protection of critical habitat for imperiled species. For example, the United States' Endangered Species Act (ESA) requires that critical habitat be identified at the time of listing (Suckling & Taylor 2006, Hagen & Hodges 2006 etc…), while Australia's Environmental Protection and Biodiversity Conservation Act (EPBCA) requires critical habitat to be identified in recovery strategies (Ortega-Argueta 2011). Despite statutory requirements to identify critical habitat, the rate of identification is typically unsatisfactory. Under the EPBCA only half of published recovery plans contain information on critical habitat, and a recent study found that critical habitat was completely identified in only 15% of recovery plans (Ortega-Argueta 2011). Similar problems have been well documented under the ESA, with a 2002 study (Hoekstra et al.) finding that critical habitat was identified for only ~10% of listed species, though recent work suggests this number has improved to just over 40% (Gibbs and Currie 2012).

The extent to which identification and subsequent protection of critical habitat contribute to successful management and conservation practices is a matter of ongoing debate. Multiple studies have linked critical habitat identification to favourable status trends under the ESA (Suckling and Taylor 2006, Taylor et al. 2005, Rachlinski 1997, Schwartz 2008 etc…) but a subsequent study (Kerkvliet and Langpap 2007) found no effect of critical habitat on status trends once funding is controlled for, and Gibbs and Currie (2012) found no evidence of a relationship between recovery and critical habitat designation. Further questions have surrounded potentially negative effects of critical habitat identification on private landowners (Brook et al. 2003, Mir and Dick 2012, Quigley and Swoboda 2007, Wilcove and Lee 2004, Zabel and Paterson 2006 etc…).

Nonetheless, recovery efforts continue to focus on protection of critical habitat. Under Canada's Species At Risk Act (SARA), critical habitat is defined as "habitat that is necessary for the survival or recovery of a listed wildlife species" (SARA s. 2) and is to be identified in recovery strategies "to the extent possible, based on the best available information" (SARA s. 41 (1)). Yet critical habitat is not identified in recovery strategies for many species, which has led to several court challenges to the government's implementation of SARA (see Campbell 2009, Zinn 2009, Russell 2010). Judgements in favour of the Alberta Wilderness Association in a case against the Minister of Environment regarding critical habitat identification for the Greater Sage-Grouse (Zinn 2009) and in favour of Environmental Defense Canada in a case against the Minister of Fisheries and

Oceans regarding critical habitat identification for the Nooksack Dace (Campbell 2009) in 2009 have profoundly influenced the identification of critical habitat in recovery strategies under SARA. Taylor and Pinkus (2012) identified a 50% increase in critical habitat designation in recovery strategies following these court judgements. Indeed, critical habitat was at least partially identified for only 23 of 98 species included in recovery strategies published before the court judgements (23%), but for 93 of 113 (87%) since, as of September 20th 2013. Taylor and Pinkus also found an effect of lead government agency on critical habitat completion, finding that species under authority of the Department of Fisheries and Oceans (DFO) were much less likely to have critical habitat identified than species under authority of Environment Canada (EC).

In this chapter, I build on the work by Taylor and Pinkus and more thoroughly investigate possible factors associated with critical habitat. Specifically, I answer two questions: What factors were associated with the identification of critical habitat in recovery strategies before the Nooksack Dace and Greater Sage-Grouse court judgments? What factors are associated with the identification of critical habitat in recovery strategies since the Nooksack Dace and Sage-Grouse court judgments? Are these similar to the factors that were associated with CH identification prior to the 2009 court decisions?

Methods

Data Selection and Analysis

As of September 20th, 2013, there were 211 species with final recovery strategies posted to the SARA online registry. Marine species (n = 17) were excluded from the analysis because they could not be tested for association with several of the land tenure variables that I expected might influence critical habitat identification for non-marine species. Extirpated species (n = 10) were excluded from the analysis because they likely face CH-identification issues unlike those faced by species with populations still found in Canada. Of the remaining 184 species, 82 ("pre") and 102 ("post") were published prior to and following the Nooksack Dace/Greater Sage-Grouse decisions, respectively.

Under SARA, critical habitat can be identified either fully or partially. In the following analysis, I treated identification as a binary response variable, with partial and fully identified combined into a single category, and pre- and post-samples being modelled independently. In both analyses I investigated a constrained set of 9 independent variables for model construction (see Appendix 1) which might be expected to be associated with critical habitat identification, or which previous work has identified as factors associated with elements of the recovery planning process, either under SARA or in other jurisdictions (Table 3.1).

I employed an information-theoretic approach to model selection, with both the residual deviance and AIC_c values (AIC corrected for small sample size) used to guide model selection (see Burnham and Anderson 2002, Burnham et al. 2010). Beginning with a null model, terms were added individually and retained if they resulted in a substantial improvement in AICc (i.e., reduced AICc by more than 7). Where there was evidentiary support for multiple models, Akaike weights were calculated for each retained model, variable importance calculated for each variable, and parameter estimates based on multi-model weighting. Separation in the cases of both strategy type and listing status over a relatively small sample necessitated the use of Firth's penalized likelihood approach in estimating model parameters.

Results

Of the 184 species included in the study, critical habitat was fully and partially identified for 41 (22%) and 66 (36%) species respectively. As initially reported by Taylor and Pinkus (2012), rates of critical habitat identification have increased post-Nooksack Dace and Sage-Grouse court judgements, a trend that has continued through 2013 (Figure 3.1). For species included in recovery strategies finalized before the Sage-Grouse and Nooksack Dace court proceedings (September 2009), three candidate predictors were included in two retained models (Tables 3.2, 3.3). Species included in multi-species or ecosystem strategies were less likely to have critical habitat identified than species with dedicated strategies ($\beta = -4.0 \pm 1.47$)(see also Figure 3.2), with none of the 36 species included in multi-species or ecosystem strategies having critical habitat identified. Threatened species were less likely than endangered species to have critical habitat identified ($\beta = -3.26 \pm 1.56$), with none of the 16 species with a 'threatened' listing status having critical habitat identified. Species whose range is located in a federal or provincial protected area were more likely to have critical habitat identified ($\beta = 1.29 \pm 0.67$), thought the effect was comparatively weak.

For species included in recovery strategies published after September of 2009, only recovery feasibility was associated with critical habitat identification ($\beta = 1.95 \pm 0.61$) with critical habitat more likely to be identified for species for which recovery was considered feasible than for which recovery was considered infeasible or of uncertain feasibility (Table 3.4, Figure 3.3). There was no detectable effect of taxon, socioeconomic conflict, responsible authority, land ownership as an information gap, or time elapsed between strategy due date and date of submission for either the pre- or post-judgement samples.

Discussion

Not surprisingly, biases associated with critical habitat identification in recovery strategies before the Nooksack Dace and Sage-Grouse court judgements seem to have been largely eliminated. The strongest effect pre-judgement was a decreased probability of critical habitat identification for species included in multi-species or ecosystem recovery strategies. This variable was correlated with Responsible Authority, as only two species under authority of Environment Canada were included in multi-species/ecosystem reports, while the Department of Fisheries and Oceans (DFO) had 15 and Parks Canada Agency (PCA) 19. There was thus some evidence for a Responsible Authority effect, with Environment Canada species much more likely than those under authority of the DFO or PCA to have critical habitat identified, but this term was not retained in any models that also included plan type (i.e., dedicated or multi-species/ecosystem). It is possible that the Responsible Authority effect on critical habitat identification reported by Taylor and Pinkus (2012) is in fact not an institutional bias, but rather a consequence of critical habitat rarely being identified in multi-species/ecosystem recovery strategies.

Potential problems with multi-species plans have been identified in other jurisdictions. Under the ESA, multi-species plans are less likely than species-specific plans to include adaptive management provisions, are revised less frequently, reflect an inferior understanding of species-specific biology (Clark and Harvey 2002) and are less effective than dedicated plans at improving status trends (Boersma et al. 2001, Taylor et al. 2005). Given what we know about the struggles with implementation of multi-species plans under the ESA, it is important that we monitor their use under SARA to ensure that we do not make similar mistakes. That multi-species plans were associated with lower rates of critical habitat identification pre-judgement is of some concern, but there seems to be no issue with post-judgement plans (though the sample of species included in multi-species/ecosystem plans did drop from 36 to 18 post-judgment, critical habitat was identified for 16 of these species). As Chapter 2 points out, plan type is not associated with either recovery feasibility or the number of identified information gaps under SARA, so at least with respect to these three elements of recovery strategy content, it does not appear that current multi-species plans are inferior to species-specific plans under SARA. I caution, however that this conclusion is based only on a partial group of important recovery strategy elements: insofar as recovery strategies inform action plans under SARA, there are other, equally important recovery strategy elements (e.g. threat characterization (McCune et al. 2013)) that may differ systematically between multi-species or ecosystem strategies and single-species strategies going forward, as they do under the ESA (Clark and Harvey 2002, Boersma et al. 2001, Taylor et al. 2005 etc…).

As with plan-type, listing status was associated with CH identification pre-judgement but not post-, with endangered species more likely to have critical habitat identified than threatened species. Though SARA does permit implicit prioritization of species with a higher threat status by allotting more time for recovery strategy completion for threatened and extirpated species (s. 42), there is no allowance for prioritizing species for critical habitat identification. Similarly, species whose range occurs in federal or provincial protected areas were more likely to have critical habitat identified pre-judgement, but not post. It is easy to see how issues typically associated with the CH identification process (e.g., relating to CH identification on private land – see Brook et al. 2003, Mir and Dick 2012 etc…) would be alleviated if CH falls on land already protected, making the CH identification process easier, but such issues should not prevent or delay identification. It is encouraging that there was no evidence for either threat status or land ownership biases post-judgement.

The lone factor associated with critical habitat identification post-judgement is recovery feasibility, with species for which recovery was considered infeasible or of unknown feasibility less likely to have critical habitat identified. I should note that recovery was considered feasible for 80 of 102 species post-judgement and 79 of 83 species pre-judgment, resulting in no power to detect a pre-judgment effect. As I discuss only briefly in Chapter 2, it is possible that, in addition to recovery feasibility impacting critical habitat identification, critical habitat identification impacts determination of recovery feasibility. Are species for which recovery is feasible more likely to have critical habitat identified because recovery is feasible, or are species for which critical habitat has been identified more likely to have recovery considered feasible because critical habitat identification has improved their chances at recovery? SARA dictates that critical habitat is to be identified regardless of the determination of feasibility (s. 41), and so – in principle – recovery feasibility and CH identification should be (causally) independent. As discussed in Ch 2, more than 80% of species with at least a special concern status from COSEWIC are, apparently suffering from habitat loss (Venter et al. 2006), and so identification of critical habitat would, for many species, pave the way to Action Plans that directly address the threats to critical habitat. If in fact species with feasible recovery are being prioritized for critical habitat identification, this prioritization is occurring contrary to the guidelines imposed by SARA.

Overall, my analysis of critical habitat identification is encouraging. Early systematic bias against species with a lower threat status and species included in multi-species or ecosystem reports seems to have been eliminated following the Nooksack Dace and Sage-Grouse decisions. The issues currently facing critical habitat identification in Canada thus seem rather unlike those facing CH designation under the ESA, where rates of identification are much lower (Hoekstra et al. 2002, Gibbs and Currie 2012) and critical habitat designation is often considered "not prudent" or "not determinable" (see ESA s. 4(a)(3)(b), Hoekstra et al. 2002, Hagen and Hodges 2006). If CH identification continues at its current rate, there is little to be concerned about as far as biases in identification are concerned.

However, one outstanding question surrounds the quality and quantity of information on which CH identification is based. Pre-judgement, many of the cases in which CH was not identified (Campbell 2009, Zinn 2009, Russell 2010) were justified on the basis that current information was insufficient for identification, not unlike what has been the case under the ESA (Hoekstra et al. 2002, Hagen and Hodges 2006 etc…). The significant increase in CH identification rates thus may not be because, post-decision, better quality/quantity information is being collected and used, but rather that, consistent with the decisions themselves , the threshold of information required to identify critical habitat has been lowered, consistent with the precautionary approach explicitly articulated in SARA s. (38). This gives rise to the implications for species recovery of CH identification which is based on quality/quantity of information previously considered inadequate to support identification.

References

Brook, A., M. Zint, & R. De Young. 2003. Landowners' response to an Endangered Species Act listing and implications for encouraging conservation. Conservation Biology 17 (6): 1638 - 1649.

Burnham, K. P. & D. A. Anderson. 2002. Model selection and multimodel inference. 2nd edition. Springer-Verlag, New York.

Burnham, K.P., D.R. Anderson & K.P. Huyvaert. 2010. AIC model selection and multimodel inference in behavioral ecology: some background, observations, and comparisons. Behavioral Ecology and Sociobiology 65: 23 - 35.

Campbell, J. 2009. Environmental Defence Fund et al. vs. the Minister of Fisheries and Oceans. Docket T-1529-07, 2009 FC 878. Available from http://reports.fja.gc.ca/eng/2009/2009fc878.html (Accessed April 2014).

Clark, J.A. & E. Harvey. 2002. Assessing multi-species recovery plans under the Endangered Species Act. Ecological Applications 12 (3): 655 - 662.

Czech, B. & P.R. Krausman. 1997. Distribution and causation of species endangerment in the United States. Science 277 (5329): 1116 - 1117.

EPBCA (Environmental Protection and Biodiversity Conservation Act). 1999. Available from http://www.comlaw.gov.au/Details/C2013C00301 accessed April 2014).

ESA (Endangered Species Act). 1973. Available from http://www.fws.gov/endangered/esa-library/pdf/ESAall.pdf (accessed April 2014).

Flather, C.H., M.S. Knowles & I.A. Kendall. 1998. Threatened and endangered species geography: characteristics of hot spots in the conterminous United States. BioScience 48 (5): 365 - 376.

Gibbs, K.E. & D.J. Currie. 2012. Protecting endangered species: do the main legislative tools work? PLoS ONE 7(5): e35730. doi:10.1371/journal.pone.0035730.

Hagen, A.N. & K.E. Hodges. 2006. Resolving critical habitat designation failures: reconciling law, policy, and biology. Conservation Biology 20 (2): 399 - 407.

Hoekstra, J.M., W.F. Fagan & J.E. Bradley. 2002. A critical role for critical habitat in the recovery planning process? Not yet. Ecological Applications 12 (3): 701 - 707.

Kerkvliet, J. & C. Langpap. 2007. Learning from endangered and threatened species recovery programs: A case study using U.S. Endangered Species Act recovery scores. Ecological Economics 63 (2-3): 499 - 510.

Kerr, J.T. & J. Cihlar. 2004. Patterns and causes of species endangerment in Canada. Ecological Applications 14 (3): 743 - 753.

Kingsford, R.T., J.E.M. Watson, C.J. Lundquist, O. Venter, L. Hughes, E.L. Johnson, J. Atherton, M. Gawel, D.A. Keith, B.G. Mackey, C. Morley, H.P. Possingham, B. Raynor, H.F. Recher & K.A. Wilson. 2009. Major conservation policy issues for biodiversity in Oceania. Conservation Biology 23 (4): 834 - 840.

McCune, J.L., W.L. Harrower, S. Avery-Gomm, J.M. Brogan, A.M. Csergo, L.N.K. Davidson, A. Garani, L.R. Halpin, L.P.J. Lipsen, C. Lee, J.C. Nelson, L.R. Prugh, C.M. Stinson, C.K. Whitney & J. Whitton. 2013. Threats to Canadian species at risk: an analysis of finalized recovery strategies. Biological Conservation 166: 254 - 265.

Mir, D.F. & K. Dick. 2012. Conservation Approaches to protecting critical habitats and species on private property. Natural Areas Journal 32 (2): 190 - 198.

Ortega-Argueta, A. 2008. Evaluating recovery planning for threatened species in Australia. PhD Thesis, School of Integrative Systems, The University of Queensland, Australia. http://espace.library.uq.edu.au/view/UQ:178617

Ortega-Argueta, A, G. Baxter & M. Hockings. 2011. Compliance of Australian threatened species recovery plans with legislative requirements. Journal of Environmental Management 92 (2011) 2054 - 2060.

Quigley, J.M. & A.M. Swoboda. 2007. The urban impacts of the Endangered Species Act: a general equilibrium analysis. Journal of Urban Economics 61 (2): 299 - 318.

Rachlinski, J. J., 1997. Noah by the numbers: an empirical evaluation of the Endangered Species Act. Cornell Law Review. 82: 356 - 389.

Russell, J. 2010. David Suzuki Foundation et al. vs. the Minister of Fisheries and Oceans and Environment Canada. Docket T-541-09, 2010 FC 1233. Available from http://reports.fja.gc.ca/eng/2012/2010fc1233.html (Accessed April 2014)

SARA (Species at Risk Act). 2002. Available from http://laws-lois.justice.gc.ca/PDF/S-15.3.pdf (accessed April 2014).

Schipper, J., et al. 2008. The status of the world's land and marine mammals: diversity, threat and knowledge. Science 332**:** 225 - 230.

Schwartz, M.W. 2008. The Performance of the Endangered Species Act. Annual Review of Ecology, Evolution, and Systematics 39: 279 – 299.

Stuart, S. N., J.S. Chanson, N.A. Cox, B.E. Young, A.S.A. Rodrigues, D.L. Fischman & R.W. Waller. 2004. Status and trends of amphibian declines and extinctions worldwide. Science 306: 1783 - 1786.

Suckling, K. F., and M. Taylor. 2006. Critical habitat and recovery. Pages 75-89 in D. Goble, M. J. Scott, and F. W. Davis, editors. The Endangered Species Act at thirty: renewing the conservation commitment. Island Press, Washington DC.

Taylor, E.B. and S. Pinkus. 2013. The effects of lead agency, non-governmental organizations, and recovery team membership on the identification of critical habitat for species at risk: insights from the Canadian experience. Environmental Reviews 21 (3): 93 - 102.

Taylor, M.F.J., K.F. Suckling & J.J. Rachlinski. 2005. The effectiveness of the Endangered Species Act: a quantitative analysis. BioScience 55 (4): 360 - 367.

Venter, O., N.N. Brodeur, L. Nemiroff, B. Belland, I.J. Dolinsek & J.W.A. Grant. 2006. Threats to Endangered Species in Canada. BioScience 56 (11): 903 - 910.

Watson, J.E.M., Bottrill, M.C., Walsh, J.C, Joseph, L.N. and H.P. Possingham. 2011. Evaluating threatened species recovery planning in Australia. Prepared on behalf of the Department of the Environment, Water, Heritage and the Arts by the Spatial Ecology Laboratory, University of Queensland, Brisbane.

Wilcove, D.S. & J. Lee. 2004. Using economic and regulatory incentives to restore endangered species: lessons learned from three new programs. Conservation Biology 18 639 - 645.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips & E. Losos. 1998. Quantifying threats to imperiled species in the United States: assessing the relative importance of habitat destruction, alien species, pollution, overexploitation, and disease. BioScience 48 (8): 607 - 615.

Yiming, L. & D.S. Wilcove. 2005. Threats to vertebrate species in China and the United States. BioScience 55 (2): 147 - 153.
Zabel, J.E. & R.W. Paterson. 2006. The effects of critical habitat designation on housing supply: an analysis of California housing construction activity. Journal of Regional Science 46 (1): 67 - 95.

Zinn, J. 2009. Alberta Wilderness Association et al. vs. Minister of Environment. Docket T-241-08 2009 FC 710. Available from http://reports.fja.gc.ca/eng/2009/2009fc710.html (Accessed April 2014)

Tables

Table 3.1. Candidate predictor variables included in analysis of critical habitat identification in recovery strategies.

Variable	Rationale	Reference(s)
Formal Conservation Area	Socioeconomic consequences of protection of CH on lands already in protected areas may be substantially lower than other lands, thereby increasing the likelihood of identification.	
Information Gap – Land Ownership	Species whose range falls on land for which ownership is unknown might be less likely to have CH identified.	
Listing status	A higher listing status might be associated with increased likelihood of CH identification given that, in principle, it would signify higher extinction risk, though no link found between status and CH identification under ESA.	Possingham et al. 2002, Redding & Mooers 2006, Brehm et al. 2010, Taylor et al. 2005 etc…
Months elapsed between RS due date and date of draft submission	Strategies that took longer to prepare might have better information and do a better job of addressing issues preventing CH identification.	
Multi-Species/Ecosystem Strategy	Under ESA and EBPCA there have been documented differences in plan quality/content depending on plan type.	Clark and Harvey (2002), Ortega-Argueta (2008)
Recovery Feasibility	Lower prioritization of species with infeasible recovery might result in lower rates of CH identification, while CH identification might also influence determination of RF	SARA s. 41

Responsible Authority	Associations with RA reported for species listing and critical habitat identification under SARA.	Findlay et al. (2009); Taylor and Pinkus (2013)
Socioeconomic conflict discussed	Species for which potential socioeconomic conflicts have been identified (especially with respect to land use and/or natural resource extraction) might be less likely to have CH identified.	
Taxon	Taxonomic bias reported for listing under SARA and in recovery planning under the ESA	Mooers (2008); Campbell et al. (2002); Hoekstra et al. (2002b); and Gerber & Schultz (2001) etc…

Table 3.2. Log Likelihoods, AICc, Akaike Weights, and Null and Residual Deviances of the two best logistic regression models for critical habitat identification in recovery strategies completed before results of court proceedings regarding critical habitat identification for the Greater Sage-Grouse and Nooksack Dace.

Model	**logLik**	**AICc**	**ΔAICc**	**Akaike Weight**	**N. Deviance**	**R. Deviance**
Multi + Status + FCA	-23.2	54.92	0	0.77	88.78	45.78
Multi + Status	-25.54	57.38	2.46	0.23	88.78	49.8

Variables: whether the species was included in an ecosystem or multi-species report (multi); whether at least some part of the species' Canadian range is found in a formal conservation area (FCA); the species' COSEWIC threat status.

Table 3.3. Weighted estimated coefficients, 95% confidence intervals, and standard errors based on multi-model weighing of logistic regression models for critical habitat identification in recovery strategies completed before results of court proceedings regarding critical habitat identification for the Greater Sage-Grouse and Nooksack Dace.

Variable	**Value**	**B (upper, lower 95% CI)**	**SE**
Multi	yes	-4.07 (-6.95, -1.19)	1.47
Status	threatened	-3.26 (-6.32, -0.20)	1.56
FCA	yes	1.29 (-0.03, 2.60)	0.67

Variables: whether the species was included in an ecosystem or multi-species report (multi); whether at least some part of the species' Canadian range is found in a formal conservation area (FCA); the species' COSEWIC threat status

Table 3.4. Weighted estimated coefficients, 95% confidence intervals, and standard errors, based on multi-model weighing of logistic regression models for critical habitat identification in recovery strategies completed after results of court proceedings regarding critical habitat identification for the Greater Sage-Grouse and Nooksack Dace.

Variable	**Value**	**B (upper, lower 95% CI)**	**SE**
RF	feasible	1.95 (0.76, 3.2)	0.61

Variable: recovery feasibility (RF).

Figures

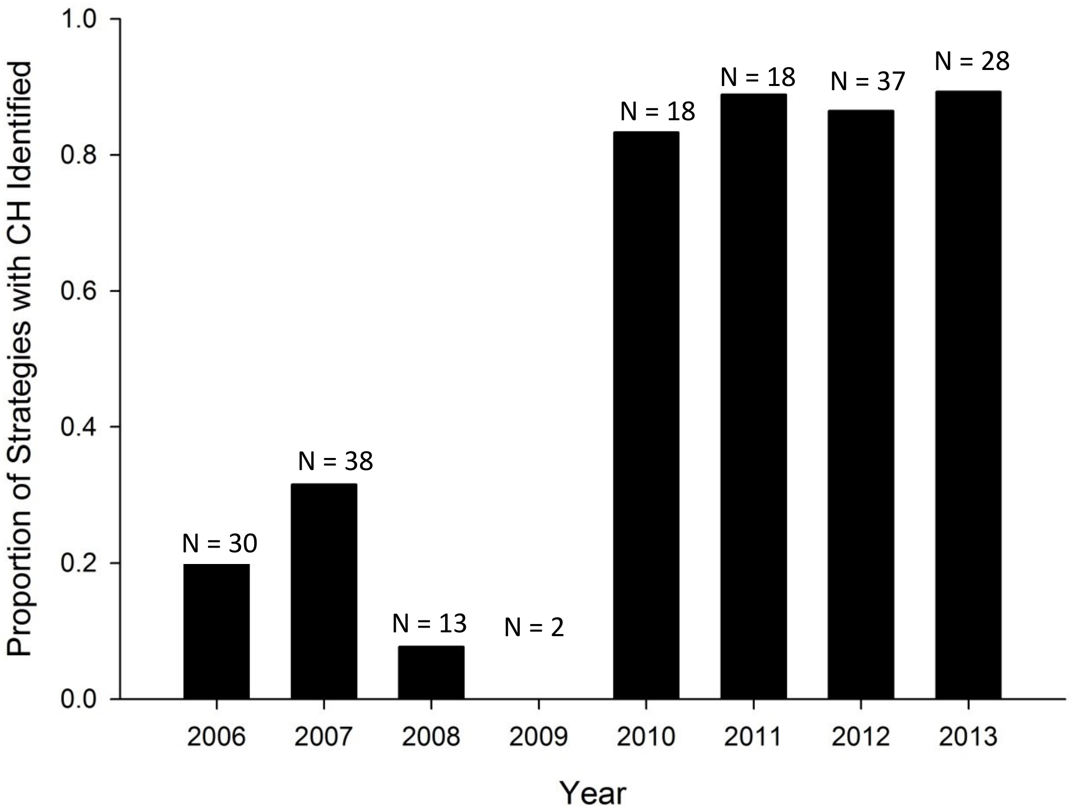

Figure 3.1. Yearly proportion of recovery strategies with critical habitat at least partially identified. 2013 group included only strategies published before September 20th. Note that results of court proceedings regarding critical habitat identification for the Greater Sage-Grouse and Nooksack Dace were released mid-2009.

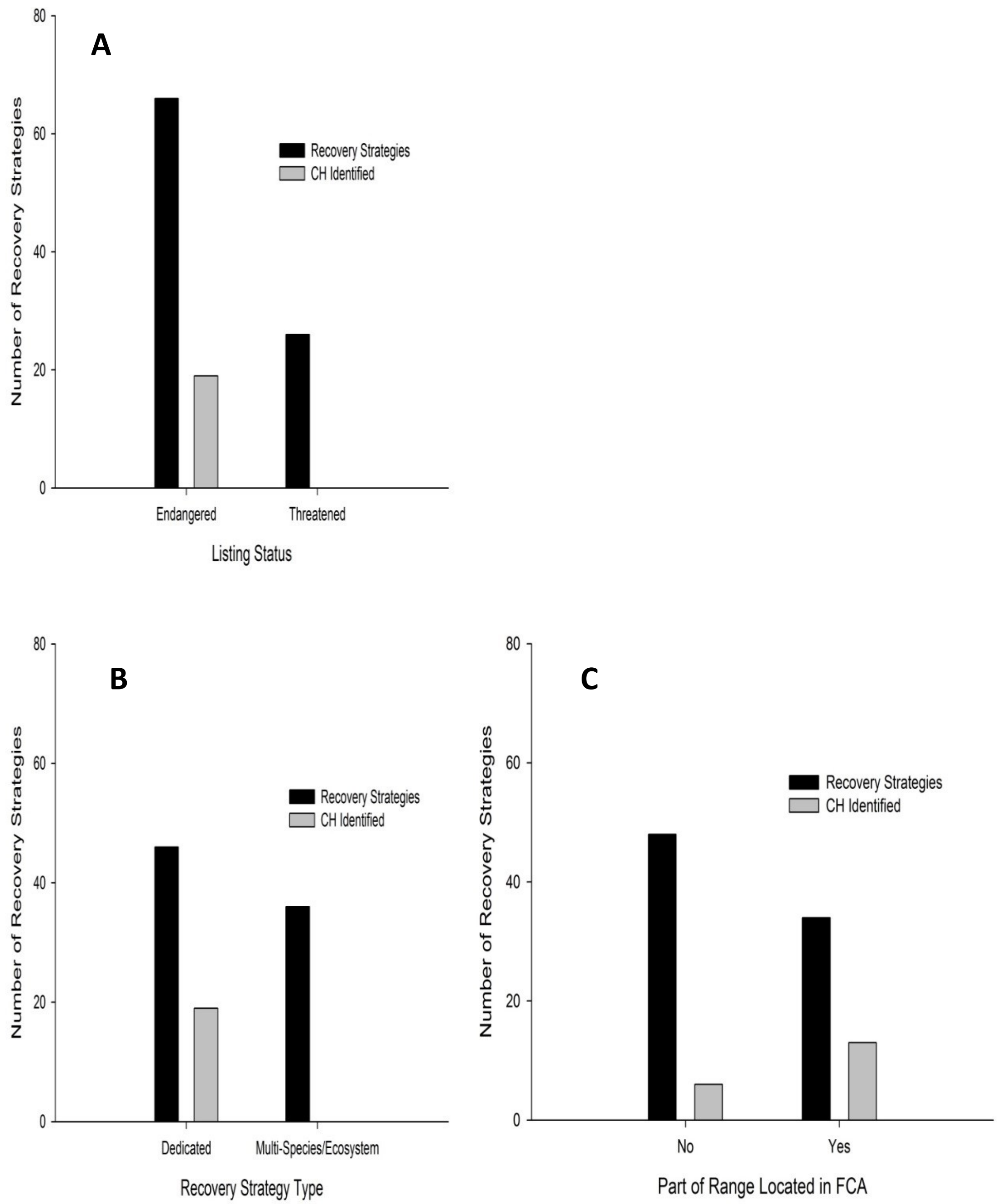

Figure 3.2. Factors associated with critical habitat identification in recovery strategies completed before results of court proceedings regarding critical habitat identification for the Greater Sage-Grouse and Nooksack Dace. Factors include threat status (A), strategy type (B), and whether or not at least some portion of a species' range is located in a formal conservation area (C). Results based on N = 82 completed recovery strategies.

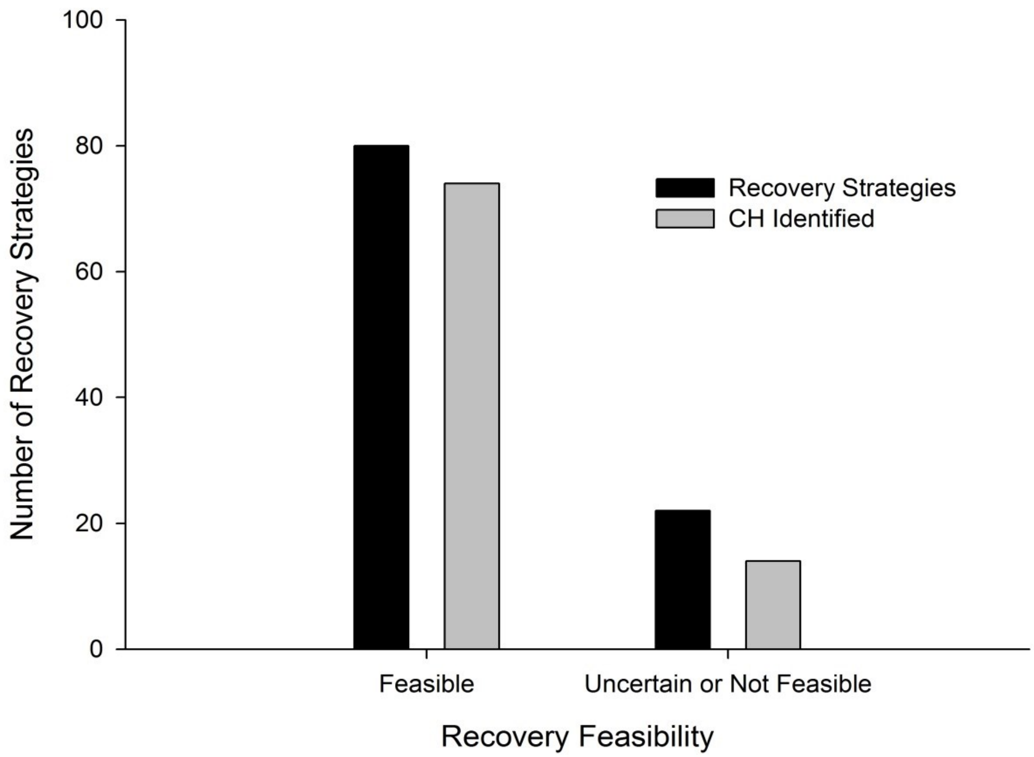

Figure 3.3. Critical habitat identification in recovery strategies completed after results of court proceedings regarding critical habitat identification for the Greater Sage-Grouse and Nooksack Dace, broken down by recovery feasibility as identified in the recovery strategy. Results based on N = 102 completed recovery strategies.

Appendix III: Candidate Predictor Variables Chapter 3

Formal Conservation Area
variable type: binary
Whether or not at least some part of the species' range occurs in a formal conservation area.

Formal Conservation Area
Yes
No

Information Gap – Land Ownership
variable type: binary
Landownership is identified as an information gap in the recovery strategy.

Land ownership is information gap
No
Yes

Listing Status (before, after)
The status assigned to the species when it was listed under SARA.
variable type: binary

Status
Endangered
Threatened

Multi-Species/Ecosystem Strategy
variable type: binary
Whether the species is included in a dedicated or multi-species/ecosystem recovery strategy.

Species Included in Multi-Species or Ecosystem Recovery Strategy
No
Yes

Number of Months Draft Late
variable type: continuous
The number of months elapsed between the draft due date and draft submission.

Recovery Feasibility
variable type: binary
Feasibility of recovery as identified in the recovery strategy.

Recovery Feasibility
Feasible
Uncertain or Not Feasible

Responsible Authority
variable type: categorical
The federal authority responsible for protection of the species.

Responsible Authority/Authorities
Environment Canada
Department of Fisheries and Oceans
Parks Canada Agency

Socioeconomic Conflict
variable type: binary
The recovery strategy contains a discussion on potential socioeconomic conflicts.

Discussion on Socioeconomic Conflict
No
Yes

Taxon
variable type: categorical

Taxon
Vascular Plants
Birds
Freshwater Fishes
Terrestrial Mammals
Lichens and Mosses
Herptiles
Arthropods
Molluscs