Anuran Habitat Associations and Minimums: Identification, Application, and Implications

by

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This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Statement of Contribution

Dorian Pomezanski was the sole author for Chapters 1, 2, and 7, which were written under the supervision of Dr. Stephen Murphy and were not written for publication.

This thesis consists in part of four manuscrips written for publication. Chapter 3 was previously published on August 6, 2021. Dorian Pomezanski was the primary and sole author of this publication and designed, conducted, and authored the research contained therein.

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Chapters 5 and 6 were written by Dorian Pomezanski under the supervision of Dr. Stephen Murphy, who provided intellectual input on manuscript drafts.

As lead author of these four chapters, I was responsible for contributing to conceptualizing study design, carrying out data analysis, and drafting and submitting manuscripts. My co-authors and main advisor provided guidance during each step of the research and provided feedback on draft manuscripts.

Abstract

Anurans (frogs and toads) are model species for habitat conservation in disturbed areas due to their reliance on a range of land covers and sensitivity to fragmentation. As a group of species that are reliant on a landscape permeability to access different habitat throughout the year, their presence across the landscape can provide valuable information about minimum habitat amounts and distributions necessary to maintain habitat connectivity for a range of species. In Ontario, historical landscape disturbance and the availability of a long-term anuran monitoring database provides a study area suitable for exploring critical landscape characteristics and thresholds related to anuran species presence. Like many jurisdictions in North America, natural heritage planning in Ontario has adopted minimum habitat disturbance and buffer recommendations but low anuran occupancy in disturbed areas suggests they are insufficient to ensure long-term species presence. Requirements related to habitat connectivity in particular lack detail regarding the amount, type, placement, and permeability of land covers across the landscape. To address these fundamental gaps, this thesis identified ecological thresholds amongst several habitat connectivity and landscape composition metrics designed to model anuran habitat usage in Southern Ontario. It also discusses the land use implications of implementing biologically informed and ecologically meaningful minimum habitat protections for maintaining anuran habitat connectivity.

Data for anuran occupancy was derived from acoustic survey data in the Birds Canada amphibian monitoring database. Due to regular species turnover and challenges with acoustic detection, the number of monitoring years required to account for all species present in a breeding wetland is uncertain. Using a sample of 66 wetlands in Southern Ontario with at least eight years of acoustic monitoring data and four identified anuran species, I constructed species accumulation curves and determined that a minimum of three years of standardized acoustic monitoring data area is required to capture a complete picture of anuran species composition. With this result, 290 wetlands across Southern Ontario with anuran acoustic data of six commonly occurring species were determined to be suitable for further analysis.

In addition to several commonly used landscape composition metrics used in amphibian habitat modelling (e.g., proportion of forest/wetland, urban, and vegetated land cover), several other metrics related specifically to anuran habitat connectivity were designed and compared to

anuran presence. Using Generalized Additive Models (GAMs), each metrics' explanatory strength of anuran species presence was compared. I detail the construction and performance of one particular metric that explicitly models the isolated impact of vehicle impact on road crossing survival; accounting for the exponential reductions in crossing survival with increasing traffic intensity in a way that is not captured by least cost, cost distance, or circuit theory modelling approaches. This metric was compared against an unaltered cost distance tool, with three maximum movement distances and three minimum survival cut-offs of 50%, 25%, and 5%. The top-performing road crossing survival metrics explained up to 22% deviance, performed best for the spring peeper and gray treefrog, and performed similarly to the top-performing unaltered resistance models. A model that accurately captures the dynamics of road mortality for amphibians and which can be applied to other taxa is important for effective conservation and land use planning.

I follow this with an expanded detailing of the construction of additional habitat connectivity metrics modelling juvenile anuran dispersal and overwintering habitat connectivity, exploring all possible combinations of explanatory metrics to identify additive habitat influences. These metrics were designed to address gaps in connectivity modelling methods which have not accounted for anuran movement behaviours. The juvenile dispersal metric divides the landscape around a source wetland into discrete wedges to simulate the auto-correlated and laterally restricted movement behaviours exhibited by juvenile dispersing anurans and outputs a measure of connectivity that reflects the proportion of directions that have reachable breeding habitat. The overwintering connectivity metric took a more traditional approach, using typical resistance modelling to output a metric quantifying the accessibility of overwintering forest habitat surrounding a breeding wetland. Both metrics used anuran occupancy as a response variable. The explanatory strength of landscape composition and habitat connectivity metric varied substantially between the six individual species, indicating notable differences in life history processes, landscape interactions, and species monitoring. Landscape composition metrics consistently explained the highest amount of variance in single-variable models regardless of species, explaining as much as 37% of deviance in anuran species occurrence using proportion of forest and wetland cover within 3000m. Habitat connectivity metrics related to road crossing survival, juvenile dispersal, and overwintering habitat performed best for the spring peeper and gray treefrog, explaining as much as 26% of variance in occupancy for spring peepers using the

overwintering habitat connectivity metric. Various areas for improvement and discussions of the implications of these results are included. The performance of landscape composition and connectivity metrics at different maximum movement distances varied, indicating species-specific differences in the effects of habitat composition, distribution, and permeability across difference spatial scales. In multi-variable GAMs, the top performing models were again for the spring peeper and gray treefrog, with up to 48% of variance in gray treefrog occupancy explained. Habitat connectivity metrics were often included in the top-performing models, suggesting that they contribute additional finer-detail significant explanatory strength to anuran population distributions and with further refinement can be valuable tools for landscape planning.

Critical thresholds in landscape composition and habitat connectivity were identified across all six species and spatial scales using a segmented regression approach. Significant thresholds were most commonly identified in the landscape composition metrics and strongest with the natural cover composition. For the spring peeper and gray treefrog which had the strongest threshold-type relationships, thresholds at ~40-60% natural cover, ~5-35% of forest and wetland cover, and ~12-55% of urban cover were identified, varying depending on radial distance. Visual breakpoint estimation differed from statistical breakpoint estimation occasionally, emphasizing the importance of critical interpretations of statistical results. Threshold presence was also moderately consistent with non-linear relationships identified in the GAMs, suggesting that species-landscape relationships require critical examination when determining biological recommendations. The identification of thresholds amongst the various habitat and connectivity metrics refines our understanding of minimum biological requirements for anurans and provides additional evidence for science-based conservation efforts.

In the concluding of this thesis, I discuss the financial efficiencies related to infrastructure, health, and planning, as well as societal improvements to quality of life for implementing biologically informed minimum habitat protections for anurans and other species reliant on landscape permeability. Identifying and planning around existing wildlife movement corridors and broader habitat thresholds associated with landscape composition and permeability can encourage planning bodies to produce a denser, more efficient, and more equitable landscape for both humans and the wildlife populations living alongside them.

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1.0 General Introduction

Loss and degradation of habitat has led to widespread reductions in anuran population presence. This loss is particularly acute in developed urban areas and in areas experiencing increased urbanization (Urban & Roehm, 2018; Luedtke et al., 2023). Preserving the diversity and integrity of human-altered habitats requires effective land management that understands and implements biologically relevant habitat protections. As important indicators of habitat quality and health, anurans play an essential role in broader ecosystem integrity (Hopkins, 2007; Price et al., 2007; Dixon et al., 2011; Saber et al., 2017). The core problem is that because anurans have a complex life cycle, they have been disadvantaged by policies that focus solely on the protection of core wetland features instead of the wider range of habitat features that are needed to fulfil their life cycle needs (Bauer et al., 2010; Sawatzky et al., 2019; Simpson et al., 2021). Although all anuran species require aquatic habitat for breeding and early development, most also require terrestrial habitat like forest and meadow for overwintering and foraging (Barrett et al., 2016; Collins and Fahrig, 2017; Sauer et al., 2022; Simpson et al., 2021). A traversable landscape that allows these small terrestrial organisms to move between critical aquatic and terrestrial habitats is essential for long-term population persistence.

In the fragmented landscapes of North America, landscapes often cannot be traversed. They are blocked to movements of many species, especially ones like amphibians that must move between two very different kinds of habitats that will be relatively far apart. The term ‘permeability’ is used in the literature to describe this phenomenon in which movement across a landscape is compromised by expanding urban infrastructure, road networks, and human-altered land covers, introducing challenges for anuran movement between critical habitats (Cartwright et al., 2021; Jones et al., 2024). This form of landscape disturbance is usually followed by reductions in anuan species occupancy over time driven partly by reduced accessibility to habitat patches, population isolation, and direct mortality pressures (Laufer and Gobel, 2017; Arntzen et al., 2017; Wright et al., 2020). Some anuran species are more likely to experience local extirpation than others given the differences between individual species movement behaviours (Arntzen et al., 2017; Wiewel et al., 2023). Nevertheless, given the causal link between reductions in landscape permeability and anuran species persistence, anuran occupancy data (i.e. presence absence) can be used to determine whether surrounding landscapes are functionally connected between necessary habitat patches and calibrate/validate models that predict movement permeability throughout the landscape (see as examples Berlow et al., 2013; Hamer et al., 2021; Vimercati et al., 2024).

Landscape connectivity modelling approaches are often used to quantify connectivity, to identify movement corridors, and toguide conservation efforts (Zeller et al., 2012; Spear et al., 2015; Unnithan-Kumar et al., 2022)). These connectivity modelling approaches generally use resistance-based theories which assume that certain land covers are more conducive to movement than others and that individuals actively select the least "resistive" land covers to move through as they encounter them (Zeller et al., 2012; Dixon et al., 2019). Anurans, particularly newly transformed juveniles often travel across land covers considered highly resistant, and exhibit auto-correlated and directional movement (i.e. they are more likely to move in the same direction as the one they came from) (Dray et al., 2010; Joly 2019; Unnithan-Kumar et al., 2022), therefore movement corridors identified by resistance modelling approaches may not be biologically meaningful in complex human-altered landscapes. Connectivity modelling must move beyond traditional modelling approaches and incorporate specific anuran movement behaviours by designing and testing connectivity metrics that reflect the movement of individuals with little to no understanding of long-range land cover, varying movement ranges, limited precautionary responses to hazards such as road traffic and hostile land covers, multiple life stages of varying movement behaviours, and proven preference for avoiding movement during energy-depleting weather conditions.

The question of how much connectivity is required to facilitate anuran movement between critical habitats also remains unanswered. While some limits of habitat area or distance have been presented for forest cover (Homan et al, 2004; Hermann et al., 2005) and urban land cover (Eigenbrod et al., 2009; Guderyahn et al., 2016) with regards to anuran wetland occupancy, they provide little information about the spatial arrangement or interacting effects of these features. It is also important to identify whether critical breakpoints in anuran responses are present and where these ecological thresholds occur (Ficetola and Denoel, 2009). To protect anuran populations for the long-term, more information is needed on the types and configurations of habitat protections required to maintain habitat connectivity. Knowledge of these habitat characteristics and the ecological thresholds they exhibit will assist policymakers and land planners in implementing long-term management plans for anuran persistence and broader livable communities.

The aim of this thesis is to explore and identify biologically informed minimum habitat requirements for long-term anuran species persistence in Southern Ontario and discuss the implications of policies that implement these thresholds. This manuscript is divided into six chapters. Chapter One details the biological, ecological, and policy context of this research, and concludes with a discussion of various literature and research gaps. Chapter Two uses long term anuran acoustic data to determine how many years of acoustic monitoring are required to reliably capture the species composition of breeding wetlands in Southern Ontario. Chapter Three explores the performance of a modified cost distance tool designed to model anuran road crossing survival. Chapter Four uses a Generalized Additive Model (GAM) approach to explore the performance of habitat connectivity and landscape composition metrics in predicting individual anuran species occupancy. Chapter Five identifies significant breakpoints within each of the tested habitat connectivity and landscape composition metrics to determine locations of ecological thresholds at which individual anuran species occupancy declines at an accelerated rate. Chapter Six concludes with a detailed discussion of the implications of implementing biologically-informed minimum habitat requirements on society, economy, and health more broadly, setting forward the case for the preservation of protection of robust wildlife corridor networks in human-altered landscapes.

2.0 Literature Review

2.1 Anuran Physiology and Life History

Southern Ontario, particularly the Carolinian zone, is one of the most biodiverse areas in Canada for anurans (ORAA, 2023). Eleven anuran species occur in varying levels of commonality throughout this area, including the American toad (*Anaxyrus americanus*), Fowler's toad (*Anaxyrus fowleri*), Spring peeper (*Pseudacris crucifer*), Western chorus frog (*Pseudacris triseriata*), Gray treefrog (*Hyla versicolor*), Wood frog (*Rana sylvatica*), Northern leopard frog (*Rana pipiens*), Pickerel frog (*Lithobates sylvaticus*), Mink frog (*Lithobates septentrionalis*), Green frog (*Rana clamitans*), and Bullfrog (*Rana catesbeiana*). These eleven species can be broadly divided into three groups: Hylidae (tree frogs; hylids), Ranidae (true frogs; ranids), and Bufonidae (toads; bufids). The hylids occurring in Ontario – spring peeper, Western chorus frog, and gray treefrog – are generally differentiated from the ranids by their adhesive pads on their fingers and toes, allowing them to climb vertical surfaces with relative ease. They are also generally smaller in size than the ranids and toads. The ranids that occur in Ontario – wood frog, leopard frog, pickerel frog, mink frog, green frog, and bullfrog – are generally large in size with powerful legs and extensive webbing in their feet. The toads are differentiated by their thick and warty skin allowing them to tolerate drier conditions for longer periods of time. The following sections will detail the ecological dynamics of these species, focusing specifically on their life histories, movement dynamics, and habitat relationships.

2.1.1 Anuran Life History and Movement Dynamics

Anurans in Ontario breed from the early spring to late summer. Exact timings vary according to species and latitude, as well as year-to-year variations in weather. The earliest breeders include the wood frog, Western chorus frog, and spring peeper. Mid-season breeders include the pickerel frog, American toad, and Northern leopard frog, while the green frog, mink frog, gray treefrog, and bullfrog are considered late season breeders. All of the anuran species in Ontario use vocalizations during their active breeding times which are unique to each species which are primarily used to attract mates, although they can also be used to defend territory, distinguish species, and as an alert mechansismThese unique calls are used as an effective means to identify the presence and composition of anurans at wetlands of interest (Tozer, 2020).

The Ontario anuran species listed above vary in their preferences for habitat, which include the amount of surrounding forest cover (Houlahan and Findlay, 2003; Rubbo and Kiesecker, 2004; Hermann et al., 2005), water permanence (Rubbo and Kiesecker, 2004; Weyrauch and Grubb, 2004; Herman et al., 2005; Chandler et al., 2015), and some measure of habitat connectivity (Rubbo and Kiesecker, 2004; Weyrauch and Grubb, 2004). The ranid species generally favour deeper and more permanent wetlands or ponds for breeding and regular occupation during the summer season. Some ranids such as the wood frog exhibit a stronger preference for ephemeral ponds, primarily as a strategy for avoiding fish predation (Burne and Griffin, 2005; Harper et al., 2008). Hylid species as the gray treefrog and spring peeper are more closely associated with forested areas as befits their behavioural tendencies and physiological capacity to climb trees and shrubs (Price et al., 2007). Regardless of each species' specific habitat preference, they all require standing water for an extended period of time in order to breed, develop, and transition through their aquatic tadpole stage to adulthood.

Surrounding terrestrial habitat is also critical for anuran population persistence (Quesnelle et al., 2015). Anurans require avenues for safe movement between suitable habitat types when dispersing to new areas as newly transformed juveniles or when migrating between overwintering and breeding habitats as adults (Semlitsch, 2008, Sinch, 2014). These two movements are distinguished from one another not only by the life stage of the individuals undertaking them, but by the differences in behaviour, path-finding capabilities, and instinctual objectives associated with them.

Anuran dispersal is a characteristic movement of newly transformed juveniles who – usually en masse – leave their natal ponds, travelling distances of up to 5km until they reach a land cover or suitable habitat (Joly, 2019). The exact destinations of choice for dispersing juveniles are not fully understood (Sinsch, 2014). Current hypotheses suggest that dispersal is a strategy for colonizing or restocking surrounding wetlands/ponds, and a method for continuous exchange of genetic diversity to take place in connected landscape matrices (Cayuela et al., 2020). Some researchers suggest that juveniles do not necessarily need to reach a different wetland or pond when dispersing, but may settle in appropriate terrestrial habitat and overwinter, resuming the dispersal-type movement in the spring (Sinsch, 2014). This theory remains unproven, however, given the challenges associated with monitoring and tracking individual juvenile anurans (Joly 2019; Petrovan and Schmidt, 2019).

Dispersal will often take place in mid to late summer when the transformations from aquatic to terrestrial stages are complete and mass movements are triggered by favourable weather conditions such as overnight rain or high humidity (Pomezanski and Bennett, 2018). This strategy of waiting for ideal conditions allows juveniles to minimize their risk of desiccation and extend the distance they can travel using their finite reserve of energy. A newly transformed juvenile dispersal is also differentiated from adult migration by the lack of path-seeking behavior. Current evidence indicates that dispersing juveniles do not actively select any particular direction or land cover based on sensory triggers or navigational cues (Rothermel, 2004; Semlitsch, 2008, Sinsch, 2014, Joly 2019). Instead, the strategy is one of mass movement in all directions from the natal pond, with the expectation that at least some of the juveniles will reach suitable habitat in the surrounding landscape (Cayuela et al., 2020). While there is no instinctual directional cue for dispersing newly-transformed juvenile anurans, micro-scale topographical and environmental conditions may funnel some of the dispersing individuals in certain directions (Joly, 2019). For example, if the banks of the wetland or breeding pond are steep in all but a few areas, the juveniles may be naturally guided towards those lower gradient areas, impacting the eventual long-term directional trajectories of the dispersers. Regardless of the initial direction of travel, newly-transformed juvenile anurans are more likely to continue in the same direction that they had travelled previously (Unnithan-Kumar et al., 2022)

The other major anuran movement pattern of adult migration takes place twice a year in those species that overwinter in habitats different from their breeding grounds (Sinsch, 2014; Joly 2019). Adult anurans appear to be capable of using some type of sensory cues to follow previously travelled paths from these two habitats, exhibiting directional preferences, and responding more strongly to differences in land cover (Sinsch, 2014; Joly 2019; Cayuela et al., 2020). However, their responses to landscape complexity are imperfect and adult migrating anurans are threatened by the rapid introductions of barriers through previously established migration corridors. Migration movements are triggered by favourable weather conditions, minimizing the risk of adult exposure to conditions that can accelerate energy depletion and desiccation (Cayuela et al., 2020).

In spite of the challenges associated with tracking anurans due to their small size and cryptic nature, there is enough research to establish a rudimentary understanding of the range and maximum movement distance of some of the common anuran species in Ontario listed above. The maximum movement distance of the adult green frog during movement to and from overwintering sites has been recorded as 1,260 m, while juveniles emigrating from their natal ponds have been recorded as travelling up to 4,800 m (Schroeder, 1976; Carr and Fahrig, 2001; Lamoureux et al., 2002). The Northern leopard frog's maximum movement distances are even greater, at 3,220 m for migrating adults and 5,200 m for dispersing juveniles (Seburn et al., 1997; Patrick et al., 2012). The American toad appears to travel shorter distances, recorded as a maximum of 1,000 m for adults and 1,650 m for juveniles (Breden 1987; Petranka et al., 1994). The smaller ranid wood frog's maximum movement distances are also shorter than the larger ranids: 430 m for adults and 2,530 m for juvenile dispersal (Baldwin et al,. 2006; Patrick et al., 2006). Information regarding movement distances of the spring peeper and gray treefrog are lacking, likely due to hylids' ability to escape pitfall traps and inability to be effectively tagged due to their size (Joly 2019).

Both of these movement stages are essential components of the anuran life history, emphasizing the importance of not only the habitat where breeding and early development take place, but also of the surrounding areas that allow for the safe and uninterrupted movement of individuals from other habitat components. Upland forests are a common habitat used by several of the species noted above for overwintering. For others, overwintering takes place underwater, but these ponds may be entirely different from the pools suitable for breeding (Tattersall and Ultsch, 2008). Vegetated areas of all sorts are also important as movement corridors that can sustain an abundance of prey, provide areas for shelter, retain moisture crucial for amphibian survival, and maintain wetland quality (Jones et al., 2018; Burrow and Lance, 2022; Lee et al., 2022).

2.1.2 Anuran Habitat Associations

The widespread decline of anuran populations in human-altered landscapes (Zhang et al., 2016; Urban & Roehm, 2018; Luedtke et al., 2023) prompted a wave of investigations into the relative importance of habitat characteristics for anuran species presence, richness, and abundance in Ontario in the late 90s and early/mid 2000s. For those habitat association analyses performed for anuran species occurring in Ontario, regression approaches were the most widely applied (Snodgrass et al., 2000; Findlay et al, 2001; Houlahan and Findlay, 2003; Porej et al., 2004; Weyrauch and Grubb, 2004; Hermann et al., 2005; Collins and Fahrig, 2017). Stepwise regressions were also used (Lehtinen et al., 1999; Rubbo and Kiesecker, 2004, Weyrauch and Grubb, 2004; Burne and Griffin, 2005) as were principal component analyses (Knutson et al., 1999), redundancy analyses (Houlahan and Findlay, 2003), neural networks (Findlay et al., 2001), and NMDS plots (Chandler et al., 2015). Since many habitat variables are closely related in terms of ecological processes and functions, most of the studies conducted basic tests for collinearity using correlation statistics, wherein variables that were most correlated were excluded.

The most frequently identified terrestrial habitat variable that demonstrated significant positive relationships with measures of anuran species richness, abundance, or presence in Ontario was adjacent forest cover. The radial distance at which forest cover showed an influence also varied among studies, but many fell within the 200m to 1000m buffer range (Knutson et al., 1999; Lehtinen et al., 1999; Houlahan and Findlay, 2003; Porej et al., 2004; Rubbo and Kiesecker, 2004; Hermann et al., 2005; Collins and Fahrig, 2017). Various variables designed to quantify landscape connectivity have also been found to be significant drivers of anuran richness, abundance, and/or presence. The most common type of connectivity factor used was the number of, or distance to nearest breeding wetlands (see Lehtinen et al., 1999; Houlahan and Findlay, 2003; Burne and Griffin, 2005). Since anuran populations rely on successful dispersal from natal ponds to neighbouring wetlands to maintain regional genetic diversity and combat stochastic environmental effects (Marsh and Trenham, 2001; Harper et al., 2008), accessibility to other breeding ponds/wetlands is an important factor for determining presence and persistence. A third, commonly identified significant landscape factor is that of adjacent urbanization, represented in various ways such as road density, urban land cover, or even human population density (see Knutson et al., 1999; Lehtinen et al., 1999; Findlay et al., 2001; Houlahan and Findlay, 2003).

There were also several commonly identified local variables (i.e. characteristics of the wetlands) that were found to impart significant influences on anuran populations. Increased hydroperiod was found by multiple studies to result in higher species richness and/or individual species presence (Snodgrass et al., 1999; Houlahan and Findlay, 2003; Rubbo and Kiesecker, 2004; Weyrauch and Grubb, 2004; Burne and Griffin, 2005; Hermann et al., 2005; Chandler et al., 2015). The presence of predatory fish was also highlighted by several studies as a factor that can depress survival rates through predation of tadpoles (Lehtinen et al., 1999; Porej et al., 2004).

Within the last two decades, relatively few habitat association analyses for Ontario anuran species have been performed compared to the decade previous. Given the changing landscape and ongoing pressures on anuran species populations, this represents a concerning knowledge gap. With changing policy and regulation landscapes in Ontario, it is more important than ever to advance and update our understanding of anuran habitat requirements to implement science-based natural heritage conservation strategies. In the next section, I will briefly outline the high-level guidance for ecological planning and how it relates to anuran species conservation in Ontario.

2.2 Anuran Species Management in Ontario

Land use planning in Ontario is governed primarily by the Planning Act which is implemented by the Provincial Policy Statement (PPS). The PPS outlines standards for municipal planning in the creation of Official Plans and decision-making processes. Pertinent to anuran conservation and protection is the section on natural heritage which first and foremost states that “natural features and areas shall be protected for the long term” (Provincial Policy Statement, 2024). More specifically, the PPS states: “the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas” (Provincial Policy Statement, 2024). Broadly speaking, this language should provide foundational protection for anurans and anuran habitat with emphasis on long-term monitoring to satisfy the conditions for long term ecological function maintenance. The PPS goes on in detail that development and site alteration are not be permitted in significant wetlands, woodlands, valley lands, or wildlife habitat (Provincial Policy Statement, 2020), prompting questions about how habitat is determined and what constitutes its classification as significant.

The Significant Wildlife Habitat Technical Guide (OMNR, 2000) provides official guidance for evaluating habitat and determining significance. Consistent with our understanding of anuran ecology, the document outlines the importance of breeding ponds and adjacent habitats, as well as the role of habitat corridors for maintaining landscape connectivity (OMNR, 2000). There are also additional recommendations for movement corridor design which include minimizing edge effects, minimizing road density, maximizing corridor width, and minimizing corridor length (OMNR, 2000). These recommendations are indicative of a fundamental understanding of threats to anuran movement, but they lack details with regards to the amount and configuration of habitat features and are limited to mentions of retaining as much surrounding upland habitat as possible. The Technical Guide is also nearly a quarter century old and would benefit from a review of more recent research with regards to minimum habitat requirements for amphibian species. Since the year of its publishing, various minimum habitat amounts have been presented such as 44% of habitat cover within 1000m for wood frogs (Homan et al., 2004) and 40% of forest cover within 1000m for overall amphibian richness (Hermann et al., 2005). Unfortunately, very little in the way of minimum habitat requirement research for anuran species occurring in Ontario has been conducted in the last 10 – 15 years, particularly with regards to landscape connectivity and movement corridor design.

For those wetlands designated as significant in Ontario using the Ontario Wetland Evaluation System (Ontario, 2022), the criteria for which extend beyond the simple consideration of wildlife abundance or diversity, a minimum terrestrial vegetated buffer of 30m from wetland edge is the standard mitigation strategy. It is also one of the only strict minimum habitat protections that are relevant to the anuran life cycle. Such buffers are widely applied across North America, but they may not be sufficient for amphibian population protection (Semlitsch and Bodie, 2003; Simpson et al., 2021), particularly for species which are dependent on upland terrestrial habitat (Quesnelle et al., 2015). Sawatzky et al. (2019) highlights that the focus on minimum buffers for wetlands in Ontario is less important than the wider landscape context including features such as forest cover at farther distances.

For those greenspaces and wildlife populations adjacent to and embedded in anthropogenically-altered landscapes, there must be consideration for the benefits they provide to human systems. Since land planning and policy is often an exercise in cost-benefit analysis, for anuran (or any wildlife) habitat to be considered worthwhile for preservation it must be presented in a value-based framework. The following section will explore these values and how they relate to wildlife habitat and biodiversity more broadly.

2.3 Human Benefits of Anuran Diversity

An increasing global urban footprint has been mirrored by a decline in natural areas, greenspace, and biodiversity (Beninde et al., 2015; IPBES, 2018). The last half century has seen advances in our understanding of the important services that can be provided by forests, wetlands, and other green areas in and around urban areas (Gómez-Baggethun et al., 2013). The benefits of urban wetlands are well documented and extend beyond their hydrological function to include urban heat regulation and recreational value (Alikhani et al., 2021). There is a wide body of research on the potential role of biodiversity in facilitating these types of ecosystem functions in urban greenspaces (Mace et al., 2012; Schwartz et al., 2017; van der Plat, 2019). In urban areas where biodiversity faces increased threats of decline from a wide range of human-induced pressures (Beninde et al., 2015), research that highlights the many benefits of biodiverse greenspaces is critical in making the economic case for anuran conservation and stewardship. This section will present the current state of knowledge regarding the benefits and value of biodiverse urban greenspaces.

2.3.1 Urban Ecosystem Services

Ecosystem services are the benefits derived by humans from ecosystems, including such common examples as pollination, air quality, soil fertility, and natural resource productivity (Garland et al., 2021). The growing disconnect between urban residents and nature (Soga and Gaston, 2016) has highlighted the loss of previously widespread ecosystem-facilitated benefits, thus augmenting the value of remaining urban greenspace to surrounding human and social systems. Recognizing this loss of ecosystem facilitated benefits, there is a substantial literature base investigating the potential of urban greenspaces to provide a variety of ecosystem services.

Perhaps the most studied impact of urban greenspace has been its role in improving human health and well-being. Proximity to urban greenspace can promote greater physical activity through access to recreational spaces (Bowler et al., 2010; Martens et al., 2011; Dennis et al., 2020). Mental health and well-being have been shown to improve in areas with access to urban canopies and other greenspaces (Annerstedt et al., 2012; White et al., 2013; Lottrup et al., 2015; Wolf et al., 2015). Urban forests and trees play an integral role in the regulation of air quality and the reduction of airborne pollutants (Nowak et al., 2018; Grylls and van Reeuwijk, 2022). Environmental contaminants, commonly found in urban runoff and waste, can be filtered, retained, or decomposed by urban greenspaces such as wetlands, forests, and streams (Vauramo and Setälä, 2011; Francini et al., 2018; Bai et al., 2020).

Benefits to infrastructure and urban communities are also commonly emphasized. Urban greenspaces are an effective tool in mitigating stormwater runoff and extreme fluctuations in water levels (McPhearson et al., 2005; Pataki et al., 2013). Vegetated urban areas can also contribute to local temperature regulation and provide spaces for shade and heat relief (Alikhani et al., 2021). Urban noise can be dampened by the presence of greenspaces and vegetation, thus mitigating negative health effects induced by noise pollution (Dzhambov and Dimitrova, 2014; Ojala et al., 2019). The characteristics of urban vegetation has shown some positive associations with reductions in crime (Kuo, 2003; Troy et al., 2012). Urban greenspace access can provide act as havens for therapy and healing (Sherman et al., 2005; Detweiler et al., 2012; Wolf and Robbins, 2015).

While these ecosystem services are valuable and widely recognized, they do not relate directly to the degree of biodiversity that characterize the natural areas providing the services. Exploring the links between biodiversity and the functioning and efficiency of natural areas in providing ecosystem services is an ongoing and challenging area of research, but one that provides insight into the incentives behind broader biodiversity conservation in human-dominated landscapes. The following section will explore the research and knowledge in this area, highlighting the role of biodiversity in the complex interactions between humans and the natural world.

2.3.2 Biodiversity-Ecosystem Service Relationships in Urban Environments

As one of the main contributors to the identity of ecosystems (another being abiotic factors such as climate), biodiversity is an integral mechanism for healthy ecological functioning (Duffy et al., 2017; van der Plas, 2019). Biodiversity broadly can be defined as: “the number, abundance, composition, spatial distribution, and interactions of genotypes, populations, species, functional types and traits, and landscape units in a given system” (Diaz et al., 2006). Literature in the last thirty years has refined our understanding of this relationship, emphasizing biodiversity’s regulation of cultural, supporting, regulating, and provisioning ecosystem services.

There are many examples of positive relationships between biodiversity and ecosystem service delivery. Culturally for example, biodiversity contributes to a greater functioning of traditional Indigenous cultures which rely on intact and diverse ecosystems for spiritual benefits (Rozzi, 2012; Watson et al., 2018). Supporting services such as primary production and ecosystem stability can be enhanced by increased functional diversity of species, but not necessarily by overall species richness (Walker et al., 1999; Paine, 2002; Hooper and Dukes, 2004; Hooper et al., 2005). In both controlled and naturally assembled communities, greater biodiversity is associated with increased ecosystem functioning and higher productivity (Duffy et al., 2017; van der Plas, 2019). Regulating services such as pollination and climate regulation are more efficient with increased diversity in functional species composition (Fontaine et al., 2005; Diaz et al., 2006; Conti and Diaz, 2013). The production of resources such as wood timber (Vila et al., 2013) and food crops (Dainese et al., 2019) are also positively related to increased levels of functional biodiversity in some circumstances, although there are often inconsistencies and sometimes reversals in these relationships (Beckman et al., 2019)

There is some evidence to suggest that biodiversity enhances ecosystem service benefits even in urban greenspaces. Much of the literature to date has focused on the benefits of biodiversity in improving perceived components of human health. In urban areas in particular, there has been a focus on the role of urban greenspaces as places of restoration and stress-relief. Self-reported restorative and well-being effects were reported in urban greenspaces with increased diversity in the form of butterfly, bird, and plant richness (Fuller et al., 2007; Dallimer et al., 2012; Carrus et al., 2015; Marselle et al., 2016; Hoyle et al., 2017). In other cases, land cover diversity was identified as having a positive role in self-reported health, emphasizing the role of landscape heterogeneity in facilitating enhanced biodiversity and human health (Wheeler et al., 2015). These self-reporting metrics are imperfect and subjective but remain commonly cited as methodologies attempt to account for the non-partial nature of self-reporting. If real, these health effects can reduce public health costs (Mills et al., 2017) and improve productivity and efficiency in urban spaces with large concentrations of workers (Colley et al., 2016).

Links between health benefits and increased biodiversity include lower rates of atopy in children in areas of greater environmental and floral biodiversity (Hanski et al., 2012), lower risks of asthma in children in areas with higher landscape cover diversity (Donovan et al., 2018), and lower rates of West Nile Virus infections in areas with higher bird diversity (Ezenwa et al., 2006). However, not all research has reported conclusive biodiversity-caused health benefits (see Chang et al. 2016), and additional research is needed to not only confirm these linkages, but to better relate them to ecological processes that can be managed and protected. Studies have also highlighted the potential of biodiversity in promoting pollination and seed dispersal which can enhance local food production and urban gardening (Andersson et al., 2007). Biodiverse ecosystems such as wetlands can also more effectively remove pollutants such as nitrate from stormwater by promoting healthy invertebrate and bacterial communities (Yao et al., 2017; Winfrey et al., 2018).

A long-standing challenge in ecological literature is determining how species biodiversity impacts ecosystem functioning. The way in which biodiversity is quantified and represented plays a major role, as varying ecosystem responses to biodiversity represented as either species richness or functional diversity are well reported (Schwartz et al., 2017; van der Plas, 2019). Moreover, the relationships between biodiversity and ecosystem function are rarely unidirectional or linear due to the effects of environmental characteristics or feedbacks from competition or other density dependent mechanisms (Hautier et al., 2009; Grace et al., 2016). Most diversity-ecosystem service relationships are also explored as isolated controlled systems (Hooper et al., 2005; Lefcheck et al., 2015), whereas in reality, ecosystem functions and species interact in complex ways which can affect each other in different ways as environmental contexts shift (Byrnes et al., 2014; Grace et al., 2016).

These and other challenges make disentangling the effects of biodiversity difficult, made potentially even more difficult in heavily altered urban environments where ecosystems may not function in the same way as reference systems. Given intense external anthropogenic pressures from habitat loss, pollution, edge effects, and/or a myriad of other disturbances, ecological processes and responses are altered (Guzy et al., 2012; Schwartz et al., 2017). In a review of urban ecosystem service research, Schwartz et al. (2017) report that 39% of all studies showed either a negative or no relationship between biodiversity and ecosystem service function. Given that many urban greenspaces demonstrate qualities of "novel ecosystems" (Kowarik, 2011), investigations into the local urban histories and contexts are needed to properly explore and identify biodiversity-ecosystem function relationships (Ziter, 2016). Moreover, just as in many investigations in naturally assembled communities, research on urban ecosystem services tends to focus on the relationship between biodiversity and a single service, overlooking the many complex interactions between services, functions, and diversity within a single ecosystem (Ziter, 2016; Schwartz et al., 2017).

2.4 Literature Gaps and Opportunities

2.4.1 Anuran Monitoring and Assessment

The idea of long-term persistence is explicitly stated in the Provincial Policy Statement, yet there is little evidence of monitoring to identify long-term impacts or assess project success. The commonly observed decline in anuran abundance and diversity in areas that have experienced recent and intensive human disturbance suggest a failure of existing policy language and criteria to protect the long-term integrity of anuran populations (Klaus and Lougheed, 2013; Stapanian et al., 2015). Short-term monitoring is commonly used to gather data on anuran populations, but it can miss species composition patterns in populations that experience regular extinction-recolonization dynamics (Marsh and Trenham, 2001; Walls et al., 2011; Lehtinen and Witter, 2014) and will struggle to capture delayed effects in response to habitat loss and disturbance (Findlay and Bourdages, 2000; Lofvenhaft et al., 2004). Therefore, to truly understand anuran population responses to habitat disturbance, long-term monitoring needs to be a priority.

Birds Canada is an example where compiling long-term anuran acoustic monitoring data is promoted to analyze temporal trends in wetland occupancy and population health (Tozer, 2020), but focusing such analyses on breeding wetlands may lead to additional management challenges (Pittman et al., 2014). Anurans are typically most detectable during the breeding life stage because they are concentrated in a relatively small aquatic habitat and use conspicuous species-specific vocalizations to attract mates. The readily detectable nature of the anuran breeding stage reinforces the idea that they are a primarily aquatic species group, which may contribute to the ongoing neglect of anuran terrestrial habitat in policy and management, which has been shown to be of critical importance for anuran population persistence (Taylor and Paszkowski, 2017; Knutson et al., 2018). Monitoring anurans in their terrestrial habitat is particularly difficult for smaller species that cannot be tracked with radio-telemetry, or those that are cryptic or low-occurring even in the breeding stage. Given these limitations, it is critical to gather long-term breeding data and integrate it with the existing body of knowledge surrounding anuran behaviours and terrestrial habitat usage. In this way, the amphibious nature of the anuran life history can be better captured in efforts at modelling and assessment, which can then in turn be used to guide landscape management for these complex species.

Despite distinct and known differences between anuran species in terms of their usage of habitat types, many analyses of anuran habitat in Ontario have used species richness as a response variable which assumes similar habitat requirements (see Knutson et al., 1999; Snodgrass et al., 1999; Burne and Griffin, 2005; Chandler et al., 2015). Fortunately, several others have performed these analyses on a species-by-species basis, which have provided more detailed information about species-specific habitat requirements (Porej et al., 2004; Rubbo and Kiesecker, 2004; Hermann et al., 2005; Collins and Fahrig, 2017). The results of these species-specific analyses are important because they have shown that significant habitat variables vary according to individual species and produce different results to those analyses performed using species richness as a response variable. These discrepancies pose several issues for anuran management as it can provide conflicting information for conservation efforts with regards to determining priority habitat features for protection. Using species richness as a response variable can also obscure the habitat needs of more specialist species such as the wood frog, which depend almost exclusively on predator-free ephemeral pools for breeding habitat (Burne and Griffin, 2005; Harper et al., 2008). Analyses which have identified longer hydroperiods as important for anuran species richness would not be able to capture the wood frog’s need for short hydroperiods, leading to potential misguided habitat management.

2.4.2 Anuran Movement and Connectivity Modelling

Anuran species populations interact with adjacent habitats through migration and dispersal processes that involve seasonal movement on the scale of up to several kilometres (Semlitsch, 2008; Joly, 2019). Dispersal and migration movement dynamics result in the exchange of genetic information, recolonization of areas where local populations were extirpated (due to either natural or anthropogenically-induced factors), and colonization of new habitats (Sinsch, 2014). The dependence on these processes for long-term landscape persistence is problematic for anuran populations because it requires some level of landscape connectivity, a characteristic which is often lacking in human-altered environments (Beninde et al., 2015). Even in cases where greenspace is set aside in urban environments to facilitate landscape connectivity, they are often placed with the assumption that wildlife will actively choose vegetated greenspaces or lower resistant land covers for movement corridors. This is often not true for anurans, which often cross through land covers considered hostile or highly resistant to movement as they instinctually move between habitats (Semlitsch, 2008; Sinsch, 2014; Joly 2019). Anuran migration, which is characterized by possible path-seeking behaviour (Semlitsch, 2008; Coster et al., 2014; Sinsch, 2014; Joly, 2019) is often the basis for corridor placement, but by neglecting to incorporate the immensely importantjuvenile dispersal stage - characterized by instinctual directional movement away from natal ponds - into corridor design, anuran populations are likely to experience long-term decline (Petrovan and Schmidt, 2019). A greater acknowledgement and application of known anuran movement behaviours across physiological stages of development in connectivity modelling is essential to better place terrestrial habitats that can facilitate safe and effective migration and dispersal (Unnithan Kumar et al., 2022).

The literature has also been challenged to provide updated guidance on habitat thresholds, amounts, and placement of habitat surrounding breeding wetlands. The majority of anuran research identifies important habitat features but rarely addresses how much habitat is needed to facilitate population persistence. The few studies that have done so (Homan et al., 2004; Eigenbrod et al., 2009; Guderyahn et al., 2016) provide little additional guidance for spatial placement or orientation of important habitat features. Given anuran species' difficulty in actively selecting suitable and safe land covers, strategic placement and orientation is extremely important (Sinsch, 2014; Joly, 2019). Future research needs to move beyond considering habitat presence and towards critical examinations of spatial habitat arrangements and how they relate to anuran life histories. Examinations of spatial habitat connectivity are a promising step forwards, but they must be tailored specifically to anuran movement dynamics (Unnithan Kumar et al., 2022). These research gaps contribute to some degree of incompatibility between scientific knowledge production and applied wildlife management. Effective anuran management in a planning context would benefit from quantifiable recommendations for habitat feature structure, extent, and placement. With such guidelines largely absent from the literature, urban anuran protection is understandably challenged to succeed.

2.5 Summary and Manuscript Structure

The aim of this thesis is to explore and identify biologically informed minimum habitat requirements for long-term anuran species persistence in Southern Ontario and discuss the implications of policies that implement these thresholds. The following chapters will address some of the literature gaps and research opportunities outlined in the previous section. Chapter Three uses long term anuran acoustic data to determine a minimum number of years of acoustic monitoring which are required to reliably capture the anuran species composition in breeding wetlands. The results from this chapter will inform the data methodologies of the subsequent three chapters. Chapter Four explores the performance of a modified cost distance tool designed to model anuran road crossing survival, addressing a fundamental shortcoming in existing landscape resistance modelling approaches. Chapter Five uses a Generalized Additive Model approach to explore the performance of habitat connectivity and landscape composition metrics in predicting individual anuran species occupancy. This chapter builds on the results of the previous two chapters by applying the minimum monitoring requirements identified in Chapter Three and the road crossing survival tool performance and parameters refined in Chapter Four. The habitat connectivity metrics designed and presented in Chapter Five are aimed at addressing the lack of connectivity models built to capture anuran-specific movement dynamics. Chapter Six identifies significant breakpoints within each of the tested habitat connectivity and landscape composition metrics to determine locations of ecological thresholds at which individual anuran species occupancy declines at an accelerated rate. In this chapter, I highlight how visual and statistical breakpoint estimations compare and discuss their ecological relevance. Chapter Seven concludes with a detailed discussion of the implications of implementing biologically-informed minimum habitat requirements on society, economy, and health more broadly, setting forward the case for the preservation of protection of robust wildlife corridor networks in human-altered landscapes.

3.0 How many years of acoustic monitoring are needed to accommodate for anuran species turnover and detection?

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3.1 Introduction

Anurans are threatened by a variety of anthropogenically induced habitat changes across their natural ranges. In heavily disturbed areas, these effects include habitat fragmentation (Lehtinen 1999; Cushman 2006; Hamer and McDonnell 2008), pollution (Karraker et al. 2008; Collins and Russell 2009), road mortality (Fahrig and Rytwinski 2009; Beebee 2013), and disease (Greer et al. 2005; Longcore et al. 2007). Given their ecological importance and functionality as indicators of environmental quality (Price et al. 2007), monitoring anuran populations is important to assess the degree of anthropogenic disturbance and/or the success of mitigation. Manual acoustic surveys are an efficient and non-invasive technique to determine species occupancy and abundance (Corn et al. 2000; Pellet and Schmidt 2005). They are widely used and are considered reliable for the determination of species composition (Shirose et al. 1997; De Solla et al. 2006).

However, there are several areas of concern with relying on acoustic surveys, in large part to the very nature of anuran population dynamics and variation between species calling behaviours. For some species such as the wood frog (*Lithobates sylvatica*), breeding occurs during a very short time span (usually in the order of two weeks) in the early spring (Crouch and Paton 2002). Given that standardized protocols such as the Marsh Monitoring Protocol require certain temperature thresholds to be met, timing is a critical component for capturing wood frog breeding calls (Bird Studies Canada 2008). Unpredictable temperature, rainfall, and wind fluctuations in the spring can also make surveying difficult, and with the short timeframes for explosive anuran breeders, it is possible to miss certain species' calling periods (Paszkowski et al. 2002; de Solla et al. 2005). The year to year variation in the amount of favourable surveying conditions may therefore contribute to the sporadic capture of certain anuran species via manual acoustic surveys.

Another challenge with anuran acoustic surveying is capturing the calls of species that are more cryptic or quiet than others. Differences in calling intensity and volume can lead to underestimation of some species when quieter acoustics are challenged to travel longer distances (Bridges and Dorcas 2000; Corn et al. 2000; Crouch and Paton 2002). In small numbers for example, species such as the leopard frog (*Lithobates pipiens*) can be difficult to hear amidst a louder chorus of spring peepers (*Pseudacris crucifer*). Augmenting challenges with recording cryptic species are issues of misidentification. Quieter or infrequent calls by certain species can make it difficult for some surveyors to verify presence of rare species within a short survey period (Bridges and Dorcas 2000; Pellet and Schmidt 2005). Many anuran calls can also be confused with other anuran species, bird species, or mammal species, particularly when relatively inexperienced surveyors are involved (Genet and Sargent 2003).

One issue that is rarely raised in anuran acoustic monitoring research is that of anuran metapopulation dynamics. Anurans undergo natural variations in pond and wetland occupancy based on annual hydrological and climatic conditions (Hecnar and M'Closkey 1996; de Solla et al. 2006). A particularly dry year may cause some ponds to dry up completely for a long period of time, leading to the local extirpation of water-dependent species (Marsh and Trenham 2001; Trenham et al. 2003). Nearby wetlands with surviving populations can then act as sources of immigration and recolonization can take place (Gibbs et al. 2005). These extinction-recolonization cycles, also known as species turnover, may take several years and may affect some species more than others (Trenham et al. 2003). The success and speed of the recolonization process is also dependent on the degree of regional habitat connectivity and the density of surrounding sources of immigration (Semlitsch and Bodie 1998; Marsh and Trenham 2001). With increasing habitat fragmentation, regional habitat connectivity and the ecological processes that depend on it are being threatened. It may take longer for dispersing juveniles to successfully recolonize habitats that have become more isolated, and disturbed wetlands may be more prone to species extirpation events (Semlitsch and Bodie 1998; Arntzen et al. 2017).

With all of these challenges in mind, how can acoustic monitoring be performed to address these issues and provide comprehensive records of anuran species composition?

Concerns surrounding cryptic species, misidentification, and survey length have been explored in recent literature, particularly with regards to the use of citizen-derived data and automated acoustic loggers (Corn et al. 2000; Genet and Sargent 2003; de Solla et al. 2005). Increasing survey effort within a survey or within a year and/or deploying remotely recording acoustic loggers can effectively address issues of seasonal calling variability and rare/cryptic species misidentification (Corn et al. 2000; Pierce and Gutzwiller 2004; de Solla et al. 2005; Pellet and Schmidt 2005). There has been no discernable effort, however, to explore the role of anuran acoustic surveys in capturing long-term year to year variations in anuran species occupancy.

Anuran acoustic survey protocols have become standardized in many areas including Ontario and the Northern U.S (Bird Studies Canada 2008). The typical three surveys in a year are distributed in such a way as to maximize the aural capture of as many species as possible. The three-minute survey duration has also been shown to be sufficient for capturing a representative picture of nightly anuran calling (Corn et al. 2000; de Solla et al. 2005). The challenges outlined above, however, may lead to significant underestimation of species richness if surveys are conducted for only a short period of time. Extinction-recolonization dynamics can also limit their short-term effectiveness in capturing a complete picture of possible anuran species composition. Using long-term anuran acoustic survey results from across Southern Ontario, I aimed to explore how many years of standardized acoustic monitoring are required to capture a complete picture of anuran species composition and occupancy.

3.2 Methods

3.2.1 Data Collection

Long term anuran acoustic survey data was acquired from Birds Canada’s Nature Counts database (Bird Studies Canada 2018). The Birds Canada organization collects amphibian survey data from across Ontario and some U.S. states conducted using the Marsh Monitoring Protocol (MMP) (Bird Studies Canada 2008). The MMP standardized protocol requires that three short acoustic surveys are conducted during the anuran breeding season of April to mid-July. Surveys being half an hour after sunset and go no longer than midnight. Each survey lasts three minutes, and species within a 100m radius half circle facing the wetland are recorded during this time period. Minimum temperatures for each survey vary according to the time of year. The first survey in early spring (typically in April) must be conducted during a night when the air temperature is higher than 5 degrees Celsius. The second survey (typically in mid-late May) is conducted when nighttime temperatures are greater than 10 degrees Celsius. The third survey (typically in mid-late June) is conducted when nighttime temperatures are greater than 17 degrees Celsius. For all surveys, wind levels must be 3 or less on the Beaufort wind scale. Persistent or heavy rain must also be avoided. Anuran calls are categorized into three call level codes: L1, L2, and L3. The first call level code (L1) is used when a particular species' calls are non-overlapping and individuals can be reliably counted. The second call level code (L2) is used when there are some overlapping calls, but individuals can still be reliably counted. The third call level code (L3) designates a full chorus of continuous and overlapping calls in which individuals cannot be reliably distinguished or counted.

3.2.2 Study Sites

Sixty-six study sites were extracted from the Birds Canada database based on the following criteria:

i) The study site must be located within the province of Ontario to ensure similar species composition

ii) The study site must have a minimum of eight years of continuous acoustic survey monitoring

iii) The study site must have had a minimum of four total species accumulated within the length of the total survey period to avoid statistical artifacts associated with low species accumulation results

iv) The study site must not be within an area that has experienced heavy land use change disturbance wherein natural metapopulation dynamics could be altered/prevented and additional landscape stresses can be imparted. Heavily disturbed areas were defined as those with more than 50% land cover change within 1 km of the calling station between the year 2000 and 2010. The Government of Canada's Land Use (LU) digital map atlas was used to determine the extent of land cover change within the specified time period.

For study sites with multiple monitoring stations, only the first station's results were extracted and used in the analysis to avoid spatial bias and autocorrelation (i.e. similarity in values based on geographical proximity).

3.2.3 *Data Analysis*

For the purposes of this study, all call level codes qualified as evidence for species occupancy. Results from each of the three surveys conducted within a year were combined to get a year-by-year record of recorded species occupancy. Species accumulation curves were calculated for each study site using the program EstimateS (Version 9.1.0) (Colwell 2013). The species accumulation curves randomized and averaged the accumulated total number of recorded species. The randomization was necessary to avoid temporal bias or correlation due to particularly favorable or unfavorable monitoring years. The EstimateS program conducted 100 randomized runs per site. The S Mean (runs) output was extracted and used to construct a species accumulation curve for each study site.

3.3 Results

3.3.1 Survey sites

The total number of species accumulated at each site varied from four (the minimum required to qualify for inclusion in this study) to nine (see Table 1 for all site summary statistics). Most survey sites recorded between 6 and 8 species in total (51 of the 66). Fourteen of the 66 sites accumulated less than 6 species, and only one site recorded all nine species. Of the 66 survey sites included in this study performed between 2008 and 2018, 5 were monitored for 8 consecutive years, 10 sites were monitored for 9 consecutive years, 18 sites were monitored for 10 consecutive years, and 33 sites were monitored for 11 consecutive years. Fifteen of the 66 sites were influenced by urban/suburban surrounding land uses (>25% surrounding developed land cover within 1 km). The remaining 51 sites were predominantly influenced by rural or natural surrounding land uses (>75% surrounding natural land cover within 1 km).

Table 1: Summary statistics for the 66 study sites included in this analysis

Number of years monitored	# sites	Number of Accumulated Species	# sites	Prevalent Surrounding Land cover	# sites
8	5	4	4	Urban/suburban	15
9	10	5	10	Rural	51
10	18	6	20		
11	33	7	20		
		8	11		
		9	1		

3.3.2 Species composition and detection

Nine unique anuran species were recorded across all 66 study sites: American bullfrog (*Lithobates catesbeianus*), American toad (*Bufo americanus*), Green frog (*Lithobates clamitans*), Gray treefrog (*Hyla versicolor*), Leopard frog (*Lithobates pipiens*), Pickerel frog (*Lithobates palustris*), Spring peeper (*Pseudacris crucifer*), Western chorus frog (*Pseudacris triseriata*), and Wood frog (*Lithobates sylvatica*). Occupancy rate, defined as the proportion of sites wherein a species was detected at least once, varied across all species. The green frog was the most commonly recorded species, occurring in each of the 66 surveyed sites at least once over the entire monitoring period. Occupancy rates of American toads, spring peepers, leopard frogs, and gray treefrogs were also high at 91%, 91%, 89%, and 85% respectively. The least commonly recorded species were the wood frog (68% of sites), western chorus frog (61% of sites), American bullfrog (48% of sites), and pickerel frog (11% of sites). Average interannual detection rates, defined as the proportion of years in which a species was detected for those sites where it was detected at least once, are presented in Figure 1. For wood frogs, northern leopard frogs, western chorus frogs, and pickerel frogs, individuals were detected in an average of less than 50% of monitoring years at those sites where the species was detected at least once. Green frogs and spring peepers were detected in an average of more than 75% of monitoring years at those sites where the species was detected at least once. For seven of the nine species included in this analysis, the average interannual detection rate was substantially lower than the overall occupancy rate across all sites. This was not the case for American bullfrogs or pickerel frogs, which also had the lowest occupancy rates of all species.

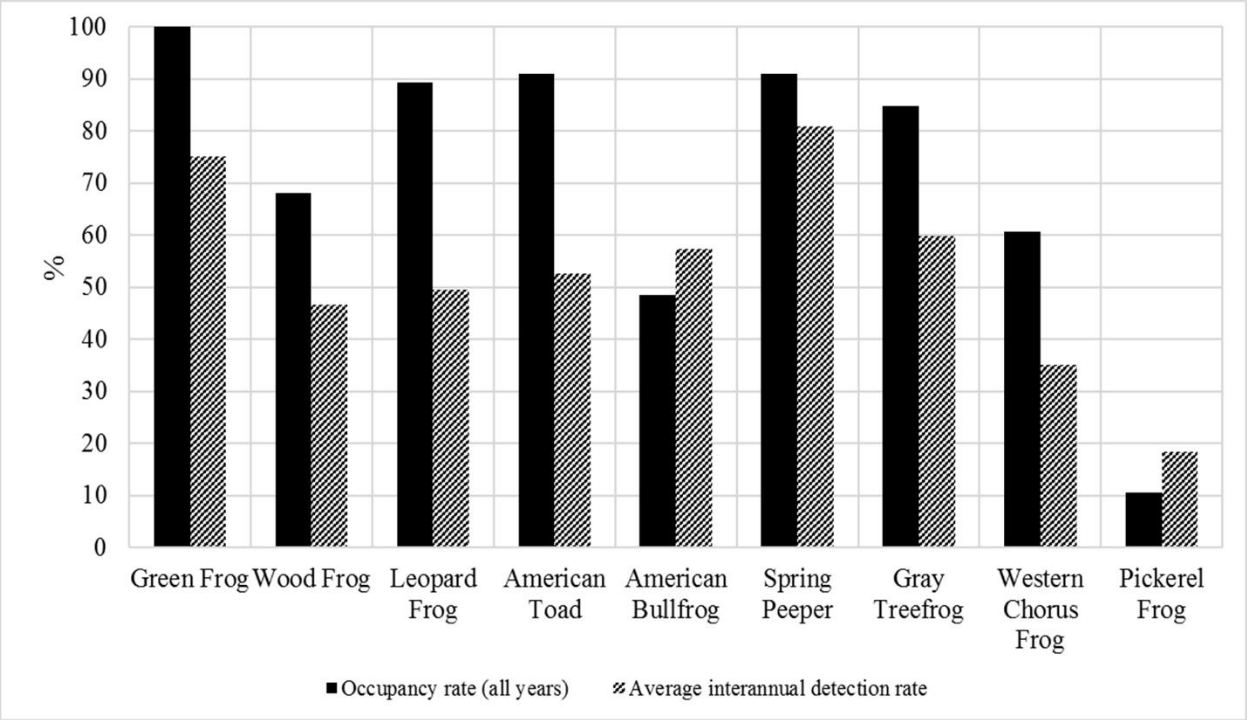

Figure 1: Anuran species occupancy rates across all sites (n=66) (i.e. percent of sites with at least one year of species detection) represented with black bars, and average interannual detection rates at those sites with at least one species record (i.e. averaged percent of total monitoring years that the species was detected per site) represented by the striped bars.

3.3.3 Species accumulation

Species accumulation curves are presented in Figure 2, separated according to the total number of accumulated species to better reflect the shapes of the accumulation curves. The shapes varied between survey sites depending on how many anuran species were rarely recorded (i.e. the more species recorded in only one or two years, the more linear the accumulation curve). Most curves followed a logarithmic curve shape as species accumulation plateaued and saturated at around the 5 to 7-year mark. Curves representing the average percentage of total accumulated species per year are displayed in Figure 3. Similarly, curves are steepest in the 1 to 4-year range and flattened out after the 5 to 6 year mark, when species accumulation surpassed 90% of total detected species.

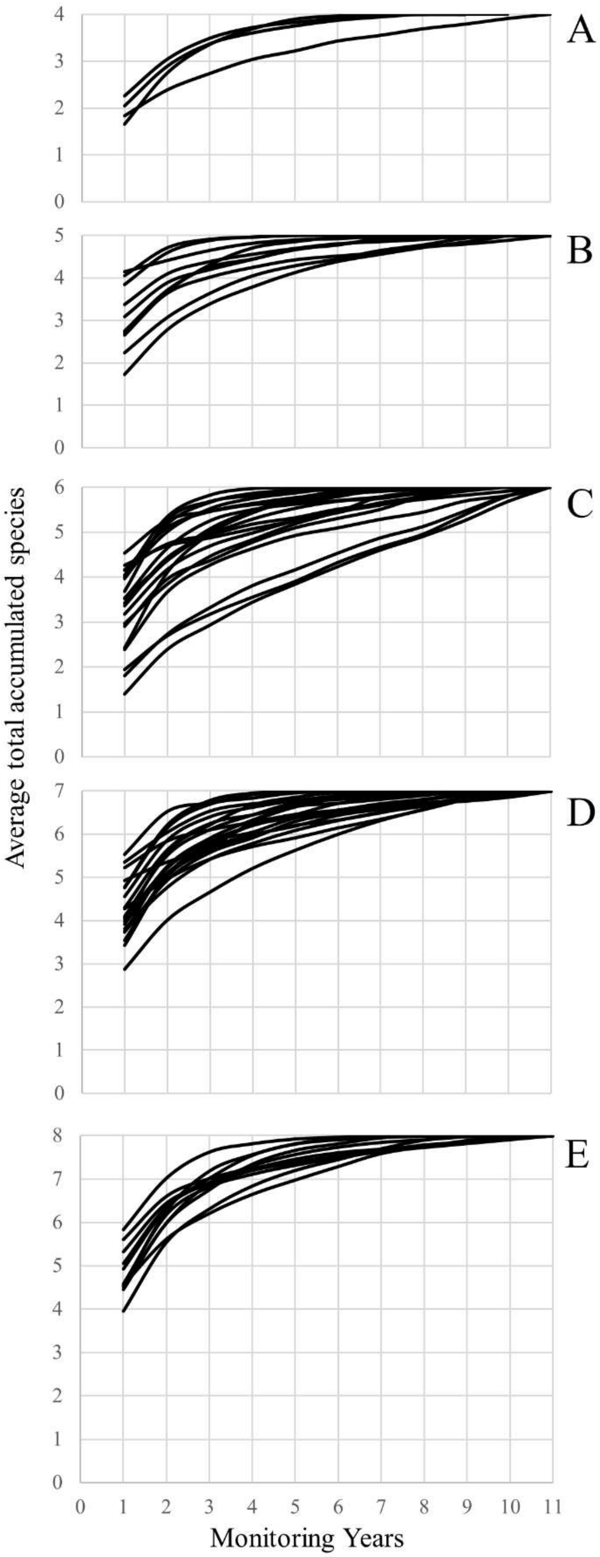

Figure 2: Species accumulation curves for A) sites with a total of 4 accumulated species, B) sites with a total of 5 accumulated species, C) sites with a total of 6 accumulated species, D) sites with a total of 7 accumulated species, and E) sites with a total of 8 accumulated species.

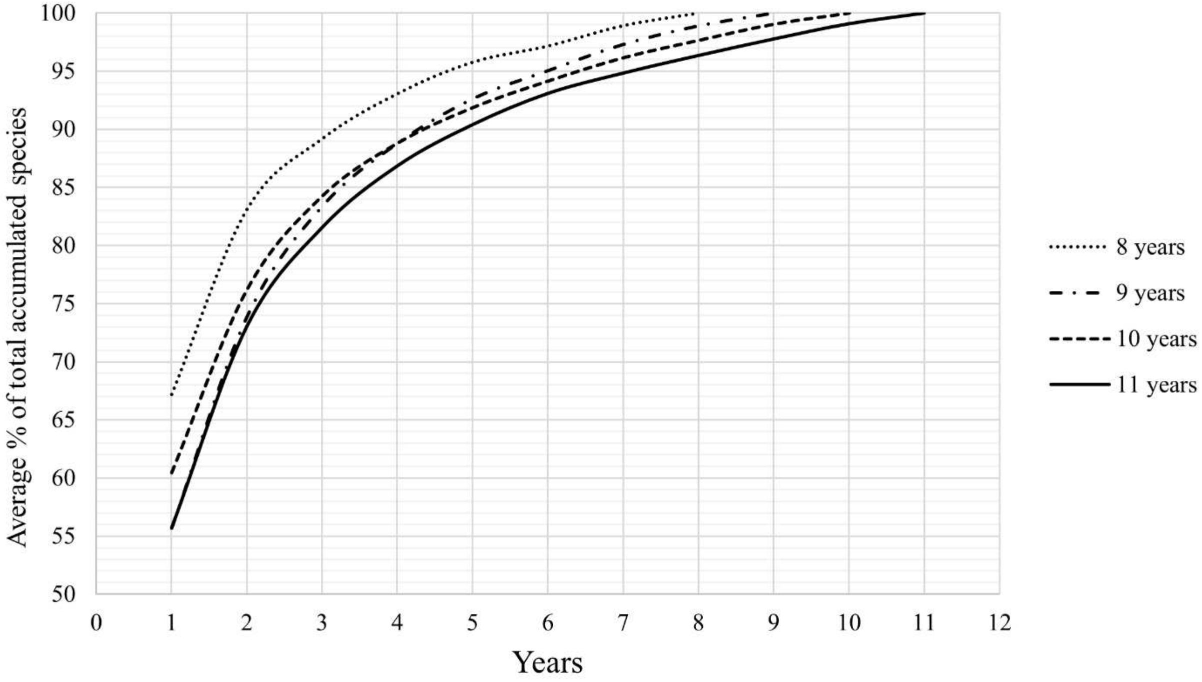

Figure 3: Average percent of total accumulated species detected with increasing monitoring effort (years) separated by number of total monitoring years

3.4 Discussion

The species accumulation curve analysis performed here clearly illustrates the potential weaknesses of short-term anuran acoustic monitoring surveys. The species accumulation curves tell us that on average, five to six years of standardized monitoring are needed capture at least 90% of anuran species at any given site. The reasons behind the variability in year-to-year anuran occupancy cannot be directly answered by this analysis but combined with current knowledge of species calling patterns and anuran metapopulation dynamics, some educated assumptions can be made.

3.4.1 Occupancy and Detectability

One reason for the apparent "turnover" in species occupancy could be high levels of disagreement between observers if some observers changed over the long monitoring period. However, both Shirose et al. (1997) and Genet and Sargent (2003) found that observer agreement on presence/absence was generally very high, with most discrepancies related to observers' reporting of abundance, not presence/absence. If observer variability is fairly low, then perhaps the inter annual variability in species composition is a product of only conducting three short surveys within a year? Shirose et al. (1997) found that longer individual surveys (longer than the MMP designated 3 minutes) rarely resulted in the detection of additional species, whereas Bridges and Dorcas (2000) documented concerning nightly variations in calling patterns that may reduce the effectiveness of short evening surveys at detecting certain species. De Solla et al. (2005) determined that between 12 and 24 randomly sampled nights for surveys are required to document between 80 and 90% of species mainly due to the lower detection probabilities of wood frogs and leopard frogs. It is possible, therefore, that some of the interannual anuran species composition variability observed in this study can be attributed to low detection probabilities and selection of less favourable surveying nights. However, high anuran species turnover has been documented in several regions in the U.S., Canada, and Brazil (Hecnar and M'Closkey 1996; Trenham et al. 2003; De Solla et al. 2006; Werner et al. 2007; Tavares and da Silva 2019). Simply augmenting survey effort within one or two years would not be sufficient to address turnover dynamics and capture the true anuran species composition of any particular wetland habitat.

Clear differences between individual species calling behaviors, detectability, and population dynamics are also important considerations. The nine anuran species detected in this study were not uniformly common in terms of detection frequency. Consistent with previous studies, this analysis found lower rates of occupancy for pickerel frogs (Crouch and Paton 2002). The pickerel frog is reported to be difficult for observers to reliably detect, due in part to its similarity to other species, the lower call volume, and general species rarity in certain areas (Lepage et al. 1997; Genet and Sargent 2003). Not only was it reported in the lowest number of study sites, but it was only detected an average of 18% of monitoring years at sites where it was recorded at least once, a much lower interannual detection rate than any other anuran species included in this study.

Occupancy was also low for wood frogs, western chorus frogs, and American bullfrogs. Crouch and Paton (2002) reported similar results in their study, wherein spring peepers, gray treefrogs, and green frogs were detected at higher rates than wood frogs and American bullfrogs. The history of the American bullfrog in Southern Ontario may also have played a significant role in the occupancy records and detection rates in the Birds Canada dataset. Despite occurring naturally in Southern Ontario, intensive hunting and human habitat modification contributed to widespread local extirpation and patchy distributions. Population rebounds and recolonization may be limited by intense landscape fragmentation and land use change, making comparisons to other, less directly impacted anuran species with widespread remnant populations, difficult. Both wood frogs and western chorus frogs breed explosively in the early spring, and also overlap with loud choruses of spring peepers (Crouch and Paton 2002; Genet and Sargent 2003; De Solla et al. 2005), likely making consistent detection more difficult.

For relatively low-occurring species, if rarity and not detectability was the greatest limitation, then modestly high interannual detection rates at those sites with confirmed occurrences would be expected, but that is not the case. Wood frogs, leopard frogs, western chorus frogs, and pickerel frogs had interannual detection rates of less than 50%, oftentimes more than 20% lower than the occupancy rates across all sites. This does not explicitly point to detectability as the cause of the lower observed interannual detection rates, but given the various well-documented challenges with detecting those species (see Lepage et al. 1997; Crouch and Paton 2002; Genet and Sargent 2003; De Solla et al. 2005) it would suggest that detectability does seem to be an issue for some cryptic and easily mis-identifiable species, requiring additional survey effort.

The strongest evidence for strong extirpation-recolonization processes comes from the results for widespread species such as the spring peeper, gray treefrog, and green frog. For these easily detectable species with long calling periods (Bird Studies Canada 2008) average interannual detection rates were lower than occupancy rates, suggesting that even for the least cryptic species, some process is preventing consistent and reliable interannual detection. The most reasonable culprit is species turnover as a result of natural or induced local extirpation-recolonization processes. This is especially likely for species that dwell in ponds year-round and would be difficult to miss such as the green frog and American bullfrog (Hecnar and M'Closkey 1996).

3.4.2 *Monitoring Significance*

Anuran acoustic survey designs aim to accommodate the biological patterns of their target species. The Marsh Monitoring Protocol for anuran surveying incorporates important considerations related to time of year, time of day, weather, and disturbance (i.e. ambient noise) (Bird Studies Canada 2008). Several pieces of research have validated the reliability of this design in capturing within-year species occupancy (Shirose et al. 1997; Genet and Sargent 2003), but rarely has literature addressed the well-documented issues of high anuran species turnover (Hecnar and M'Closkey 1996; Trenham et al. 2003; de Solla et al. 2007; Werner et al. 2007; Tavares and da Silva 2019). Anurans species populations particularly those in Ontario, behave as metapopulations and require connected habitat matrices to travel between overwintering, breeding, and foraging habitats (Semlitsch 2008; Sinsch 2014). This landscape connectivity is also necessary to spread genetic diversity among population patches, mitigate stochastic extirpation events, and facilitate recolonization (Marsh and Trenham 2001). These well-recognized landscape processes are rarely reflected in the design of long-term monitoring programs. The species accumulation curves presented here suggest that 5 or more years of standardized acoustic monitoring surveys are required to surpass the 90% accumulated species detection threshold. This suggests that it may be more prudent to distribute limited monitoring resources across many years instead of concentrating them within a single year or two. If standardized procedures such as those outlined by the MMP protocol are followed correctly, then this should address issues of interspecies calling period variability, unfavorable weather conditions, observer bias, and extirpation-recolonization dynamics. Additional survey effort can be used to target species that are known to be rare, cryptic, and/or difficult to identify or detect such as the pickerel frog.

This paper, and others that have reported strong anuran species turnover, also emphasize the importance of connectivity for vulnerable species groups such as anurans. Short-term monitoring is likely insufficient to paint a comprehensive picture of species responses to habitat loss, fragmentation, and disturbance, especially when persistence is limited not by within-habitat quality, but by the ability of surrounding populations to recolonize habitat that experience natural and/or induced extirpation.

3.5 Conclusions

Anuran acoustic call surveys are an efficient and non-invasive technique for monitoring species occurrence. Variations in seasonal calling periods, ease of detection, calling behaviors, and turnover dynamics emphasize the need for ecologically guided monitoring programs to capture complete species compositions. Data from 66 long-term acoustic monitoring efforts across Southern Ontario showed differences between nine species' occupancy and detection rates, and clearly demonstrated the need for long-term monitoring to accumulate reliably complete pictures of anuran species composition.

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4.0 A tool for modelling anuran landscape connectivity through road crossing survival

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4.1 Introduction

The effects of road mortality on wildlife have seen increasing attention as evidence of its impacts on population persistence continue to be uncovered (Fahrig and Rytwinski, 2009; Beebee, 2013). Road mortality impacts wildlife not only through direct mortality to individuals but also through the interruption of crucial landscape movements that satisfy individual species' lifecycle needs and metapopulation dynamics (Forman and Alexander, 1998; Marsh and Trenham, 2001; Glista et al., 2008). The cumulative result of these effects is a complex but fragmented landscape in which individual pocket populations are subject to varying extents of physical and genetic isolation.

A wide range of mitigation measures have been developed and implemented to address the growing concerns over wildlife population integrity in areas that experience high rates of road mortality including wildlife underpass crossing structures and exclusion fencing (Glista et al., 2009; van der Grift et al., 2013). A commonly used tool to guide the implementation and placement of these mitigation measures is landscape resistance modelling (Zeller et al., 2012). In these models, each grid-square in a pixelated landscape is assigned a value which represents the resistance to movement. The resistance values are defined by the amount of energy required for a species to cross a pixel of specified land cover compared to the energy required to cross through ideal habitat. When executed, these models spread outward from a single or series of starting areas until the initial designated energy (determined by the maximum distance the species can travel) is expended.

Human infrastructure such as roads are typically assigned higher resistance values to account for the impacts of road mortality, contributing to reductions in the overall amount of accessible habitat in the resulting models. Although assigning higher resistances to land covers is appropriate for anthropogenic land covers such as parking lots, lawns, and open areas which can drain the movement energy of wildlife (Houlahan and Findlay, 2003; Patrick et al., 2012), it may not be a suitable technique for modelling road mortality on its own. Roads, particularly during inhospitable weather conditions (dependent on species), not only reduce the energy of wildlife, but also reduce the probability of successful crossing. In this case, the unaddressed component is that of exponential reductions in the probability of survival after crossing multiple roads and not one of linear loss of energy.

Among the taxa most threatened by road mortality are anurans (frogs and toads). Most post-metamorphic juvenile anurans move away from their natal ponds in large numbers in a critically important process known as dispersal that allows new wetlands to be colonized, depleted populations to be rejuvenated, and genetic information to be spread across the landscape (Sinsch, 2014). Unfortunately, dispersal is also understudied and poorly embedded in existing modelling approaches, despite representing the bulk of anuran mortality (Petrovan and Schmidt 2019). Mass mortality during dispersal is common because the movement is unguided/exploratory and involves frequent movement across roads in areas where transportation networks have fragmented anuran habitat (Lamoureux et al., 2002; Watson et al., 2003; Sinsch, 2014; Taylor and Paszkowski, 2017).

Curiously, most juvenile anurans will time their movements to correspond with favourable weather conditions during the night hours (Pomezanski and Bennet, 2018). What is typically a hostile land cover characterized by exposure, dryness, and heat during the daytime becomes a relatively barrier-free avenue for movement during rainy nights. In these cases, the energy loss associated with road surfaces is minimized. Despite these adaptations and resilience to energy loss, the threats of mortality from vehicle collision remain regardless of time of day or weather conditions (Glista et al., 2008; Eigenbrod et al., 2009; Carr and Fahrig, 2015). Our understanding of anuran dispersal timing, weather selection, and persisting road mortality risk is longstanding, yet resistance-based energy loss models applied to anuran connectivity have stubbornly persisted (Unnithan Kumar et al., 2022). A greater consideration for approaches that can model and isolate the exponential reductions in anuran road crossing survival during dispersal would be valuable for understanding where and how mitigation can be placed to improve dispersal success, enhance habitat connectivity, and reduce genetic isolation.

In this paper, we describe a modified cost surface Geographic Information System (GIS) tool that behaves similarly to a traditional dispersive landscape resistance tool but specifically isolates the multiplicative effects of vehicle collisions on road crossing survival. We compare these results to that of a traditional resistance tool by relating the amount of accessible marsh to the presence of six anuran species. We hypothesize that the road crossing survival (RCS) tool has comparable predictive power to traditional resistance (TR) tools and discuss opportunities for improvement and refinement for future applications.

4.2 Methods

4.2.1 Species and Survey Data

Data on anuran presence was taken from Birds Canada's Great Lakes Marsh Monitoring Program, a long-term database of anuran calling data. Anuran acoustic survey data was collected using a citizen science approach at a wide variety of wetland habitats across Ontario (Bird Studies Canada, 2008; Bird Studies Canada, 2018; data available at birdscanada.org/gl_mmp.). This database provided us with a large sample size of surveyed wetlands with long-term monitoring data. Due to the possible year-to-year variations in anuran detectability and presence, a single year or two of monitoring is likely to be unsuitable for adequately capturing the anuran species composition of a wetland (Pomezanski, 2021). Consequently, only wetlands with three or more years of acoustic survey data were deemed suitable for inclusion in this analysis. The monitoring years did not need to be consecutive. We also excluded wetlands that were part of larger, connected wetland complexes and whose boundaries were difficult to delineate because these wetlands might introduce unintended complexities to the landscape connectivity analysis. In cases where wetlands included more than one survey station, the acoustic data was combined.

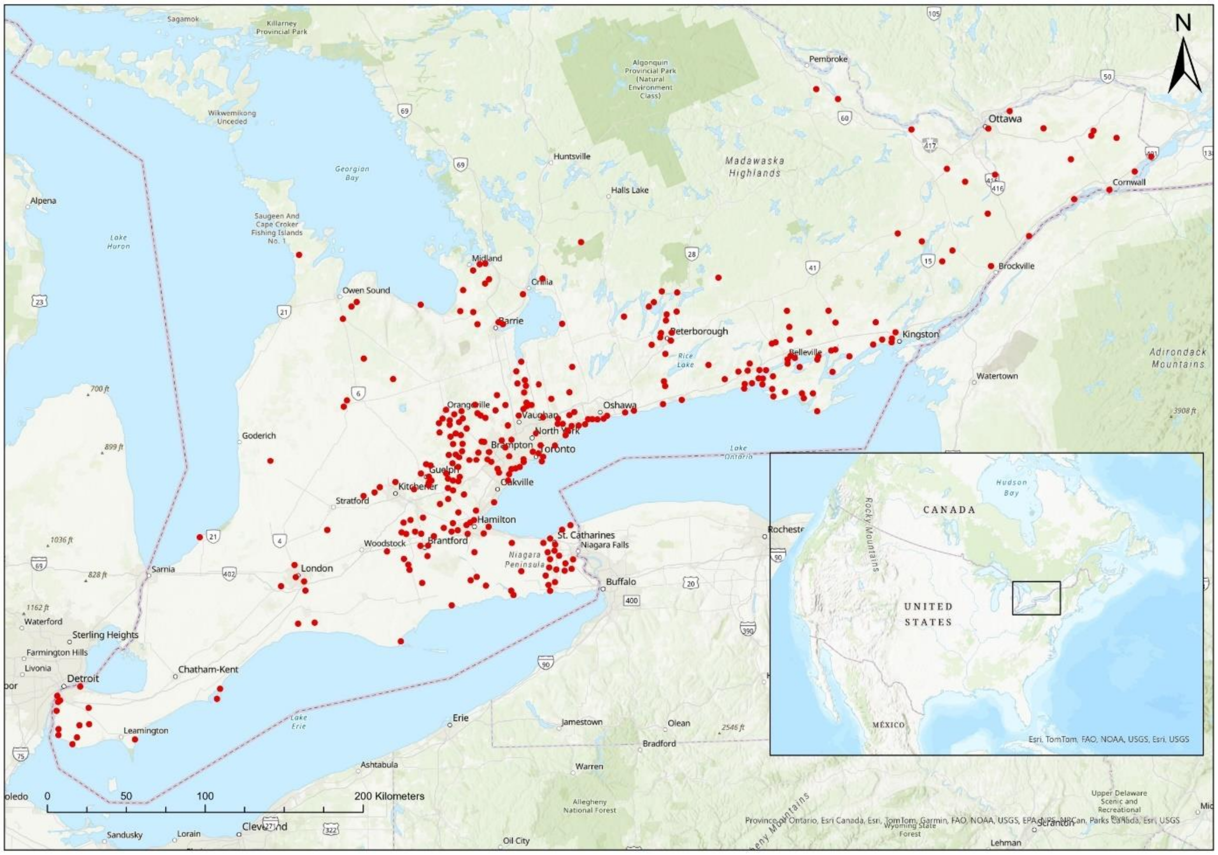

Figure 4: Locations of selected wetland study sites included in the RCS and TR models (n=290)

After applying the filters outlined above, 290 wetlands were identified as suitable for analysis, the locations of which are shown in Figure 4. For each suitable wetland, the presence and/absence of six commonly occurring and readily identifiable Ontario anuran species were recorded: wood frog (*Lithobates sylvaticus*), green frog (*Rana clamitans*), Northern leopard frog (*Lithobates pipiens*), American toad (*Anaxyrus americanus)*, gray treefrog (*Dryophytes versicolor*), and spring peeper (*Pseudacris crucifer*). A species was confirmed present at a site if more than one individual was recorded. A single calling individual was deemed unsuitable for confirming presence because of the increased chance of the record being an anomaly or a misidentification.

4.2.2 ***Land cover classification***

Wetland boundaries for each survey site were delineated manually by referencing both the Southern Ontario Land Resource Information System (SOLRIS) version 3.0 and the Ontario Wetlands vector dataset. Both datasets are publicly available via the Ontario GeoHub. The SOLRIS layer is a 15m resolution land cover raster which defines a variety of land covers including wetland types. Due to the slight, but sometimes significant differences between the SOLRIS raster and the wetland vector, satellite aerial imagery from Google Earth was also used to substantiate wetland boundaries in cases of notable disagreement between layers.

4.2.3 ***Road Classification***

The Ontario Road Network (ORN) vector layer, also available via the Ontario GeoHub, was rasterized based on the layer-defined road classifications to a 15m resolution. The ORN classifies roads based on road traffic intensity, width, and function, but it does not classify roads as occurring within urban or rural zones. I assigned a binary urban/rural sub-classification to these roads by creating "urban-influences zones" around built-up areas (delineated by the Ontario Built-up Areas vector layer) exponentially scaled based on the size of the built-up area polygon such that large urban centers extended their urban influence across a wider surrounding area to a maximum of 5000m from polygon boundary (See Equation 1). Roads that fell within the "urban-influence zones" were classified as urban, and those outside were classified as rural. This simple binary classification allowed us to differentiate between roads with the same functional ORN classification but divergent traffic intensities due to their proximity to areas of densely constructed infrastructure and provided an additional level of realism for our models.

Equation 1: Formula used to calculate the buffer extent of urban influence from the boundary of identified built-up area polygons. U = Built-up area polygon area (m^2)

$$Urban\ Buffer\ (m) = \left(\frac{\sqrt{U}}{Max\ U}\right) * 5000\ m$$

Average hourly traffic intensities based on road categorizations in urban and rural areas were taken from Hallenbeck et al., (1997). Although these average hourly traffic intensities were measured from roads in the United States, their road classifications are comparable to those used in the ORN dataset. Although anuran calling activity is most concentrated from sunset to midnight, movement takes place throughout the night as evidenced by camera trap data in wildlife tunnels in areas overlapping the geographical focus of this study (Pomezanski and Bennett, 2018). The seasonal window of anuran movement is quite wide, stretching from as early as March to as late as October, and therefore timing of sunrise and sunset varies widely. Nevertheless, since most individual anuran movement throughout the year is composed of mid-summer juvenile dispersal (see Pomezanski and Bennett, 2018), we only averaged the hourly traffic intensities between 21:00 and 5:00, which exhibit dark or darkening conditions during the juvenile dispersal period.

4.2.4 *Survival Rates*

We came across few references to anuran road crossing survivability based on varying rates of traffic intensity and derived from field-based measurements. Both Joly et al. (2003) and Bouchard et al. (2009) recorded road crossing survival by anuran species at varying rates of traffic, but only Joly et al. (2003) reported this relationship with more than two rates of traffic intensity, so we used it here to match hourly traffic rates to probability of road crossing survival. Despite the age and location of this study, we believe that the relationships between rates of road traffic and anuran survivability remain fairly consistent over time and space and can be applicable to the species and locations used here given the exploratory nature of this study.

Other studies such as Hels and Buchwald (2001) use a more indirect approach by modelling survivability using anuran movement speeds, tire widths, and hourly traffic rates, but we lacked the data on species-specific movement speeds to be able to implement this technique. Using the interpolated relationship between road traffic and survivability illustrated in Joly et al. 2003, we identified approximate survival rates for each road classification (Table 2: Road crossing survival rates for urban and rural roads based on road classification traffic rates. Inverse survival rates used for model execution are included in brackets.). The survival rates we identified are fairly consistent with those recorded by Bouchard et al. (2009) and those calculated by Hels and Buchwald (2001) when matching species based on their physiological similarities (e.g. American toads to Common toads). The relationship exhibits a negative exponential shape, potentially due to the behavioral phenomenon of crossing times increasing as traffic intensities increase (Bouchard et al., 2009).

Table 2: Road crossing survival rates for urban and rural roads based on road classification traffic rates. Inverse survival rates used for model execution are included in brackets.

Road Classification	Rural		Urban	
	Average Nighttime Traffic per Hour	Survival Rate, S_r ($1/S_r$)	Average Nighttime Traffic per Hour	Survival Rate, S_r ($1/S_r$)
Freeway	370	0.1 (10)	1318	0.0 (0)
Ramps and Expressways	181	0.25 (4)	547	0.0 (0)
Arterial	72	0.55 (1.818)	205	0.2 (5)
Collector	17	0.925 (1.081)	59	0.6 (1.67)
Local	3	1.0 (1.0)	6	1.0 (1.0)

4.2.5 ***Road Crossing Survival (RCS) Model***

The road crossing survivability tool we tested is a modified version of the r.cost function available in the Geographic Resources Analysis Support System (GRASS) software suite (original tool available at GRASS (2023)). The r.cost tool creates a raster surface map showing the cumulative cost of travelling from a source cell or collection of cells to each other cell within the computational area. When applied to wildlife movement, maximum costs can be specified to delineate movement extents for dispersing individuals. The primary input to this tool is a raster cost surface wherein each cell's value represents that cost of travelling through that cell's land cover.

The unmodified r.cost tool uses additive processes that calculate cumulative costs and assigns output cell values based on the minimum cost to travel there so as to allow for the determination of least cost pathways and lowest resistance movement corridors. We modified the tool in a single fundamental way: to use multiplicative processes instead of additive. In the modified RCS tool, each road cell in the input raster cost surface was assigned a value corresponding to the inverse of the survival rate for that type of road. Since the r.cost tool is built to identify and keep the lowest possible value (minimum) attainable at each cell, the survival rates in Table 2 needed to be inversed for the tool to function properly. Each non-road cell was assigned a value of 1 corresponding to a 100% survival rate, allowing the impact of road crossing mortality to be isolated for our analysis. After the RCS tool was executed for each of the 290 source wetlands each of the outputs were inversed separately to produce raster surfaces wherein each cell's value represented the maximum probability of reaching it from a source wetland.

No "maximum cost" was assigned in the RCS tool. Instead, we ran a separate resistance model for each site wherein each land cover was assigned a resistance value of 1 and only buildings were considered barriers that would require anurans to move around (see resistance values in Table 3). Large bodies of water such as lakes and rivers were also assigned slightly higher resistances to account for energy loss associated with swimming in waterbodies with currents (a resistance to movement which would be present regardless of time of day or weather conditions). The output extent of each resistance model was considered the maximum possible dispersal extent of any anuran species when accounting for ideal dispersal conditions characterized by rain, humidity, and darkness. Previous studies have identified different maximum dispersal distances for anuran species. Of the species examined in this study, the Northern leopard frog has potentially the farthest recorded dispersal distance of around 5km (Seburn et al. 1997; Carr and Fahrig 2001; Patrick et al. 2012). Several of the other species have maximum dispersal distances within the 1km to 3km range (Patrick et al. 2006; Baldwin et al. 2006; Patrick et al. 2012). Given the range of possible maximum movement distances, we executed these resistance models with three maximum distances – 5000m, 2500m, and 1000 m - with the aim of identifying whether maximum distance affects the performance of the models in this study. We clipped the RCS tool outputs with their associated maximum dispersal extents for each site. Sites with no wetlands within the maximum movement extents or with wetlands with survival rates of only zero were assigned final values of zero.

We considered any marsh habitat to be a candidate destination for dispersing anurans because it is typically associated with standing water for a large portion of the breeding season, if not year-round. Swamps were not considered a candidate destination habitat because the SOLRIS and wetlands vector layers did not indicate where (or if) standing water was present, which is required for the selected anuran species' breeding habitat. The total number of marsh wetland cells (as classified by SOLRIS) within each dispersal distance at which the chances of arriving successfully were at least 50%, 25%, and 5% for each species was summed for each site.

We decided to test three rates of survival because there is a persisting uncertainty around which levels of dispersal success are required to consider a wetland functionally connected. Figure 5 details the RCS modelling process in a work-flow diagram.

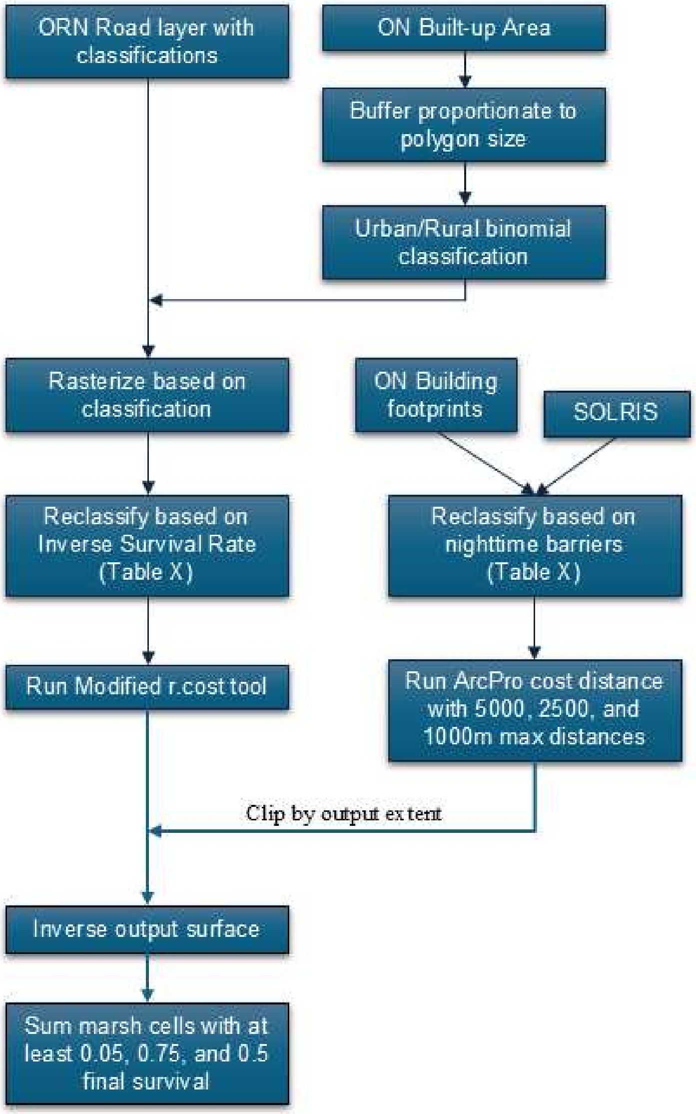

Figure 5: Work-flow diagram for the Road Crossing Survival (RCS) Model

4.2.6 ***Traditional Resistance (TR) Model***

For the TR model, we again used SOLRIS and re-classified each land cover by its resistance to anuran dispersal movement. Resistance values were partially derived from Patrick et al. (2012) and Compton et al. (2007). All land cover resistance values used in our landscape resistance model are included in Table 3. The TR models were run in ArcGIS using the “cost distance” function and conducted three times for each site using maximum dispersal distances of 5000m, 2500m, and 1000m for comparison with the road crossing survival tool. An example output is illustrated in Figure 6. The total number of marsh wetland cells (as classified by SOLRIS) within each dispersal distance and for each species after accounting for energy expenditure was calculated for each site.

Table 3: Land cover resistance values used for each the Traditional Resistance (TR) Model and the Road Crossing Survival (RCS) Model

Land Cover	Cost to Traverse 1 metre	
	TR Model	RCS Model
Forest	1	1
Wetland	1	1
Agriculture	3	1
Open Water	6	2
Developed (pervious)	3	1
Developed (impervious)	6	1
Alley/Resource Road	3	1
Local Road	3	1
Collector Road	6	1
Arterial Road	15	1
Expressway	30	1
Freeway	5000	1
Buildings	N/A	5000

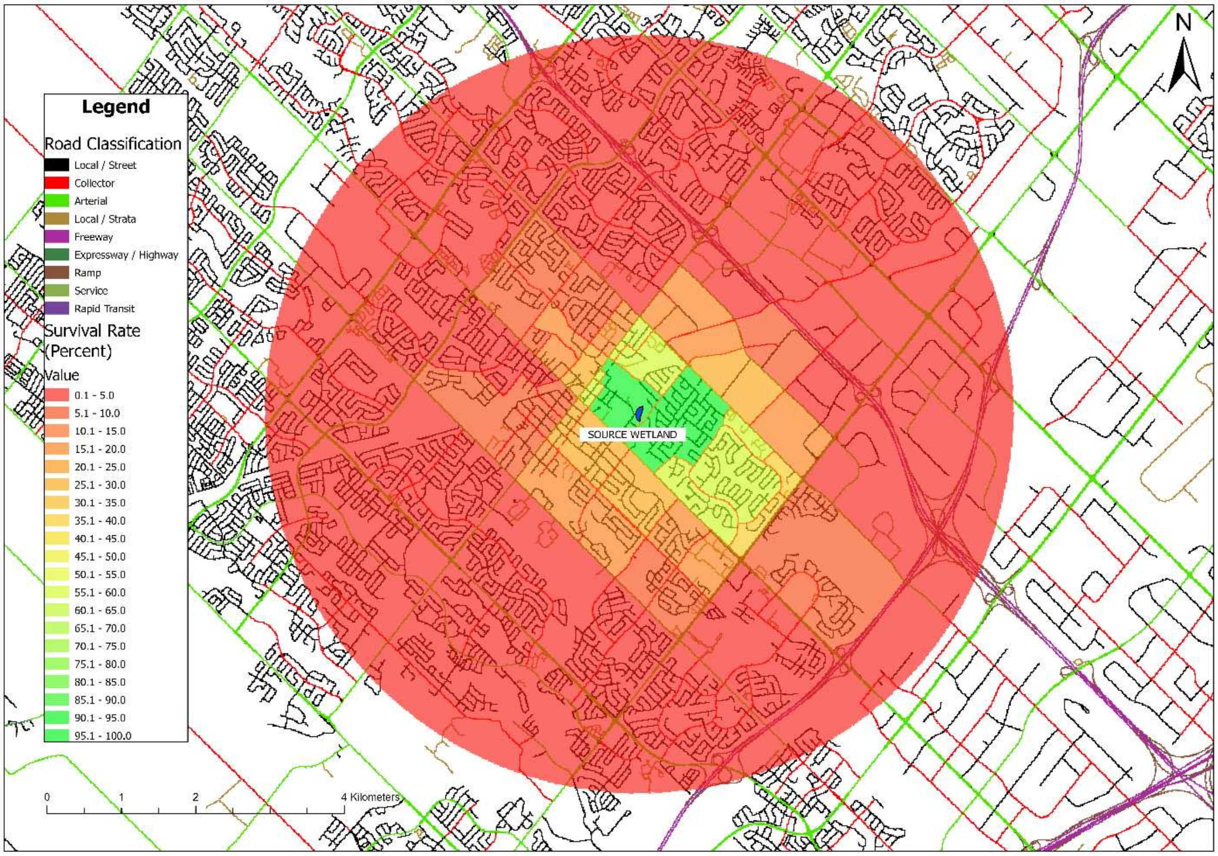

Figure 6: An example output for the RCS model showing the resulting survival probabilities in a 6km radius from the source wetland edge.

4.2.7 ***Statistical Analysis***

To test the strength of associations between anuran species occurrence and accessible marsh habitat, generalized additive models (GAMs) were constructed. Generalized Additive Modelling is a non-parametric approach to regression modelling that can accommodate a range of data distributions and possible non-linear relationships between predictor and response variables (Ravindra et al., 2019). This approach was deemed appropriate for this study in order to accommodate the uncertainty regarding the shape of the ecological relationships between anuran species occurrence and habitat availability. Furthermore, the GAM modelling approach is able to accommodate non-parametric characteristics of both the predictor and response variables allowing for more flexibility in the types of data that were used.

The “r” package “mgcv” was used to construct and analysis the GAMs (Wood, 2023). GAMs were run for each species, for each method (TR model-derived available marsh vs RCS model-derived available marsh), for each distance (1000m, 2500m, and 5000m) and each survival threshold (50%, 25%, and 5%). When modelling individual species occurrence, a binomial family was specified to reflect the nature of the response variables (i.e. 1 for presence, 0 for absence). Each habitat metric included in the GAM model was “smoothed”, which indicates to the program to use thin-plate regression splines to estimate non-linear relationships between predictors and the response where appropriate. The smooth functions were assumed to be smooth and continuous, controlled via penalization of wiggliness.

The upper bound for effective degrees of freedom (k) was set at 10 for all models to provide an upper limit to the complexity of the smooth without being overly restrictive. The value of “k” was verified for adequency using gam.check() in the mgcv package. Smooth terms with high estimated degrees of freedom approaching k-1 low k-index values, or significant p-values ($p<0.05$) would prompt re-fitting with increased k until diagnostic criteris were met and edfs stabilized. The binomial distribution family was used for individual species presence/absence GAMs with a logit link function. The restricted maximum likelihood (REML) method was used to estimate smoothing parameters as recommended by Wood (2011) for numerical stability.

The effective degrees of freedom (edf) was recorded for each smoothed term in the model output. An edf close to or equal to 1 indicates that the relationship is linear or close to linear. The higher the edf, the more non-linear or “wiggly” the relationship. For each smoothed term in the model, the p-value for approximate significance was recorded. The deviance explained (%) was recorded for all models instead of the adjusted r-square because of the binomial distribution specified in the. The Akaike Information Criterion (AIC) value was also recorded for each model and Delta AIC ($\Delta AIC = AIC_i - AIC_{min}$) was calculated to compare the models’ relative performance (Burnham and Anderson, 2002). Typically, a ΔAIC value of <2 suggest that the differences between the model and the best model are relatively small and/or indistinguishable. Given the uncertainties of the underlying ecological mechanisms and inputs for these models, and due to the exploratory nature of this study, we interpreted any model with a ΔAIC of between 2 and 4 as indicating moderate support for the models compared to the best model, and values of over 10 indicated no support for the model.[1]

4.3 Results

4.3.1 ***Study Sites***

The 290 sites (Figure 4) included in this study were distributed across two ecozones, with 98% of sites occurring within the mixed-wood plains ecozone. Representation of sites in the heavily agricultural areas of Southern Ontario that stretch from the Bruce Peninsula to Windsor and Lake Erie was lower compared to the areas with the Golden Horseshoe that are characterized by a mixed-use and urban landscape. Only five sites (~2%) were located within the Ontario Shield Ecozone which generally occurs north of Lake Simcoe.

The wetlands of study ranged widely in size from less than one hectare to more than 300ha (Figure 7a). About 58% of all wetlands were less than 10ha in area, and 17% were greater than 30ha, with 25% of sites between 10ha and 30ha. Consistent with the diverse geographical distribution of the sites included in this study, the landcover compositions surrounding each wetland exhibited a wide degree of variance. Within 3000m of each site, wetland cover (including swamp, marsh, bog, and fen classifications) typically varied between 5% and 35% of all landcover (Figure 7b). When limiting to the marsh wetland classification only, 95% of sites contained less than 15% wetland cover. Bogs and fens were relatively rare compared to marshes and swamps, contributing a negligible amount to the total wetland composition at the vast majority of sites. Forest cover followed a similar distribution to that of wetlands with 95% of sites containing less than 40% forest cover which included all types of forest such as deciduous,

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[1] The calculation of marginal effects in the GAMs is being made more explicit in the final draft manuscript based on this chapter

coniferous, mixed, plantation, and hedgerows (but not treed swamp). When adding together all wetland and forest land cover classifications, the distribution moved away from a left-skewed distribution to a normal distribution, with the highest proportion of sites containing 20-25% forest cover within 3000m (Figure 7c). Only 5% of sites contained more than 60% forest and wetland cover.

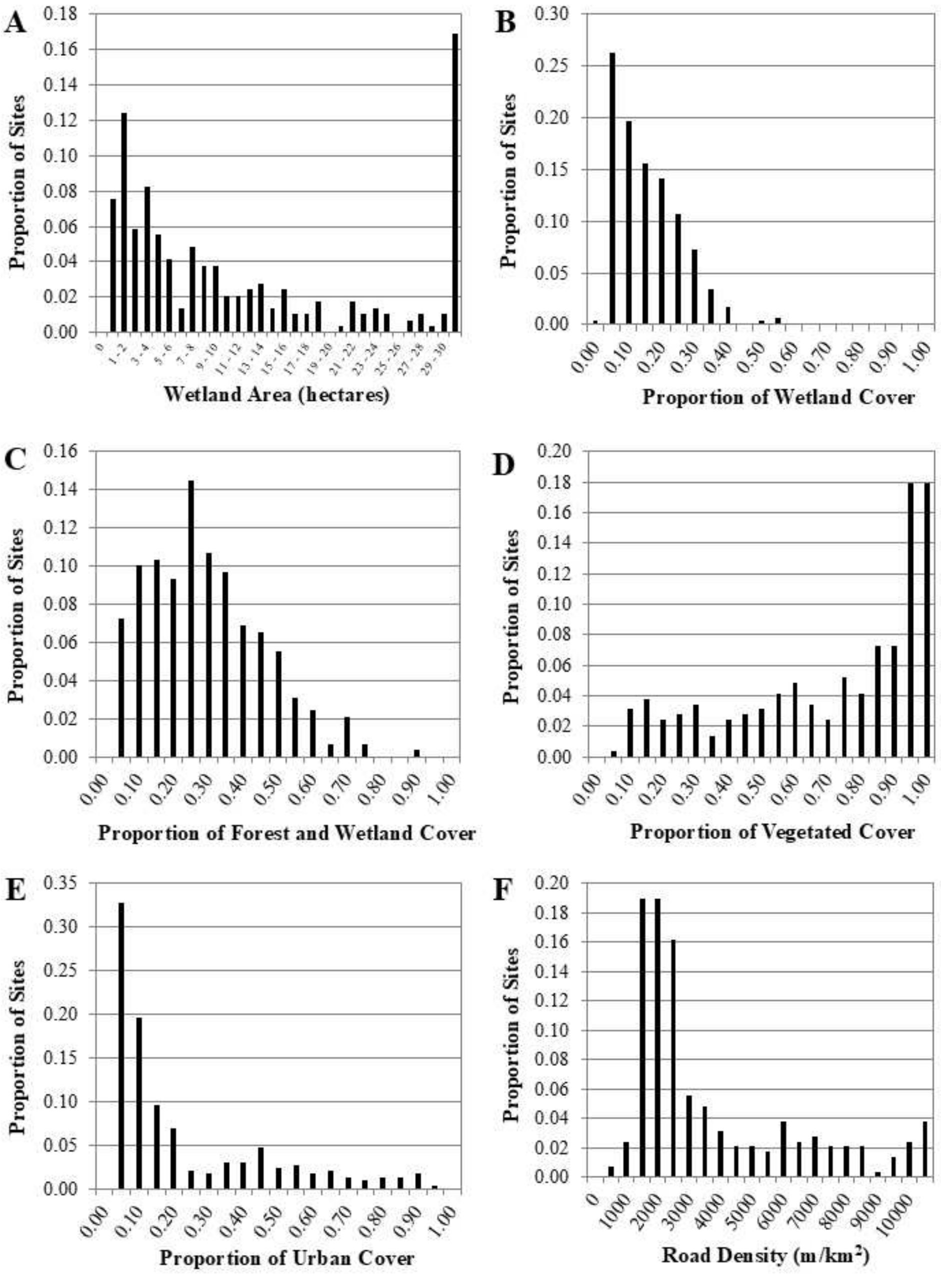

Figure 7: Study sites characteristics of the 290 wetlands included in this study. All total land covers (b-e) and road density (f) were calculated at 3000m radii from wetland edge

When considering all naturally vegetated and agricultural land covers, including undifferentiated classifications (idle land, brown fields, hydro corridors, thickets, forest openings), 36% of sites contained more than 90% vegetated land cover (Figure 7d). The remaining sites exhibited a fairly even distribution of vegetated/agricultural land cover. About 70% of the study sites contained less than 20% urban land cover, including both pervious and impervious as defined by SOLRIS (Figure 7e). Road density followed a similar pattern, with 54% of sites containing between 1000-2500 m/km2 of roads (Figure 7f).

4.3.2 ***Anuran Composition***

Anuran species presence was generally high across study sites. The green frog and American toad were the most commonly observed as being present based on acoustic surveys, occurring at 95% and 89% of sites respectively. The wood frog was the least frequently observed of the six study species, occurring at 60% of study sites. The leopard frog, spring peeper, and gray treefrog fell in between, occurring at 76%, 82%, and 78% of wetland sites respectively.

4.3.3 ***Monitoring Years***

Monitoring years took place from 1995 to 2019 with the years 2012 – 2017 most frequently monitored at the selected study sites. The number of sites with years monitored before 2012 decreased steadily from 2012 - 1995 and decreased forward in time from 2017 – 2019 (Figure 8a). About 20% of all selected study sites were monitored for 4 years or less, and 80% of sites were monitored for 12 years or less (Figure 8b). The most frequently surveyed sites had 25 years of monitoring data, but this only applied to 3 of the sites.

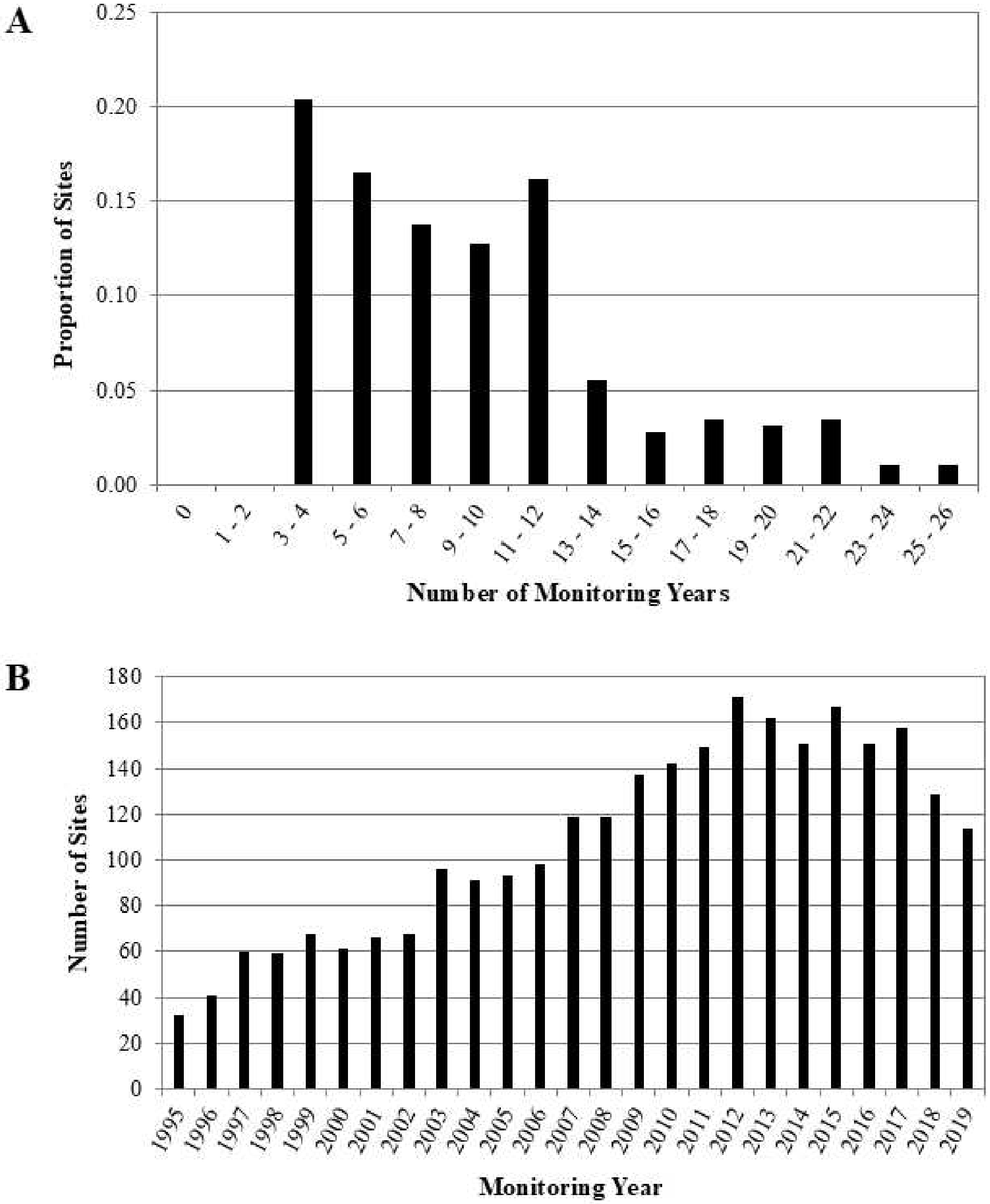

Figure 8: Distribution of the number of monitoring years for all 290 study sites (a) and the frequency of years monitored (b).

4.3.4 Model Performance

Generalized additive model results are summarized in Table 4 using the deviance explained (DE) values for each model. DE values were generally highest for the models with 5000m maximum dispersal distance for the green frog, spring peeper, and gray treefrog. There was no consistent effect of maximum dispersal distance for the remaining three species. DE values were generally lowest for the American toad and the wood frog and highest for the two hylids. The TR models had the highest DE values for the gray treefrog and the green frog at the 5000m maximum dispersal distance as did the RCS models using a 5% survival cutoff.

Table 4: Deviance explained values for the generalized additive model (GAM) results for each species and model combination. . GRFR = green frog, WOFR = wood frog, LEFR = Northern leopard frog, AMTO = American toad, SPPE = spring peeper, GRTR = gray treefrog

Model		**Deviance Explained (%)**					
Maximum Dispersal Distance	**Connectivity Model Method**	**GRFR**	**WOFR**	**LEFR**	**AMTO**	**SPPE**	**GRTR**
5000m	TR	15.5	3.0	6.2	1.0	18.9	22.8
	RCS: 5% Survival	8.8	2.5	4.9	0.1	19.8	22.0
	RCS: 25% Survival	5.1	4.0	5.1	0.0	20.9	20.3
	RCS: 50% Survival	6.4	3.1	5.3	0.0	19.2	17.7
2500m	TR	9.1	5.1	8.8	0.9	12.9	15.5
	RCS: 5% Survival	6.6	2.3	6.1	2.3	9.5	13.3
	RCS: 25% Survival	6.5	2.5	6.6	1.6	10.9	13.6
	RCS: 50% Survival	6.6	3.0	6.6	1.4	17.6	12.4
1000m	TR	5.6	3.1	7.7	1.7	3.6	5.5
	RCS: 5% Survival	6.3	2.2	7.7	1.9	4.9	8.2
	RCS: 25% Survival	6.3	2.2	7.6	1.9	4.9	8.1
	RCS: 50% Survival	6.3	2.2	7.6	1.9	4.9	8.1

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Generalized additive model results are summarized in Table 5 using the ΔAIC scores to determine which models were reasonably similar to each other. All GAMs which included American toad were indistinguishable from one another, demonstrating no support for either the TR models or RCS models. The 5000m resistance model was the best performing for the green frog but was relatively similar in explanatory performance to the 5000m RCS model at the 5% survival rate cutoff. TR models performed substantially better than the RCS models for both the wood frog and Northern leopard frog. For the two hylids, the TR and RCS models performed best at the 5000m distance. For the spring peeper, RCS models at 5000m outperformed the TR model with the top models using the 5% and 25% survival rate cutoff. For the gray treefrog, the 5000m TR model and 5000m 5% RCS model performed similarly. In general, RCS model performance for the gray treefrog decreased as the survival cutoff rate increased from 5% to 50%.

Table 5: ΔAIC values for the generalized additive model (GAM) results for each species and model combination. GRFR = Green frog, WOFR = Wood frog, LEFR = Leopard frog, AMTO = American toad, SPPE = Spring peeper, GRTR = Gray Treefrog. Values that are bolded with an * indicate ΔAIC values of <4, ** indicates a ΔAIC value of 4-10.

Method		**Species**					
Maximum Dispersal Distance	**Connectivity Model Method**	**GRFR**	**WOFR**	**LEFR**	**AMTO**	**SPPE**	**GRTR**
5000m	TR	0	9.80**	7.00**	**2.10***	5.90**	0
	RCS: 5% Survival	**3.80***	14.30	11.10	**1.40***	**3.20***	**2.40***
	RCS: 25% Survival	8.90**	9.90**	10.40	**1.50***	0	7.90**
	RCS: 50% Survival	7.00**	11.70	10.00	**1.50***	4.90**	16.00
2500m	TR	**3.50***	0	0	**2.10***	16.40	15.30
	RCS: 5% Survival	6.80**	7.00**	7.20**	**0.40***	26.60	23.20
	RCS: 25% Survival	6.90**	6.50**	5.50**	**1.40***	22.80	22.40
	RCS: 50% Survival	6.80**	5.50**	5.70**	**1.70***	**3.40***	26.20
1000m	TR	8.20**	6.40**	**1.90***	0	38.50	42.70
	RCS: 5% Survival	7.20**	13.50	4.10**	**0.80***	39.40	43.50
	RCS: 25% Survival	7.20**	13.40	4.10**	**0.80***	39.40	43.60
	RCS: 50% Survival	7.20**	13.40	4.10**	**0.80***	39.40	43.60

4.4 Discussion

Although the generalized additive model results differed between the six species included in this study, in general the top-performing RCS models performed similarly to the TR models. Unsurprisingly, the highest explained deviances across all models and species were quite modest (maximum of ~23%) since anuran species occurrence is also determined by a wide array of additional local and landscape factors such as hydroperiod, predators, and land cover composition (Porej et al., 2004; Burne and Griffin, 2005; Herrmann et al., 2005; Chandler et al., 2015). Nevertheless, Hermann et al., (2005) previously demonstrated similar maximum amounts of explained variance for the spring peeper and other amphibian species occurring in Ontario using surrounding forest cover as measure of landscape fragmentation, lending credence to the potential for the RCS tool in this for use in modelling connectivity. In addition, since the RCS tool was only modelling a single component of landscape connectivity (i.e. road induced mortality) and still managed to obtain levels of explained variance to those obtained using more wholistic measures of landscape suitability (i.e. forest cover), adding additional local and landscape model components would certainly lead to even greater explanatory performance.

One of the main assumptions in conducting this study is that under the weather conditions specifically selected by anurans for long-range juvenile dispersal, road surface resistance is no different than the resistance offered by any other land cover typically considered "favourable". In fact, we suspect that a wetted road surface at night may facilitate farther and faster movement in the absence of surface-level debris, dense vegetation, and micro-topographical variation that can require greater energy expenditure to navigate through. The approach of assigning high friction values to road surfaces in TR modelling is likely meant to represent road mortality in a basic sense, but risks overestimating connectivity and including wetlands which anurans have a near zero percent chance of reaching when considering the exponentially driven reduction in survivability when crossing multiple roads. We emphasize that TR modelling approaches use a linear additive approach, which cannot adequately address the multiplicative nature of road crossing survival no matter which resistance values are used for the road surfaces.

Perhaps the most fundamental differences between the TR and RCS modelling techniques tested in this study are the methods by which the resistance and survival values can be derived. Most resistance models have relied on friction values derived from expert opinion (Zeller et al., 2012, Unnithan Kumar et al., 2022), which present challenges both in terms of their consistency and in their susceptibility to observational bias (Cushman, 2006), although recently there has greater emphasis on techniques that use empirical movement data (e.g. telemetry, genetic) to create resistance surface (Zeller et al., 2012). The RCS tool is able to incorporate empirically sourced values relating to the relationship between traffic intensity and the probability of crossing roads successfully. Unfortunately, there is limited validation for these relationships in published literature, and it is easy to understand why, given that anurans are small, difficult to track remotely, and typically move at night and in the rain when observation is challenging. Controlled experiments would likely be less representative of real-life behaviours unless intricate care was taken to replicate the conditions that facilitate dispersal and migration (Mazerolle et al.

2005). Survival rates can be calculated by using simpler anuran physiology such as average movement speed and body size to calculate the probability of survival based on vehicle frequency, road width, and vehicle footprint as demonstrated by Hels and Buchwald (2001), but this would require detailed species-specific data on anuran crossing speeds and vehicle composition. Furthermore, these calculations would likely not include induced behavioural effects such as road hesitance, a problem that also arises when developing resistance surfaces (Unnithan Kumar et al., 2022). Nevertheless, in the absence of validated field results, these calculations present a reasonable avenue for future research as our understanding of each individual component (e.g. anuran movement speeds, traffic patterns) can be improved.

An advantage of a road crossing survival tool that we want to emphasize is that it can provide an output which can be readily understood and interpreted in the context of connectivity. From a metapopulation perspective, a certain success rate of anuran dispersal into a breeding habitat is required to not only replenish depleted population numbers but also to maintain genetic diversity and build population resilience (Marsh and Trenham 2001; Harper et al. 2008; Sinsch 2016). By producing an output that can be directly linked to the number of individuals that can successfully travel from one breeding habitat to another, we produce a metric better suited for the identification of conservation objectives. An output that allows us to communicate, for example, that at least 5% of dispersing anurans need to be able survive the journey between wetlands to maintain resilient genetic connectivity is a simple yet effective goalpost for those who are involved in making decisions about land cover alteration. Since anuran dispersal is a mass movement event that plays an outsized role in maintaining regional genetic connectivity, mass road mortality plays an equally outsized role in determining the success of dispersal and metapopulation connectivity more widely (Petrovan and Schmidt, 2019). With the RCS modelling approach – which this analysis shows to perform similarly to the widely accepted TR modelling approach for certain species – we can explore specific survival thresholds as we did in this study and provide readily interpretable recommendations to stakeholders involved in land management, planning, and landscape design. Although there was inconsistent support for any one survival cutoff rate over another in the models we examined, results from the strongest performing models suggest that a 50% survival cutoff rate is too low of a threshold to affect species persistence.

The GAM results demonstrated that the RCS tool performed similarly to the TR tool for predicting hylid species presence, but both methods had reduced predictability for Ranids and Toads. The presence of spring peeper and gray treefrog exhibited stronger relationships to all model outputs possibly due to the usage of marsh as suitable destination (discussed below) or greater susceptibility to vehicle collision. In their post-metamorphic juvenile stage, both species are extremely small and difficult to detect by drivers, are able to easily climb over any roadside barriers using their padded feet, and may take longer to cross roads given their size. Spring peeper presence in the Great Lakes Basin has previously been identified as suitable for use as an indicator species (Price et al. 2007), making them and similar species such as the gray treefrog potential candidates for modelling the effects of road mortality on overall species richness and other metrics of habitat quality in landscapes of interest.

Conversely, the presence of the American toad was not significantly related to any of the model outputs used in this study and in general does not exhibit significant positive relationships with most landscape habitat or connectivity metrics in the literature (Lehtinen et al. 1999; Houlahan and Findlay 2003; Rubbo and Kiesecker 2004). This is likely due to it being a generalist species and being better adapted to atypical and drier microhabitats commonly present in agricultural, residential, and urban settings. The breeding limitations of American toads are also not as strict as those of other species such as the wood frog, which shows a strong preference for ephemeral breeding ponds (Homan et al. 2004; Porej et al. 2004).

Potential Refinements

Our study relied on the assumption that road traffic intensities were the same across all roads of the same classification. Since the geographic extent of our study sites was broad and overlapped with thousands of individual road segments across Southern and Eastern Ontario, these assumptions were not only pragmatic, but necessary. However, local traffic conditions and patterns will certainly have varied substantially from many of our assumed levels, contributing to a reduction in model strength across all sites. Fortunately, for those looking at smaller areas to examine the effects of road mortality on habitat connectivity, the logistics of obtaining site-specific traffic data to include in an RCS tool are more realistic, aiding in model accuracy.

Important information about the surveyed sites was also incomplete. It is well noted that water depth, fish presence, and hydroperiod have a significant impact on anuran species composition and richness (Burne and Griffin 2005; Herrmann et al. 2005; Chandler et al. 2015; Porej et al. 2004). For instance, anuran species richness is generally suppressed in habitats with predatory fish (Lehtinen et al. 1999; Porej et al. 2004). Another example is the wood frog's preference for ephemeral ponds; a classification of wetland which is not included in SOLRIS because they are typically quite small, difficult to identify via certain remote sensing techniques, and may not reliably re-occur from year to year. This could be a contributing factor to the wood frog's weaker model performance in both the RCS and TR models compared to species like the spring peeper or gray treefrog. In our analysis, we also only included marshes as suitable wetlands for anuran breeding. Wetlands classified as swamps are likely to have ephemeral pools and smaller pocket wetlands, but this level of detail was not present in SOLRIS, and there was therefore no way of knowing whether the swamp areas within the processing extent actually included any standing water suitable for anuran breeding. For analyses with smaller geographic extents, targeted surveys of wetland boundaries, hydrological characteristics, and wildlife community structure could improve RCS model performance.

Urban infrastructure may also play a role in altering the movement matrix for certain anuran species. Structures such as fences, road dividers, and concrete curbs may provide additional complexity by impacting movement pathways, accentuating mortality by preventing perpendicular movement across roads, and depleting energy by requiring non-linear routes through complex urban landscapes. We attempted to include some of this complexity in our models by using building footprints as absolute barriers, but smaller urban structures and infrastructure remain unaccounted for. Most studies using resistance models do not even attempt to include building footprints, which can reduce model relevance in urban settings.

4.5 Conclusions

The road crossing survival tool tested in this study is a simple but effective way to model the isolated effects of road mortality on a landscape scale. Our analysis revealed that it performs similarly to traditional resistance modelling tools when examining the relationship between the metrics for connectivity and certain anuran species occurrence, but it can also be further refined to potentially improve model strength and contextual accuracy. Future avenues of research should examine the relationship between traffic intensity and probabilities of survival for anurans (and other amphibians and reptiles) in greater depth to provide researchers with the quantifiable survival rates needed to model road mortality. Model strength can also be improved by collecting local details related to wetland characteristics, road traffic, ephemeral wetland presence, and anthropogenic barriers to movement. As efforts to reduce habitat fragmentation continue to progress globally, tools designed to specifically address the impacts of road mortality will be incredibly valuable to guide mitigation and understand the true impacts of infrastructure design.

4.6 References

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5.0 Design and Assessment of Habitat Connectivity Metrics for Anurans

5.1 Introduction and Objectives

Anurans are considered biological indicators in their respective ecosystems due to a variety of environmental sensitivities and range of habitat needs (Dixon et al., 2011; Sumanasekara et al., 2015; Amarasinghe et al., 2021). As amphibious species, they require aquatic habitats to breed and develop during their early tadpole stages. As newly transformed juveniles and adults, they require terrestrial habitat like forests and meadows for foraging and overwintering. Although each anuran species has different degrees of dependence on these habitats and varying habitat preferences, strong relationships with general landscape characteristics have been established. In Eastern North America, the amount of forest cover surrounding breeding wetland habitat is a commonly identified variable in the top-performing models for predicting individual anuran species occupancy, explaining between 7 – 29% of variance in single-variable models depending on species (Hermann et al., 2005; Barrett et al., 2016; Collins and Fahrig, 2017; Sauer et al., 2022; Simpson et al., 2021). Adjacent urbanization in the form of road density or proportion of urban land cover is also a widely identified predictor of anuran species occupancy (Guderyahn et al., 2016; Grenat et al., 2023; Marsh et al., 2024).

In fragmented landscapes, such as those present across much of Southern Ontario, and North America more broadly, roads, urban infrastructure, and other anthropogenic land cover changes introduce a range of challenges for anurans that travel between habitat patches (Cartwright et al., 2021; Jones et al., 2024). These landscape disturbances can result in reductions in anuran species occupancy over time as are become more isolated and habitat less accessible (Laufer and Gobel, 2017; Arntzen et al., 2017; Wright et al., 2020). Anuran occupancy data (i.e. presence and/or absence of a species from any particular wetland) can be used to infer functional connectivity and be used in a variety of connectivity and movement modelling approaches (see as examples Berlow et al., 2013; Hamer et al., 2021; Vimercati et al., 2024).

For anurans, connectivity modelling has in large part focused on the theory of land cover resistance, the idea that certain land covers are more conducive to movement, while others – through introduction of mortality risk or environmentally unfavourable conditions – resist movement by depleting individuals' energy reserves (Zeller et al., 2012). Resistance-based approaches have been applied to anuran landscape connectivity modelling for some time (see Ray et al., 2002 and Joly et al., 2003 for early examples) and are still widely used. In recent years, circuit-theory based approaches have gained popularity for their ability to incorporate multiple source/destination habitats, produce regional connectivity maps, and identify movement corridors between critical habitats (Zeller et al., 2012; Cayuela et al., 2020; Unnithan Kumar et al., 2022).

Despite the widespread usage of these tools and the application of their findings to various scales of land management, they may not be properly tailored to model anuran movement dynamics. Anurans lack well developed long-range navigational senses, particularly when they are in their newly transformed juvenile stage when they instinctually and directionally disperse from their natal ponds(Semlitsch, 2008, Sinsch, 2014). They also do not always actively select the least resistant adjacent land cover during movement, as evidenced by their frequent encounters on hostile urban land covers (e.g. roads, open urban spaces) when adjacent land covers such as forest and meadow are present as options (Graeter et al., 2008). While some evidence of path-following has been presented for adult anurans during migration to or from overwintering habitat (Sinsch, 2014; Joly 2019; Cayuela et al., 2020), these pathways are only able to be remembered and followed by adults if they can be reasonably discovered by dispersing juveniles following directional and auto-correlated movement trajectories through complex human-altered landscapes in the first place (Unnithan Kumar et al., 2022). For this reason, movement corridors identified by resistance modelling may not be ecological meaningful for anurans if they are applied as sinuous or indirect pathways, are long and narrow in shape, or require assumptions of complex environmental/behavioural responses to land cover.

For anuran movement modelling approaches to be most effective, they need to incorporate the movement behaviours characteristic of various life stages (themselves determined by anuran physiological state and spatio-temporal environmental variation) which are currently absent from the most commonly used resistance models (Unnithan Kumar et al., 2022). This means designing and testing connectivity metrics that reflect the movement of slow-moving individuals with no understanding of long-range land cover, auto-correlated directional dispersal, limited precautionary responses to hazards such as road traffic and hostile land covers, and proven preference for avoiding movement during energy-depleting weather conditions. As a species group with notably different life stages, movement dynamics, and habitat requirements, crafting modelling approaches that adequately consider these complex processes is essential for identifying effective corridors and planning for ecologically connected landscapes.

In this Chapter, I will detail the construction and testing of several connectivity and habitat metrics as they relate to six anuran species widespread in the province of Ontario, Canada. The first connectivity metric captures juvenile anuran movement behaviours/patterns during dispersal from natal habitats to surrounding wetlands. The second metric considers the accessibility of forest cover surrounding breeding wetlands for overwintering habitat. The third connectivity metric uses only the risk of vehicle-induced mortality while crossing roads to quantify the functional connectivity of surrounding wetlands. Using a large repository of anuran acoustic collected over more than two decades across more than a thousand sites, I compare the performance of these exploratory metrics and comment on their design and improvement, as well the implications for wider habitat connectivity management.

5.2 Methods

5.2.1 Study Area

The study area for this analysis occurred in the Southern half of Ontario stretching from Windsor in the southwest to Ottawa in the northeast. The natural areas in this region are characterized by Carolinian Forests in the south and Great Lakes-St. Lawrence Forests in southern, central, and eastern Ontario. Much of the region in southwestern Ontario has been cleared for agriculture and urban development over the last few centuries, reducing the number of wetlands in those areas by as much as 85% (Walters and Shrubsole, 2003; Penfound and Vaz, 2022). Further north as soil conditions become less favorable for agriculture, forest and wetland landscapes are larger and more intact.

Urbanization, sprawl, and expansion of road networks are common occurrences in the area of Southern Ontario focused on in this study. As the population in Ontario continues to grow, this trend is expected to continue, putting greater pressure on remnant forest and wetlands in areas of heavy existing anthropogenic influence as well as intact landscapes where expansion of development is planned (Bourne and Gad, 1972; Caldwell et al., 2022). Road networks in the area are extensive and varied in their magnitude of traffic intensity. Several large freeways cross through the Toronto metropolitan area, extending north through Barrie, west through London, Windsor, and Sarnia, and East through to Ottawa and the Quebec border.

The fertile Great Lakes-St. Lawrence Lowlands, a physiographic region characterized by deep soils and glacial features, is dominated by agricultural land in the southern area and a network of grid-like roads. To the north, the road systems continue through increasingly intact forests, often forced around the many lakes and rivers characteristic of the glacially influenced landscape where the population density is much lower.

5.2.2 Study Species

Of the 11 anuran species that occur across Ontario in meaningful numbers, only six were selected for analysis in this study due to their widespread distribution and easily distinguishable calls: green frog, wood frog, Northern leopard frog, American toad, spring peeper, and gray treefrog. The Fowler's toad was excluded because it occurs only in a small area of Ontario along the northern shore of Lake Erie and is not thoroughly widespread to warrant inclusion in this analysis. The Western chorus frog is adequately widespread, but is rather difficult to reliably identify by call, given that the spring peeper is far more common and has a similar vocalization (Crouch and Paton, 2002; de Solla et al., 2005; Genet and Sargent, 2003). The pickerel frog and mink frog are less common and less well known, which puts the reliability of their call identification and consistent detectability in question (Crouch and Paton, 2002; Genet and Sargent, 2003; Pomezanski, 2021). The American bullfrog, despite occurring naturally in Southern Ontario, has historically been targeted for hunting and affected by habitat modification, therefore it was omitted from this analysis to avoid complications with patchy distributions and confounding occupancy determinants.

5.2.3 Dataset

The data used in this research was taken from Birds Canada's Great Lakes Marsh Monitoring Program database which has been collecting data on anuran calling surveys since 1994 (Bird Studies Canada 2018; data available at birdscanada.org/gl_mmp.). The database includes anuran surveys from the Great Lakes basin in both the US and Canada and is collected primarily by Marsh Monitoring Program (MMP) volunteers. The survey follows a standardized protocol as detailed in the Marsh Monitoring Protocol document (Bird Studies Canada, 2008). The surveyed wetlands are non-randomly selected by users and include wetlands in Areas of Concern, but the reasons for selection vary depending on the objectives of the individuals selecting the survey sites. Nevertheless, given a minimum of three years of survey data, this standardized acoustic monitoring approach can sufficiently capture a wetland's species composition (Pomezanski, 2021). A total of 290 wetlands were chosen for inclusion in this analysis based on a series of selection criteria outlined in Section 5.2.4.

The selected stations/sites are surveyed three times per year, the exact timings of which vary according to location to account for the effect of latitude on temperature (see Table 6). Each of the three surveys has an optimal timing window and includes specific temperature, wind, and precipitation requirements.

Table 6: Timing of anuran calling surveys used in the Marsh Monitoring Program for amphibians

	Survey #1	**Survey #2**	**Survey #3**
South (south of the 43rd parallel)	1 – 15 April	1 – 15 May	1 – 15 June
Central (between the 43rd and 47th parallels)	15 – 30 April	15 – 30 May	15 – 30 June
North (north of the 47th parallel)	1 – 15 May	1 – 15 June	1 – 15 July

The first survey is conducted when air temperature is greater than 5 degrees Celsius and is meant to target the earliest calling anuran species (Western chorus frog, wood frog, and spring peeper). The second survey is conducted when air temperature is greater than 10 degrees Celsius and targets the American toad, Northern leopard frog, and pickerel frog. The third survey is conducted when air temperature is greater than 17 degrees Celsius and targets the gray treefrog, mink frog, green frog, and American bullfrog. The surveys are conducted when wind speeds are at or below 19 km/h (Beaufort Scale 3) and in the absence of persistent or heavy rainfall. Each station is surveyed for three minutes, and the survey is focused on a 100m half circle in front of the surveyor. Calls are characterized using three call level codes and abundance counts, although only presence/absence was used in this study (i.e. abundance was not considered in the response variable).

5.2.4 Survey Sites

The MMP amphibian calling data was accessed and downloaded in 2019 and included nearly 90,000 individual anuran call records across Ontario. The database required careful filtering ("data cleaning") in order to remove sites with insufficient data, unsuitable wetland types, and problematic landscape orientations for analysis. The following sections describe the rationale and procedures that were followed to filter the original raw anuran calling data.

5.2.4.1 Number of Survey Years

The sites included in the MMP database were surveyed for a wide range of years, with some only surveyed for a single year, and others surveyed for as many as 25 years. The most recent survey data is from 2019 as that was the year that the data was accessed. One or two years of anuran calling survey data is generally insufficient to get a complete picture of the anuran composition at any particular wetland sites due to a variety of reasons (Pomezanski, 2021), outlined below.

The first is that certain species' calls are quieter than others, which can lead to underestimation and/or exclusion of their presence in the database records (Bridges and Dorcas, 2000; Corn et al, 2000; Crouch and Paton, 2002). For example, the Northern leopard frog's calling period overlaps almost entirely with the spring peeper, but despite their smaller size, the spring peepers' calls are much louder and often are heard in full chorus. The overwhelming volume of a spring peeper chorus can easily mask the low and relatively quiet guttural snores that are characteristic of the Northern leopard frog's male breeding calls, therefore multiple surveys are needed to confidently determine presence or absence.

The second reason is that at least two of the species – Western chorus frog and wood frog – are known to begin breeding very early in the spring when ideal weather conditions can present themselves for short periods of time (Crouch and Paton, 2002). This makes their breeding window less predictable than the other species, whose calling windows are generally slightly longer allowing surveyors a greater opportunity to capture their presence during calling surveys (de Solla et al., 2005; Paszkowski et al., 2002). In the early spring, these ideal weather conditions are usually abrupt and characterized by light rain (or oftentimes fog/mist) and can emerge before surveyors are ready to survey. Although the timing windows specified in the MMP Protocol are generally accurate, year-to-year variations in spring and late-winter conditions can play a significant role in determining whether the first calling survey is able to capture the presence of these early breeding species.

The third reason relates to the natural process of anuran species turnover in the landscape context. Year-to-year variations in weather, hydrological conditions, disease, and other disturbance can cause individual wetland anuran populations to collapse if conditions for breeding or survival are not maintained (Hecnar and M'Closkey, 1996; de Solla et al., 2006). A particularly dry year, for example, may cause some wetlands to completely dry up which can threaten the survival of larval and juvenile anurans who remain water-dependent in their aquatic stage (Marsh and Trenham, 2001; Trenham et al., 2003). A landscape with many inter-connected wetlands of varying resistance to hydrological stress may contain several wetlands that act as sources of immigration in these situations, allowing for eventual re-colonization of depleted wetland sites (Gibbs et al., 2005). These local extinction-recolonization dynamics (or species turnover dynamics) may take several years, depending on the degree of connectivity and recovery of wetlands to hydrological stress (Marsh and Trenham, 2001; Semlitsch and Bodie, 1998), and during these times, single-year anuran calling surveys may fail to capture the typical composition of that wetland.

In consideration of all of these factors, any sites with less than three years of anuran calling surveys were omitted from the analysis. A previous exploration of anuran species accumulation using calling surveys found that a minimum of five years of monitoring is needed to reliably detect at least 90% of anuran species at a site (Pomezanski, 2021), but this included some of the less common and difficult to identify species that will not be included in this analysis. Accordingly, three years was determined to be a reasonable number of years to balance sample size (i.e. the inclusion of as many sites as possible for statistical power) and data accuracy (i.e. reliable species composition).

5.2.4.2 Type of Wetland

Although all types of naturally occurring wetlands were included in this analysis, anthropogenically created bodies of water such as stormwater ponds were omitted to avoid any confounding associations between surrounding landscape cover and species composition.

The shape and size of wetland was also a determinant in whether they were suitable for inclusion in this analysis. Each wetland required confident and reasonable boundary delineation for proper buffers and connectivity analyses to take place. Wetlands that were part of larger hydrological features such as river corridors or wetland complexes were omitted because their boundaries could not be clearly delineated using any of the spatial datasets used (described in Section 5.2.6) or satellite imagery. Extremely large wetlands were also omitted in order to minimize model confoundment. Some examples include Point Pelee, Rondeau Park, and Long Point, which sprawl across a wide area and are bounded on several sides by a major body of water. These determinations were made on a case-by-case basis during initial filtering.

5.2.5 Response Variables

The primary response variables used in this analysis were individual species presence/absence of the previously identified six species. Given the causal link between reduction in landscape permeability and anuran species persistence (Arntzen et al., 2017; Wiewel et al., 2023), anuran occupancy data (i.e. species presence or absence) was deemed a suitable response metric. Species presence was confirmed and noted if at least two individuals of that species were recorded over the course of all of the surveys for that particular wetland. If only one individual was recorded (i.e. a calling level code of 1 with only one estimated individual calling), it was deemed to be insufficient to confirm species presence because some species calls, particularly when they occur singularly, can be confused with bird or insect vocalizations.

In cases where there were multiple monitoring stations per wetland, results were combined to determine the species composition and species presence/absence of that particular wetland. Although this means that survey effort is variable across the monitoring sites, a site with more than one monitoring station is usually indicative of a larger wetland requiring greater survey effort to reliably capture species composition.

The choice to use presence/absence of anuran species as a response variable was driven by the desire to model anuran species persistence as opposed to finer population responses.

Anurans have a range of tolerances with regards to habitat loss and degradation and can persist in smaller populations numbers for quite some time in suboptimal landscapes (Hamer and McDonnell, 2008; Metzger et al., 2009). In this study, the objective was to explore and identify landscapes in which these populations can no longer persist as a result of insurmountable interruptions to life history processes. By requiring survey sites to have at least 3 years of monitoring data and excluding single records from being counted as a confirmed presence, I assert that absence of any of the six species was adequately and reliably determined in general.

5.2.6 Spatial Data

This analysis required careful consideration of landscape composition and structure. Previous explorations of the relationships between anuran presence or abundance and landscape composition have identified forest, wetland, and urban land cover as important drivers (Knutson et al., 1999; Houlahan and Findlay, 2003; Porej et al., 2004; Burne and Griffin, 2005). Table 7 details a list of the spatial layers used in this study to incorporate these important landscape covers in this analysis.

Table 7: Spatial layers accessed and used for producing connectivity and landscape composition metrics

Dataset	Description	Source
Southern Ontario Land Resource Inventory System (SOLRIS)	Raster layer with 15x15 metre pixels representing dominant land cover. Extends throughout Southern Ontario	Ontario GeoHub
Wetlands (Vector Boundaries)	Vector layer delineating wetlands across the entire province of Ontario	Ontario GeoHub
Wetlands (Satellite Imagery)	Satellite imagery used to validate and adjust wetland boundaries in cases of disagreement	Google Earth
Ontario Road Network (ORN)	Vector layer of all roads in Ontario with categories of road classification	Ontario GeoHub
Ontario Built-Up Areas	Vector layer showing the boundaries of large, relatively uninterrupted built-up (typically urban) areas	Ontario GeoHub
Building to Scale	Vector layer outlining the footprints of all permanent buildings in Ontario.	Ontario GeoHub

	Only structures that have one dimension larger than 50 metres are included.	
Individual municipalities and regions building footprints: • Brampton • Brantford • Burlington • Durham Region • Guelph • Halton Hills • Hamilton • Kingston • London • Mississauga • Niagara Falls • Oakville • Orangeville • Ottawa • Peteroborough • Simcoe County • St. Catherines • Toronto • Kitchener-Waterloo-Cambridge • Welland • Windsor • York Region	Vector layers outlining the footprints of all permanent buildings (no size restriction).	Various municipalities' and regions' GIS portals

The primary dataset that was used in this analysis was the Southern Ontario Land Resource Inventory System (SOLRIS), which divides the landscape of Southern Ontario into 15x15m pixels and categories them based on their dominant land cover, a summary of which is included in Table 8. The SOLRIS dataset was the primary spatial layer used to delineate boundaries of the wetlands that were surveyed in the MMP database. Occasionally, wetland boundaries specified in the SOLRIS dataset did not match up well with the location of the monitoring stations so the vector wetlands dataset available via the Ontario GeoHub and satellite imagery available on Google Earth were used to substantiate wetland boundaries where applicable. For the measures of connectivity and surrounding landscape composition that required forest cover, all types of woodlands were considered suitable. This included deciduous, coniferous, and mixed forests, as well as forested swamp, hedgerows, and plantations.

Table 8: Southern Ontario Land Resource Information System (SOLRIS) land cover classification and resistance values (i.e. energy to travel 1 metre through the associated land cover) used for connectivity modelling.

SOLRIS Classification	Resistance Values (Road Crossing Survival Metric)	Resistance Values (Juvenile Dispersal Metric; Overwintering Habitat Metric)
Open Beach/Bar	1	3
Open Sand Dune	1	3
Treed Sand Dune	1	1
Open Cliff and Talus	1	3
Treed Cliff and Talus	1	1
Open Alvar	1	3
Shrub Alvar	1	3
Treed Alvar	1	1
Open Bedrock	1	3
Sparse Treed	1	1
Open Tallgrass Prairie	1	3
Tallgrass Savannah	1	3
Tallgrass Woodland	1	1
Forest	1	1
Coniferous Forest	1	1
Mixed Forest	1	1
Deciduous Forest	1	1
Treed Swamp	1	1
Thicket Swamp	1	1
Fen	1	1
Bog	1	1
Marsh	1	1
Open Water	2	2
Plantations – Tree Cultivated	1	1
Hedge Rows	1	1
Tilled	1	3
Transportation	1	4
Built-up Area – Pervious	1	3
Built-up Area – Impervious	1	4
Extraction – Aggregate	10000 (absolute barrier)	10000 (absolute barrier)
Extraction – Peat/Topsoil	1	3
Undifferentiated	1	3

The SOLRIS dataset does include pixels which represent roads and other urban transportation infrastructure, but does not include additional information regarding road classification, size, or traffic intensity. As such, the Ontario Roads Network (ORN) vector layer was the primary spatial layer used in the road crossing survival metric described in Section 5.2.7.3. The ORN layer included information regarding road classifications, which are detailed in Table 9.

For all three of the connectivity metrics described in the following sub-sections, buildings were considered absolute barriers to movement. In other words, the models assumed that anurans could not cross over or through any structure the size of a house or larger. Certainly, some hylids are capable of climbing vertical surfaces such as houses, but this type of behavior is not characteristic of dispersal and migration. This was also necessary to include a degree of realism in the connectivity models that is often absent in many resistance-based modelling approaches and which is critically important in urban areas where dense buildings can create a challenging maze of obstacles for small animals to navigate around.

To include buildings in the connectivity models, vector layers outlining the footprints of buildings were retrieved from a variety of municipal, provincial, and regional GIS repositories (see Table 7). The layers were combined and rasterized to produce a comprehensive map of building footprints that covered the maximum movement distance around each of the 290 wetland sites included in this study.

Table 9: Classifications assigned to each road in the Ontario Road Network (ORN)

Road Class	Description (from ORN documentation)
Freeway	An unimpeded, high-speed controlled access thoroughfare for through traffic with typically no at grade intersections, usually with no property access or direct access and which is access by a ramp. Pedestrians prohibited.
Expressway/Highway	A high-speed thoroughfare with a combination of controlled access and intersections at grade level
Arterial	A major thoroughfare with medium to large traffic capacity
Collector	A minor thoroughfare mainly used to access properties and to feed traffic with right of way
Local/Street	A low-speed thoroughfare dedicated to providing full access to the front of properties
Alleyway/Laneway	A low-speed thoroughfare dedicated to providing access to the rear of properties
Resource/Recreation	A narrow passage which has as a primary function access for resource extraction and may have a role in providing an access for the public to back country
Rapid transit	A thoroughfare restricted 24 hours a day, for the sole use of public transportation buses
Ramp	A system of interconnecting roadways providing for the controlled movement between two or more roadways
Local/unknown	A low-speed thoroughfare dedicated to providing access to the front of properties but for which the access regulations ore unknown

Service	A stretch of road permitting vehicles to come to a stop along a Freeway or Highway. These include weigh scales, emergency lanes, lookouts, and rest areas
Winter	A road that is only useable during the winter months when conditions allow for passage over lakes, rivers, and wetlands

5.2.7 Habitat Metrics

Three metrics were designed to capture the effects of landscape composition on anuran movement tested in this study. They are outlined below:

5.2.7.1 Juvenile Dispersal Connectivity

The first landscape connectivity metric was designed to consider the behaviours and life stage functions of juvenile anuran dispersal. Juvenile dispersal in anuran species is differentiated from adult migration in two major ways: the destination, and the path-seeking behaviours (or lack thereof) (Semlitsch, 2008; Sinsch, 2014). Juvenile anuran dispersal results in the discovery and use of other wetlands in the surrounding landscape, which increases genetic diversity across connected wetlands and provides an avenue for recolonization if localized populations experience stochastic extirpation (Cayuela et al., 2020). Dispersing juveniles seem to have a limited long range sensory capacity, choosing their initial directions and subsequent movements across the landscape matrix somewhat randomly (barring the effects of micro-topography and variations in wetland vegetation), and therefore occurring regularly in land covers not typically suitable or preferred by amphibians (e.g. roads and impervious urban covers) (Sinsch, 2014). Most abrupt changes in direction are likely caused by anthropogenic (e.g. buildings), physical (e.g. fast-flowing rivers), or topographical (e.g. cliffs) barriers.

Resistance-based modelling techniques are valuable tools for examining landscape connectivity (Zeller et al., 2012; Unnithan Kumar et al., 2022). Approaches such as least-cost resistance make some assumptions that are incompatible with anuran juvenile dispersal behavior, including that: 1) individuals travelling through the landscape have an understanding of the landscape as a whole and are able to select optimal pathways, 2) individuals have long-range sensory capabilities for identifying where suitable destination land covers are located, and 3) individuals respond strongly to short-range changes in land cover, avoiding hostile land covers. Circuit-theory approaches also incorporate matrix resistance as a core principle and consider multiple movement pathways (McLure et al., 2016; Dixon et al., 2019). This may partly address some of the assumptions of cost distance approaches, particularly those relating to wider landscape understanding, but maintain the assumptions the individuals will actively select the least resistive neighbouring land cover and avoid hostile land covers where possible. This lingering assumption contribute to the failure of these approaches to adequately capture the consequences for connectivity in organisms that exhibit auto-correlated and directional movement and frequently travel through hostile land covers even when presented with less resistive options (Graeter et al., 2008).

The juvenile dispersal connectivity metric outlined in this section is exploratory in nature and was designed to model juvenile dispersal movement. To do this, twelve wedges were constructed from the geometric centre of each survey wetland extending 6 km from the centre point. Since the maximum recorded dispersal distance for the species included in this study is about 5000m (see Section 2.1.1), the wedges needed to extend at least 5km to accommodate this best-case scenario. An additional 1km was added to the wedge inconsideration of the radius of the starting wetland itself (the wedge radius is measured from the wetland centroid). Each wedge was 60 degrees wide ensuring complete overlap between half of the previous wedge and half of the next wedge so as to limit the effects of artificially induced linear boundaries on the modelling analysis (see Figure 9 for an illustration of the juvenile dispersal metric). I decided to limit the number of wedges for each site to 12 in consideration of computational effort and labour, although there is notable uncertainty with regards to this component of the model. A 60-degree arc was deemed appropriate to accommodate the likelihood of lateral meandering that dispersing individuals are likely to demonstrate when travelling thousands of metres from their natal pond. This arc also accounts for any lateral movement widths that are necessary when being diverted around barriers such as buildings, rivers, or other human infrastructure. However, the true movement patterns and deviations of dispersing juveniles are mostly unknown, therefore the number of wedges in this model should be considered exploratory.

The cost distance tool was executed in ArcGIS Pro for each of the 12 wedges. Resistance costs were adapted from Patrick et al. (2012), but simplified and reduced to account for minimized risks of desiccation during peak dispersal movement which general take place at night or during active or recent rainfall (See Version 2 resistance values in Table 8). The study species in Patrick et al. (2012) overlap with those in this study area, and the methods for determining land cover resistance values (expert opinion) are consistent with those used widely in resistance-based modelling approaches across a wide range of species (Zeller et al., 2012). Movement resistance values were lowest for all wooded land cover classifications, higher for open grassland and agriculture, and highest for impermeable urban land cover (including roads). Building footprints and resource extraction sites (e.g. mines, open pits, and quarries) were considered absolute barriers to movement since anurans cannot reasonably cross over them.

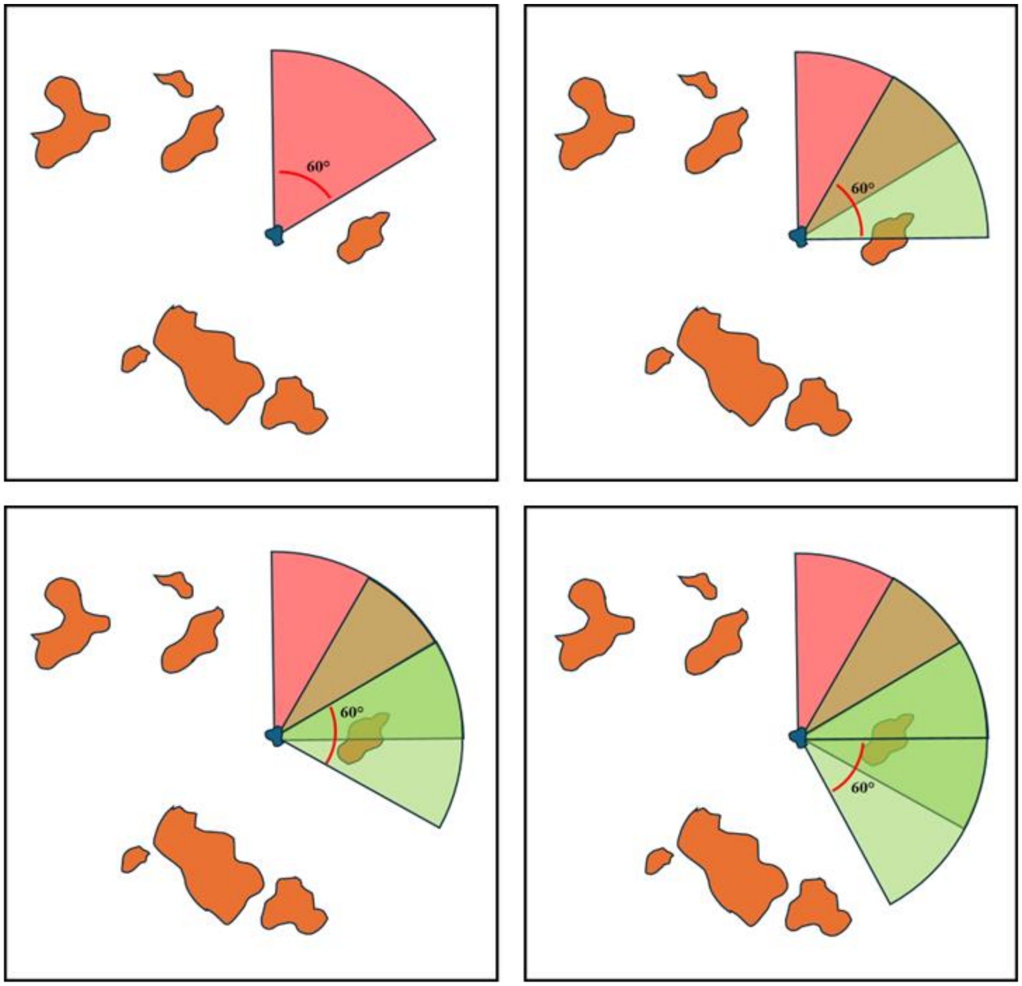

Figure 9: Illustration of the juvenile dispersal metric process. Each overlapping wedge is 60 degrees. Red wedges indicate those that do not overlap marsh (in orange), and green wedges indicate those wedges that do overlap marsh.

The resistance-based cost distance models were also performed with three maximum dispersal distances which can be specified in the “Cost Distance” tool in ArcGIS Pro (see: https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/cost-distance.htm) , soon to be replaced by a similarly “Distance Accumulation” tool. The three distances of 1000m 2500m, and 5000m reflecting approximate and rounded maximum movement distances observed for the six anuran species of study (see Section 2.1.1). The cost distance tool stops executing if it reaches any of the specified maximum distances.

Once each cost distance tool was complete for each site, distance, and wedge, the total number of pixels representing marsh land cover within the accessible zone of movement was calculated. The number of wedges for each site that had at least 10 marsh cells were summed to provide a response variable that communicates how many of the 12 original dispersal directions lead to suitable breeding wetlands for juvenile anurans. This response is meant to quantify how well connected a particular breeding wetland is to other breeding wetlands with specific reference to juvenile anuran dispersal. The workflow for the juvenile dispersal metrics is illustrated in Figure 10.

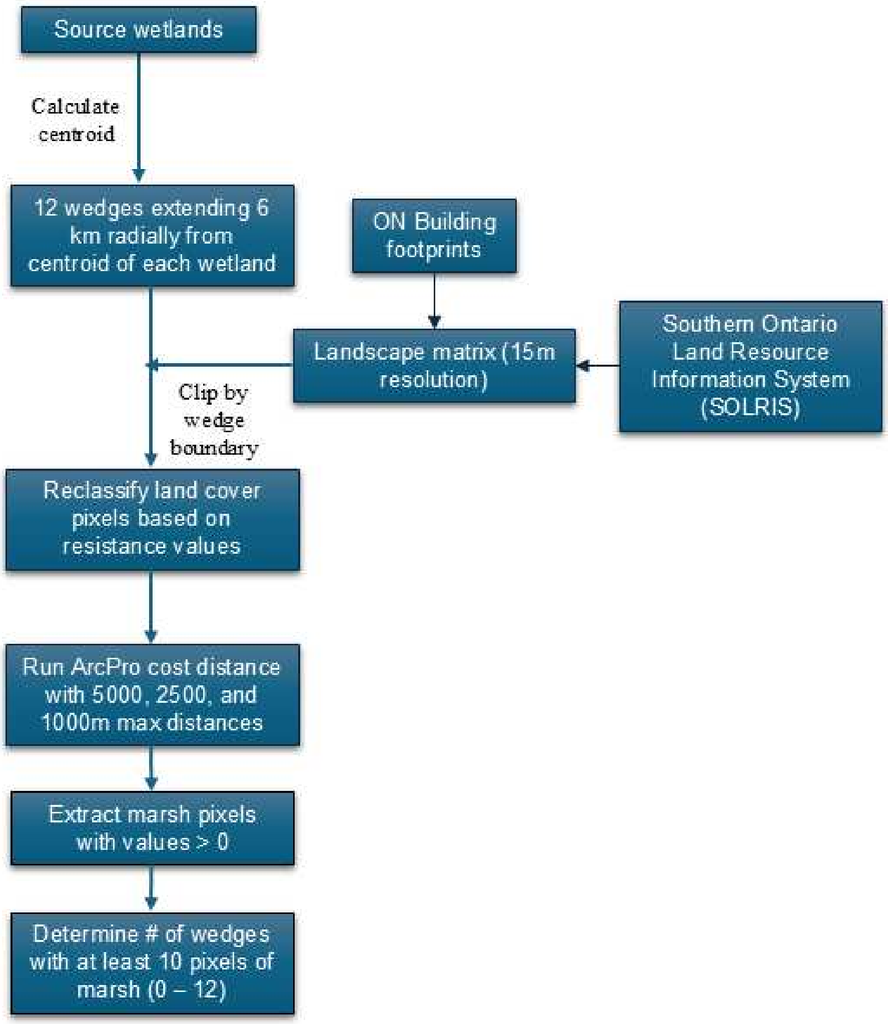

Figure 10: Workflow diagram for the juvenile dispersal connectivity metric

5.2.7.2 Overwintering Forest Habitat

The second landscape connectivity metric was designed to consider the behavior and life stage functions of adult anuran migration. Several of the species examined in the study (wood frog, spring peeper, gray treefrog, American toad) require accessible forested habitat for overwintering and will hibernate underneath forest leaf litter or in shallow hollows in the ground. Suitable overwintering habitat is thought to be discovered during dispersal, however the exact mechanisms remain uncertain (Sinsch, 2014). In any case, those adults that have previously overwintered in a forest appear to have some sensory mechanisms for recalling where that habitat is and will often use the same route to return there in the fall. Adult anurans also appear to have some degree of response to the characteristics of the land covers that they encounter (Semlitsch, 2008; Sinsch, 2014; Cayuela et al., 2020). As such, the adult overwintering metric in this study took a more traditional resistance-based modelling approach. The cost distance tool in ArcGIS Pro was executed for each surveyed wetland using the same resistance values as those used in the juvenile dispersal metric (See Table 8), reflecting movement during ideal and preferred weather conditions. In consideration of adult anurans' increased path-seeking capacities, no lateral limitations were imposed in the models.

The resistance models were executed at three distances of 500m, 1000m, and 3000m, reflecting approximate and rounded maximum migration distances exhibited by the six anuran species included in this study (see Section 2.1.1). The remaining "energy" value of each forest land cover pixel was standardized to a value from 0 – 1 relative to the maximum movement distance of each model wherein values closer to 0 indicated forest pixels that took more energy to reach. Each forest pixel with a value greater than 0 was summed for a final metric of overwintering connectivity for each wetland and each movement distance. All types of forest were considered suitable as overwintering habitat in this study to accommodate for the variable forest preferences exhibited by the forest overwintering species in this study. The workflow for the overwintering habitat connectivity metric is illustrated in Figure 11.

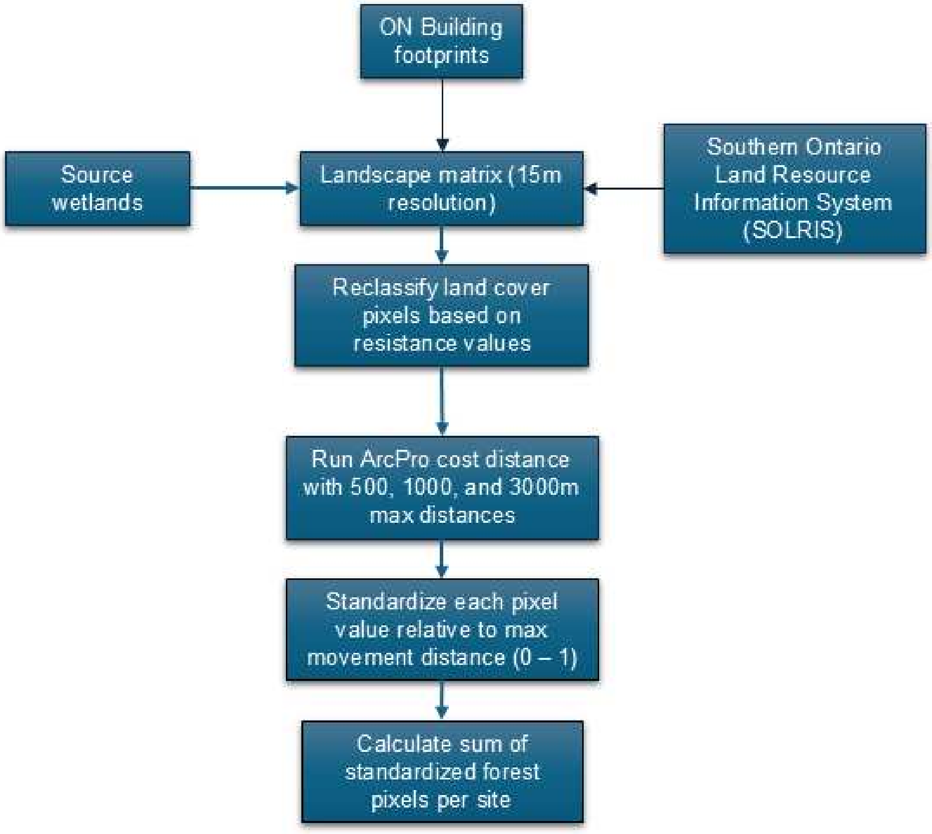

Figure 11: Workflow for the overwintering habitat connectivity metric

5.2.7.3 Road Crossing Survival Connectivity Metric

The final metric of connectivity explored in this study was designed to model the isolated effects of vehicle-induced mortality on anuran individuals crossing roads during migration and dispersal. It used a modified cost distance tool to model the exponential reductions in occurrence probability induced by crossing multiple roads.

The road crossing survivability tool used in this study was a modified version of the r.cost function available in the Geographic Resources Analysis Support System (GRASS) software suite (original tool available at GRASS (2023); edited tool available at Zietara (2023)). The r.cost tool works almost identically to the "cost distance" tool available on ArcGIS Pro, but is an open source option, which allowed the baseline code to be manipulated and tested. Similar to the ArcGIS "cost distance" tool, the unmodified GRASS "r.cost" tool uses additive processes that calculate cumulative costs and assigns output cell values based on the minimum cost to travel to any particular cell from a specified source. The tool was modified to use multiplicative processes instead of additive in order to reflect how survival probabilities decrease exponentially when anurans cross multiple roads.

The Ontario Road Network (ORN) vector layer assigns each road segment in Ontario with a classification based on function and expected traffic volume (see Table 9). Despite substantial differences in traffic volume between urban and rural roads of the same classification (Hallenbeck et al., 1997), the ORN does not make this distinction between urban road and rural roads of the same classification. Since traffic volume (i.e. # vehicles/hour) is one of the primary determinants of road crossing survival, it was important to make a reasonable effort to differentiate between urban roads and rural roads. To do this, buffers were constructed around polygons derived from the Ontario Built-Up Areas vector dataset (see Table 7) that were proportional to their area, resulting in buffers that extended further for larger built-up areas compared to smaller build-up areas. This reflects the theoretical increase in area of effect on traffic volume that is proportional to the size and intensity of urban areas. Road that fell within the buffers were sub-classified as urban, while those that fell outside the buffer were sub-classified as rural.

Hallenbeck et al. (1997) provided a substantial and detailed analysis of average hourly traffic intensities across multiple classifications of roads, across all hours of the day, and across both rural and urban roads. Although these figures were derived from roads in the United States, the functional road classification system employed in the study was extremely similar to the one used in the ORN dataset and is typical of road classification systems used in North America. The vast majority of anuran movement takes place during the nighttime between 21:00 and 05:00 when there is little to no sunlight (Pomezanski and Bennett, 2018), although this timing may shift throughout the year as day length changes, therefore the average hourly traffic intensities during those hours were averaged to determine how many vehicles/hour were using each classification of road. These rates are detailed in Table 10.

Table 10: Average nighttime traffic rates and road crossing survival rates for anurans for each rural and urban road classification in the ORN.

Road Classification	**Rural**		**Urban**	
	Average Nighttime Traffic per Hour	**Survival Rate, S_r ($1/S_r$)**	**Average Nighttime Traffic per Hour**	**Survival Rate, S_r ($1/S_r$)**
Freeway	370	0.10 (10)	1318	0.0 (0.00)
Ramps and Expressways	181	0.25 (4.00)	547	0.0 (0.00)
Arterial	72	0.55 (1.82)	205	0.2 (5.00)
Collector	17	0.93 (1.08)	59	0.6 (1.67)
Local	3	1.00 (1.00)	6	1.0 (1.00)

Using this information and previous explorations of the relationship between traffic intensity and anuran mortality rates, the road crossing survival rates for each road classification were able to be estimated. There are relatively few studies which have explored anuran road crossing survivability as functions of traffic rates, and which are derived from field-based measurements. While two studies met these criteria, only Joly et al. (2003) used more than two rates of traffic to plot the shape of the real-world relationship. The underlying data that was used in this study is about 30 years old, but the relationship between road crossing survival and traffic intensity should remain consistent over this time period. There was also the option of modelling the road crossing survival rates using formulas that take into account species movement speeds, vehicle traffic rates, road width, and tire width as demonstrated by Hels and Buchwald (2001), but species-specific data was not available to reliably implement this method.

As the best field-observation derived example of a quantifiable relationship between traffic rates and anuran road crossing survival, the interpolated relationship illustrated in Joly et al. (2003) was used to match the traffic rate of each road classification to a road crossing survival rate. The survival rates estimated using this method were similar with those calculated by Hels and Buchwald (2001) using their modelling approach, and those observed by Bouchard et al. (2009). All survival rates used in this study are detailed in Table 10.

The ORN vector layer was rasterized using road classification (including rural vs urban sub-classifications) to differentiate output pixel values. The resulting values were then reclassified based on the inverse survival rate for each classification of road. Since the unmodified tool calculates minimum costs as part of its utility for determining least-cost pathways, the survival rates associated with each classification of road were inversed in order for the modified tool to ultimately determine maximum survival rates for any particular point in the landscape. Any cell that was not representing a road was assigned a value of 1, which indicated a 100% survival rate (predation and other mortality was not considered in this tool). The outputted raster surfaces for each site were inversed such that the final result was a surface in which each cell's value represented the maximum probability of occurrence after travelling from the source wetlands and after accounting for road mortality.

No maximum distance was specified in the modified tool given the changes that were applied to the underlying algorithm rendering that optional variable meaningless. In order to delineate the maximum potential movement area for each site, a separate cost distance resistance model was performed at maximum distances of 1000m, 2500m, and 5000m. These distances reflect the maximum recorded movement distances for the six species included in this study. In these cost distance models, only absolute barriers such as building footprints and resource extraction sites (e.g. mines, open pits, quarries) and large bodies of water and fast flowing rivers were considered resistant to movement (see Version 1 resistance values detailed in Table 8). In this way, the isolated effects of road mortality on landscape occurrence were maintained while also imposing a reasonable maximum area of interest for each site. The modified r.cost output for each site was clipped using the output extents from the cost-distance models at the three distances.

No published figure for the minimum rate of survival between two habitats for anurans was available, nor is there likely a definitive minimum survival rate given variations in population sizes and varying amount of source and destination habitats in any particular landscape. Given this uncertainty, I explored three minimum survival rates in this study: 50%, 25%, and 5%. Results of the comparisons of these minimum survival rates are presented and discussed in greater detail in Chapter 4. For each maximum movement distance and each minimum survival rate, the number of marsh habitat pixels within each movement zone and meeting the minimum survival rate criteria were summed to produce a metric representative of the amount of habitat available at each site. The workflow for the road crossing survival connectivity metric is illustrated in Figure 12.

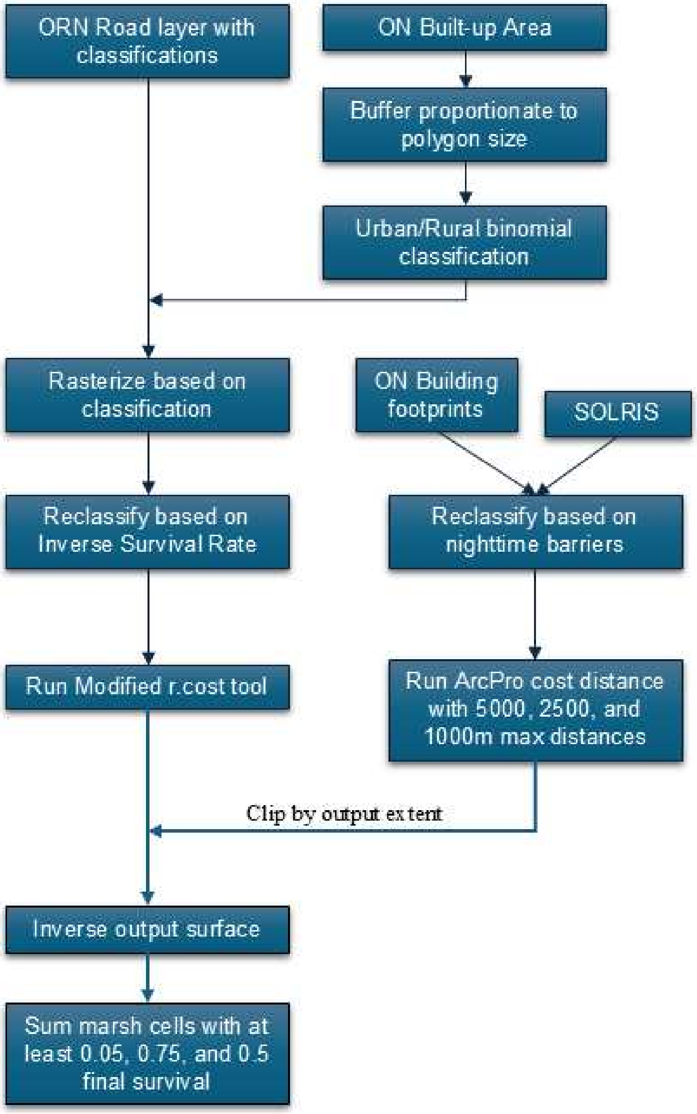

Figure 12. Workflow for the road crossing survival connectivity metric

5.2.7.4 Surrounding Landscape Composition Metrics

In addition to testing for connectivity and metrics for landscape movement, the land cover surrounding each survey site was characterized at three distances of 500, 1000, and 3000m. Previous explorations of anuran habitat associations in Ontario have frequently identified the area of forest cover, wetlands, and urban land cover as important determinants of anuran species presence and/or richness at distances of 200m (Porej et al., 2004), 500m (Lehtinen et al., 1999), 750m (Houlahan and Findlay, 2003), 1000m (Lehtinen et al., 1999; Findlay et al., 2001; Porej et al., 2004; Rubbo and Kiesecker, 2004; Hermann et al., 2005; Collins and Fahrig, 2017), 2500m (Lehtinen et al., 1999), and 3000m (Houlahan and Findlay, 2003). Overall, four surrounding land cover characterizations were developed for each site at each of the three distances: 1) total area of forest cover, including forested wetlands (i.e. swamp), hedgerows, and plantations, 2) total area of impermeable urban land cover, 3) total area of vegetated land covers, including all forests, grasslands, agriculture, and wetlands, and 4) density of roads (m/m^2).

5.2.8 Statistical Analysis

5.2.8.1 Multicollinearity

Before analyzing the data, Pearson correlations were run between all of the habitat metrics in order to identify any occurrences of multicollinearity. It was likely that, given the similarity between many of the habitat metrics constructed in this study, that some would need to be removed to avoid redundancy and unnecessary complexity to the resulting models. Landscape composition metrics that had correlation coefficients greater than or equal to 0.60 (or equal to or less than -0.60) were flagged for removal. All of the habitat connectivity metrics were retained, but correlation coefficient between and within habitat connectivity metrics were noted for interpretation of and discussion of results.

5.2.8.2 Habitat Association

To test the strength of associations between anuran species occurrence and the various habitat metrics used in this study, generalized additive models (GAMs) were constructed. Generalized Additive Modelling is a non-parametric approach to regression modelling that can accommodate a range of data distributions and possible non-linear relationships between predictor and response variables (Ravindra et al., 2019). This approach was deemed appropriate for this study in order to accommodate the uncertainty regarding the shape of the ecological relationships between anuran species occurrence and habitat compositions. Furthermore, the GAM modelling approach is able to accommodate non-parametric characteristics of both the predictor and response variables allowing for more flexibility in the types of data that were used.

The “r” package “mgcv” was used to construct and analysis the GAMs (Wood, 2023). Models were constructed for each individual species occurrence. When modelling individual species occurrence, a binomial family was specified to reflect the nature of the response variables (i.e. 1 for presence, 0 for absence). Each habitat metric included in the GAM model was "smoothed", which indicates to the program to use thin-plate regression splines to estimate non-linear relationships between predictors and the response where appropriate. The smooth functions were assumed to be smooth and continuous, controlled via penalization of wiggliness.

The upper bound for effective degrees of freedom (k) was set at 10 for all models to provide an upper limit to the complexity of the smooth without being overly restrictive. The value of "k" was verified for adequency using gam.check() in the mgcv package. Smooth terms with high estimated degrees of freedom approaching k-1 low k-index values, or significant p-values ($p<0.05$) would prompt re-fitting with increased k until diagnostic criteris were met and edfs stabilized. The binomial distribution family was used for individual species presence/absence GAMs with a logit link function. The restricted maximum likelihood (REML) method was used to estimate smoothing parameters as recommended by Wood (2011) for numerical stability.

The effective degrees of freedom (edf) was recorded for each smoothed term in the model output. An edf close to or equal to 1 indicates that the relationship is linear or close to linear. The higher the edf, the more non-linear or "wiggly" the relationship. For each smoothed term in the model, the p-value for approximate significance was recorded. The deviance explained (%) was recorded for all models instead of the adjusted r-square because of the binomial distribution specified in the. The Akaike Information Criterion (AIC) value was also recorded for each model and Delta AIC ($\Delta AIC = AIC_i - AIC_{min}$) was calculated to compare the models' relative performance (Burnham and Anderson, 2002). Typically, a ΔAIC value of <2 suggest that the differences between the model and the best model are relatively small and/or indistinguishable. Given the uncertainties of the underlying ecological mechanisms and inputs for these models, and due to the exploratory nature of this study, we interpreted any model with a ΔAIC of between 2 and 4 as indicating moderate support for the models compared to the best model, and values of over 10 indicated no support for the model.[2]

Models were constructed for each connectivity and surrounding landscape composition metric separately, but also for each combination of metrics. Only one connectivity metric of each

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[2] The calculation of marginal effects in the GAMs is being made more explicit in the final draft manuscript based on this chapter

type (i.e. of different distances) and one surrounding landscape composition metric (i.e. of different type: Forest/Wetland, Urban, or Natural/Agricultural) was included in each model, and a maximum of four habitat metrics were included in a model. The variables (i.e. connectivity and habitat composition metrics) were considered independent and non-linear. No randon effects or correlation structures were included, therefore all observations were assumed to be independent. No interaction terms were included and no automatic variable selection of shrinkage was used.

5.3 Results

5.3.1 Descriptions of Selected Sites

The 290 sites included in this study (Map 1) were distributed across twenty eco-districts across Ontario (Map 2). Sixty-eight percent of all sites occurred within the Lake Simcoe-Rideau ecoregion, and 98% of sites occurred within the mixedwood plains ecozone. The three Eco-districts with the most wetland sites were Oak Ridges, Stratford, and Toronto, whose boundaries overlap with some of the largest urban areas in Ontario (Figure 10). Representation of sites in the heavily agricultural areas of Southern Ontario that stretch from the Bruce Peninsula to Windsor and Lake Erie is lower compared to the areas with the Golden Horseshoe that are characterized by a mixed-use landscape. Only five sites were located within the Canadian Shield ecoregion which generally occurs north of Lake Simcoe.

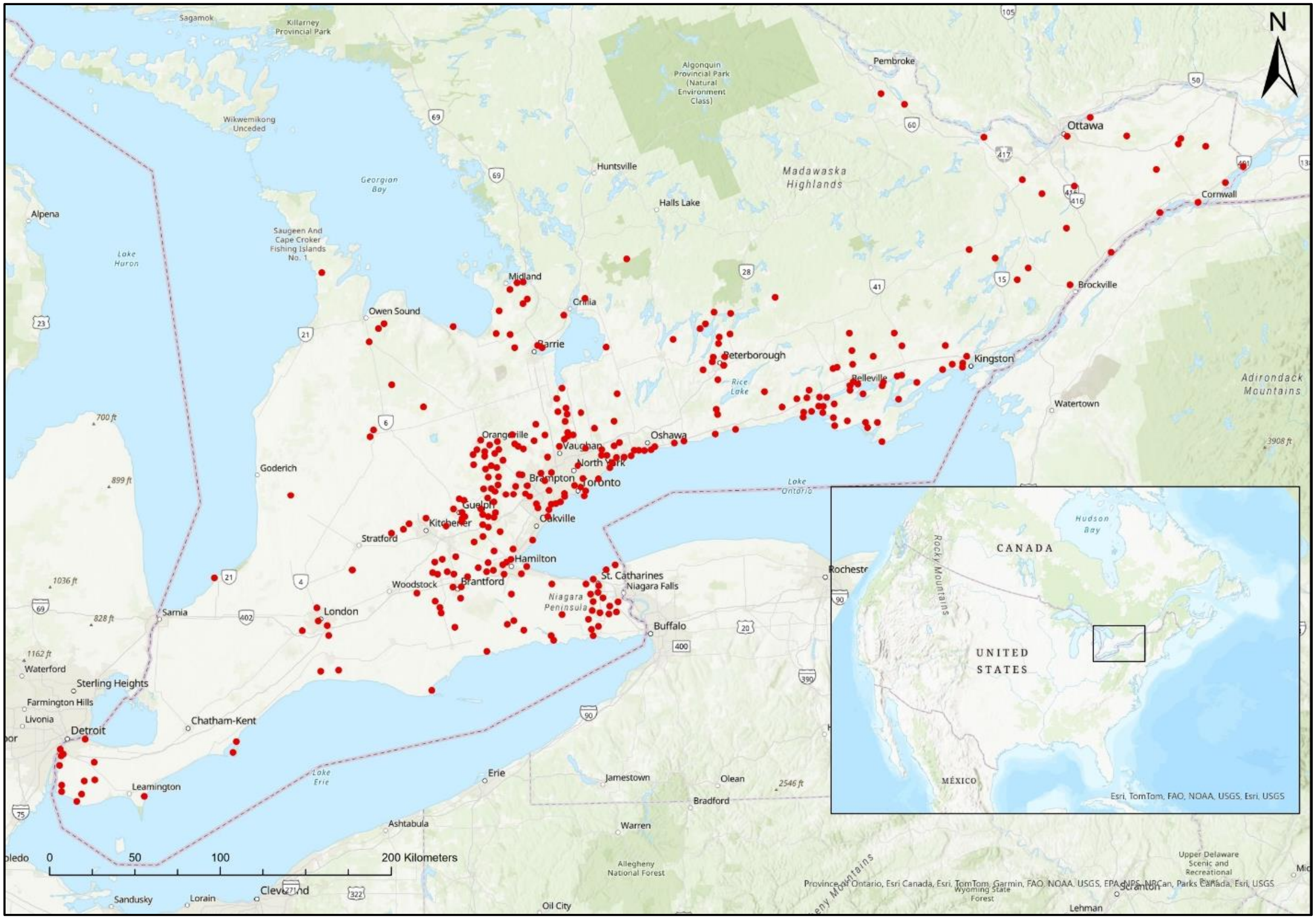

Figure 13: Location of the 290 breeding wetlands with anuran acoustic data included in this study

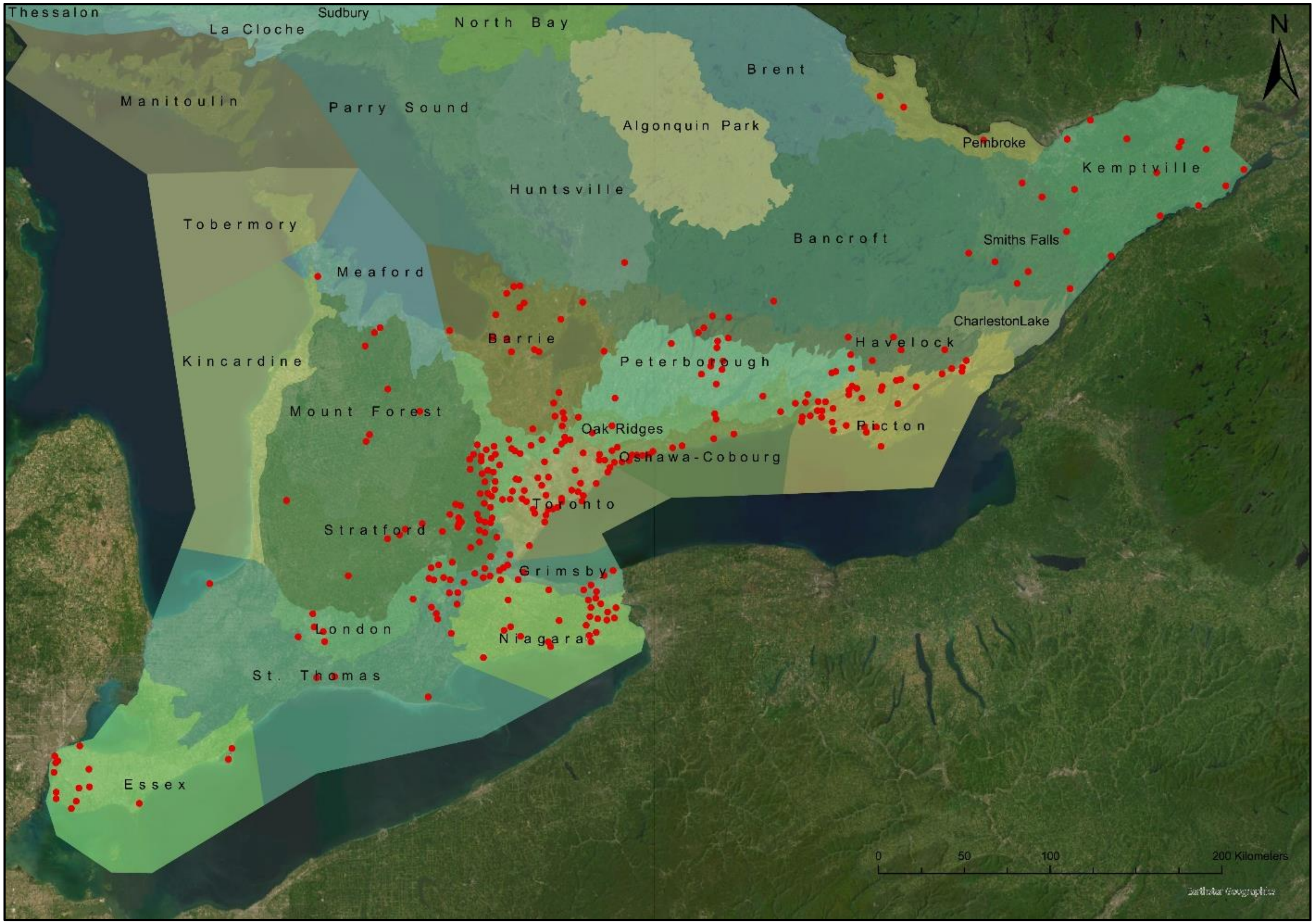

Figure 14: Location of the 290 breeding wetlands included in this study distributed across ecodistricts of Southern Ontario

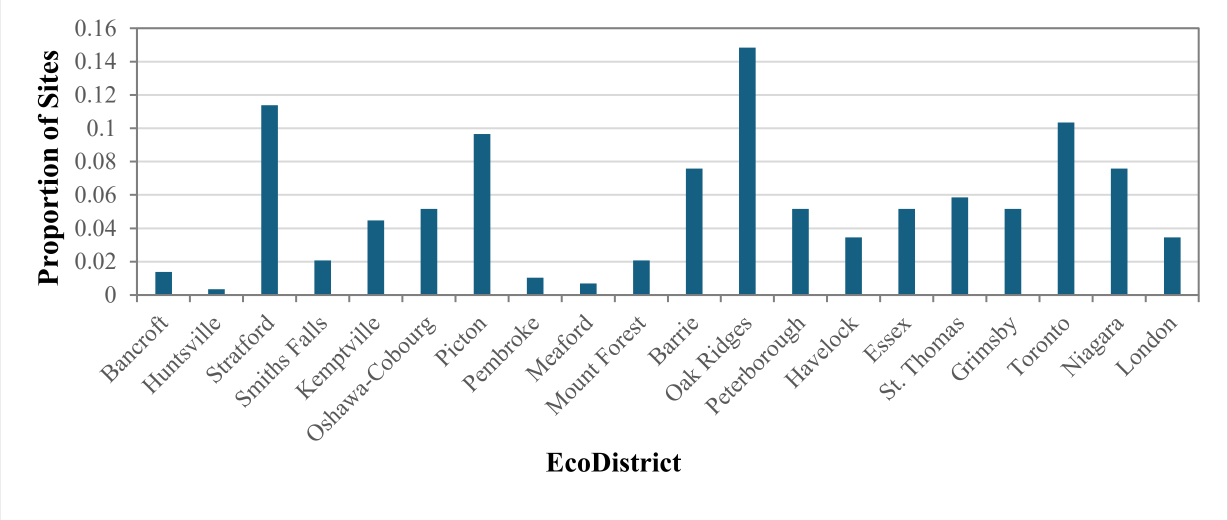

Figure 15. Proportion of total wetland study sites across Ecodistricts in Ontario (n=29*0*)

The wetlands of study ranged widely in size from less than one hectare to more than 300 hectares. About 58% of all wetlands were less than 10 hectares in area, and 17% were greater than 30 hectares, leaving only 25% of sites between 10 and 30 hectares (Figure 16).

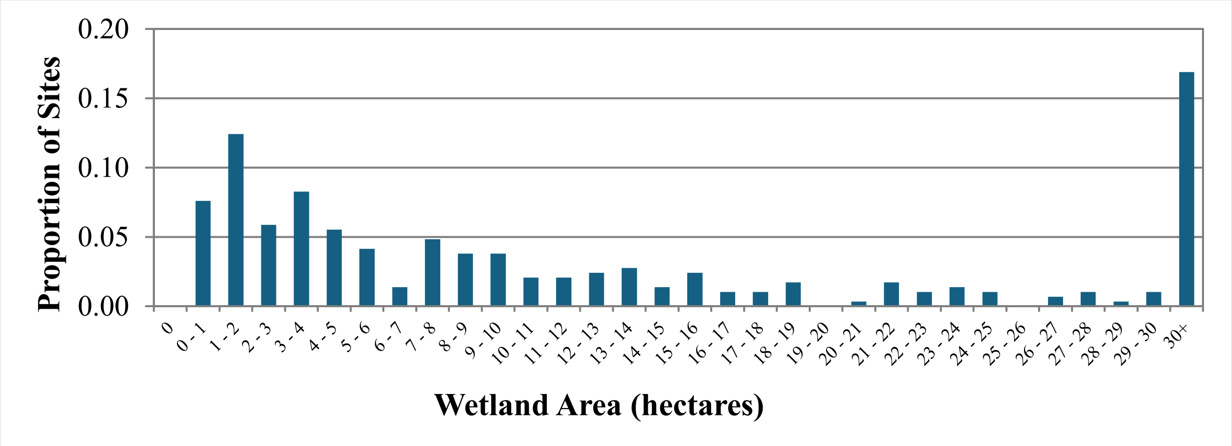

Figure 16. Proportion of wetland study site area (ha) (n=29*0*)

Consistent with the diverse geographical distribution of the sites included in this study, the landcover compositions surrounding each wetland exhibited a wide degree of variance. Within 3000 metres of each site, wetland cover (including swamp, marsh, bog, and fen classifications) typically varied between 5% and 35% of all landcover (Figure 17A). When limiting to the marsh wetland classification only, 95% of sites contained less than 15% wetland cover. Bogs and fens were relatively rare compared to marshes and swamp and contributed a negligible amount to the total wetland composition at the vast majority of sites.

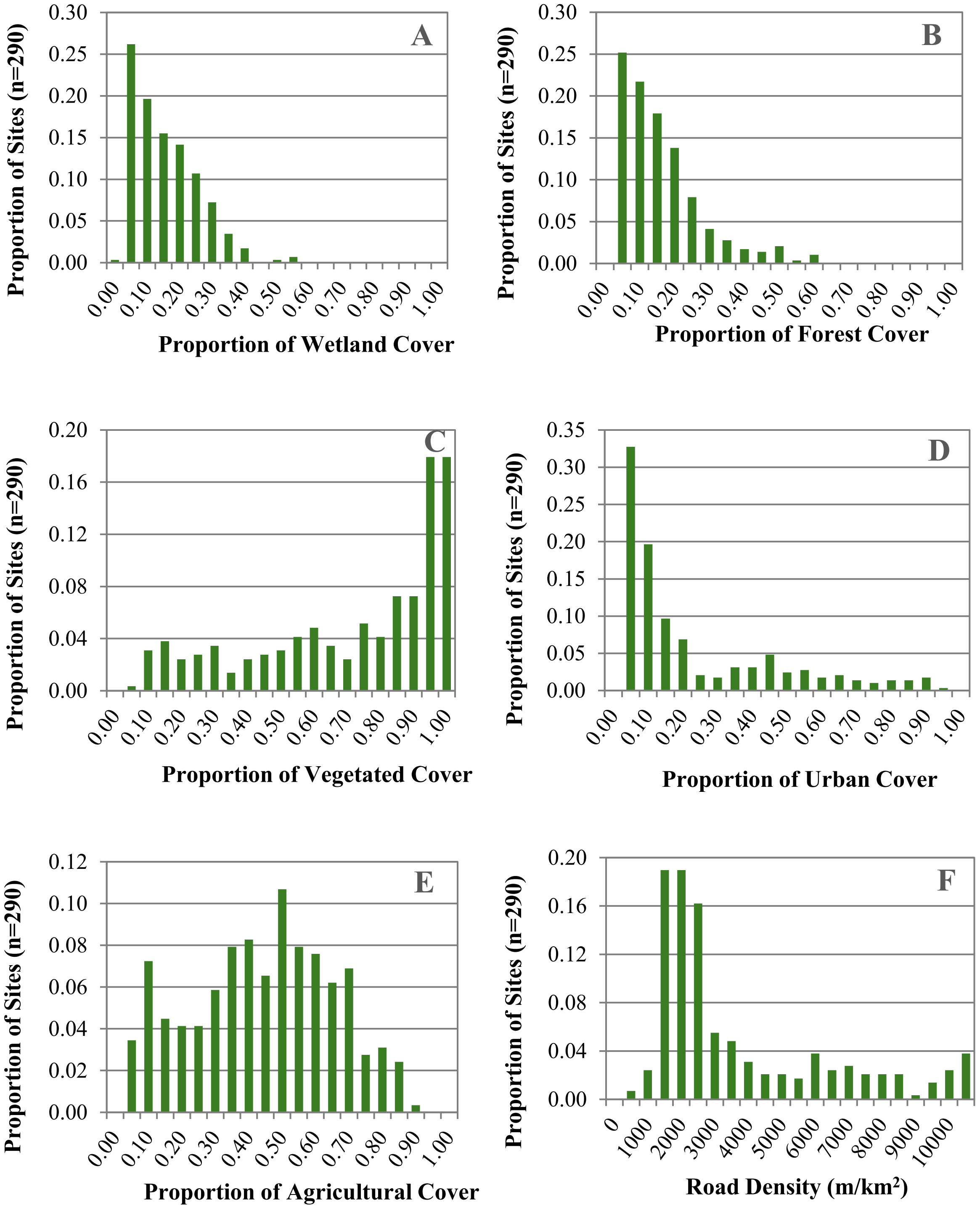

Figure 17. Proportion of land cover within 3000m of study sites classified as: A) wetland (marsh, bog, fen, swamp), B) forest (deciduous, coniferous, plantation, hedgerows), C) vegetated cover (all wetland,

forest, agricultural, D) urban, E) agricultural land. Road density within 3000m of study sites is illustrated in F).

Forest cover within 3000 metres of each sites followed a similar distribution to that of wetlands with 95% of sites containing less than 40% forest cover which included all types of forest such as deciduous, coniferous, mixed, plantation, and hedgerows (but not treed swamp) (Figure 17B). When adding together all wetland and forest land cover classifications, the distribution moved away from a left-skewed distribution to more of a normal distribution, with the highest proportion of sites containing 20-25% forest cover within 3000 metres. Only 5% of sites contained more than 60% forest and wetland cover.

When considering all naturally vegetated and agricultural land covers, including undifferentiated classifications (idle land, brown fields, hydro corridors, thickets, forest openings), 36% of sites contained more than 90% vegetated land cover (Figure 17C). The remaining sites were fairly evenly distributed between 0 and 89% vegetated/agricultural land cover. The proportion of agricultural land cover followed a typical normal distribution with the greatest number of sites falling in the 45-50% agricultural land cover category (Figure 17E). About 70% of the study sites contained less than 20% urban land cover, including both pervious and impervious as defined by SOLRIS (Figure 17D). Road density followed a similar pattern, with 54% of sites containing between 1000-2500 m/km2 of roads (Figure 17F).

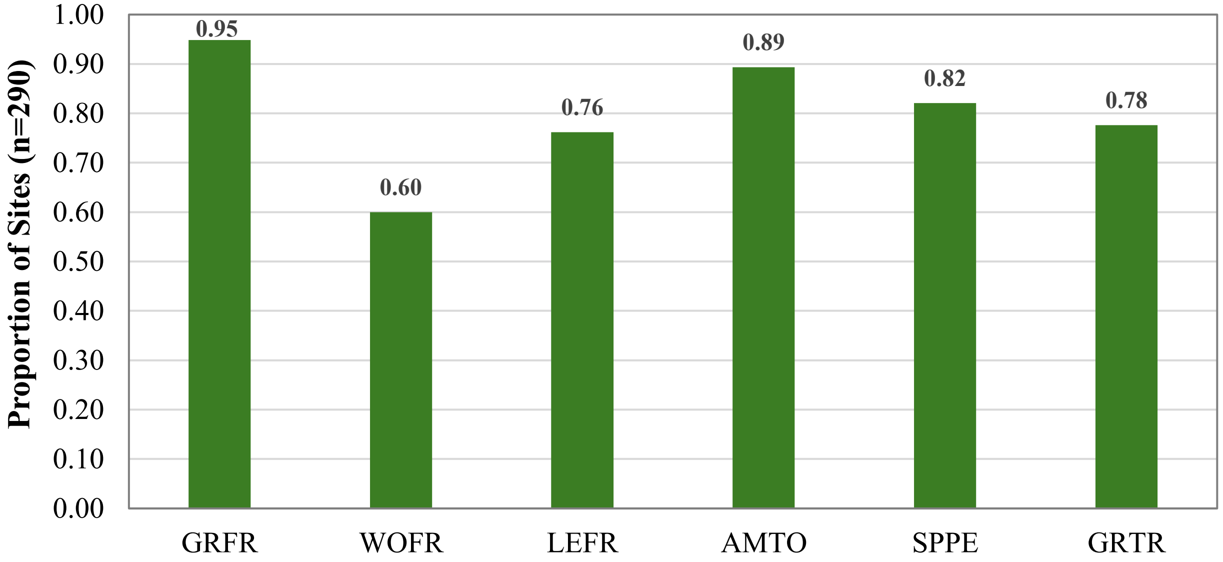

Figure 18. Proportion of sites (n=290) with at least one record of each of the six anuran species included in this study

Anuran species presence was generally high across study sites (Figure 18). The green frog and American toad were the most commonly observed as being present based on acoustic surveys, occurring at 95% and 89% of sites respectively. The wood frog was the least frequently observed of the six study species, occurring at 60% of study sites. The leopard frog, spring peeper, and gray treefrog fell in between, occurring at 76%, 82%, and 78% of wetland sites. The average richness at the 290 study sites was 4.75.

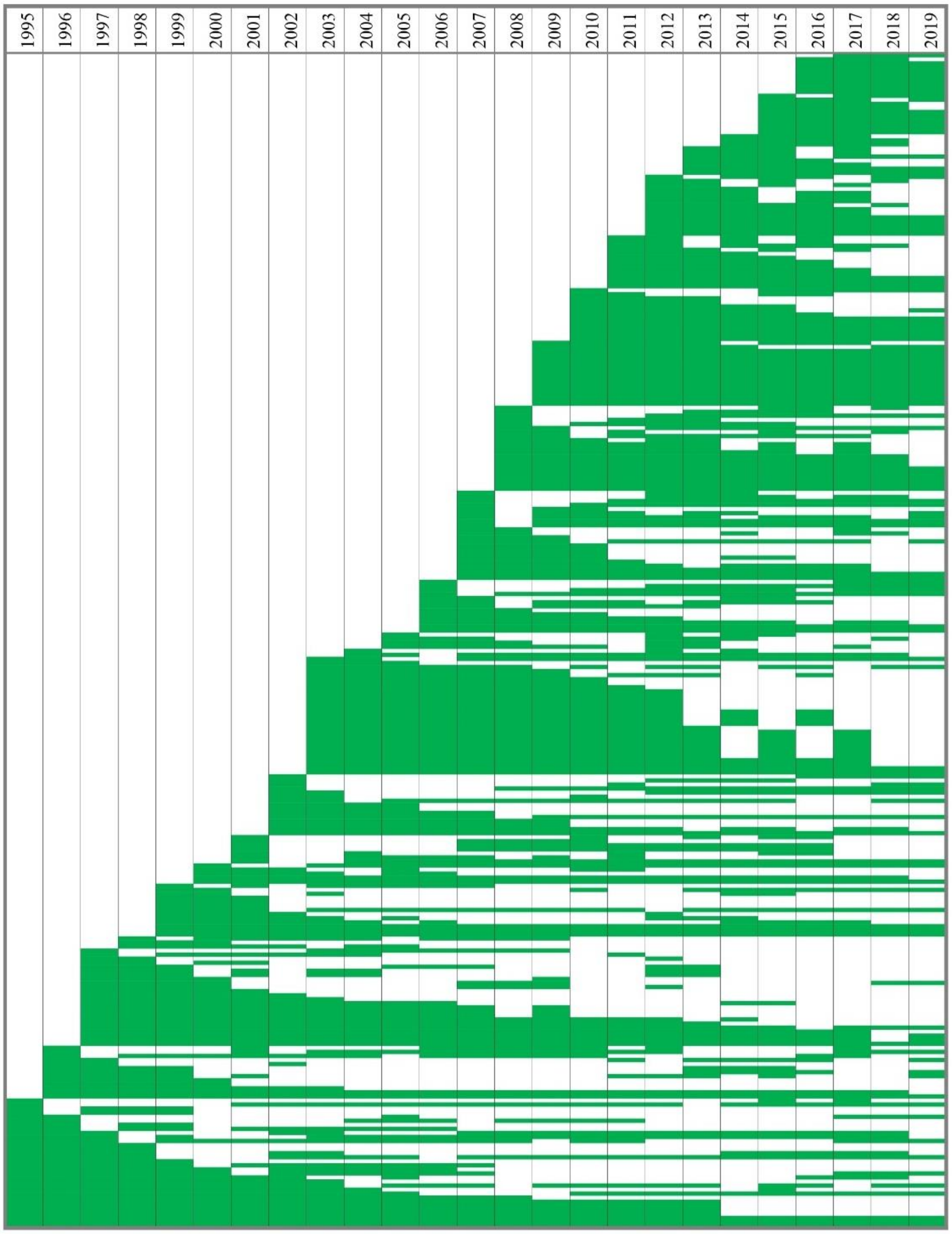

Figure 19. Years from 1995 to 2019 surveyed for each wetland included in this study. Each line represents one site

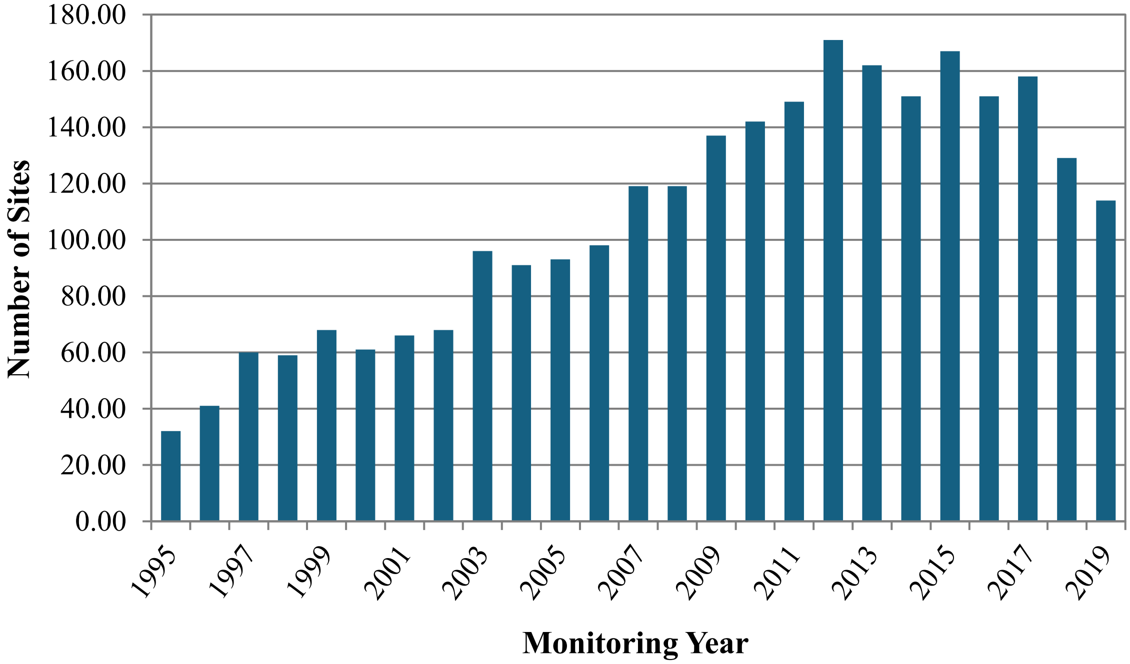

Figure 20. Number of wetland study sites that included acoustic monitoring from each year from 1995 – 2019

Monitoring years took place from 1995 to 2019 (Figure 19) with the years 2012 – 2017 most frequently monitored at the selected study sites (Figure 20). The number of sites with years monitored before 2012 decreased steadily from 2012 - 1995 and decreased forward in time from 2017 – 2019 (Figure 20). About 20% of all selected study sites were monitored for 4 years or less, and 80% of sites were monitored for 12 years or less (Figure 21). The most frequently surveyed sites had 25 years of monitoring data, occurring in 3 of 290 sites.

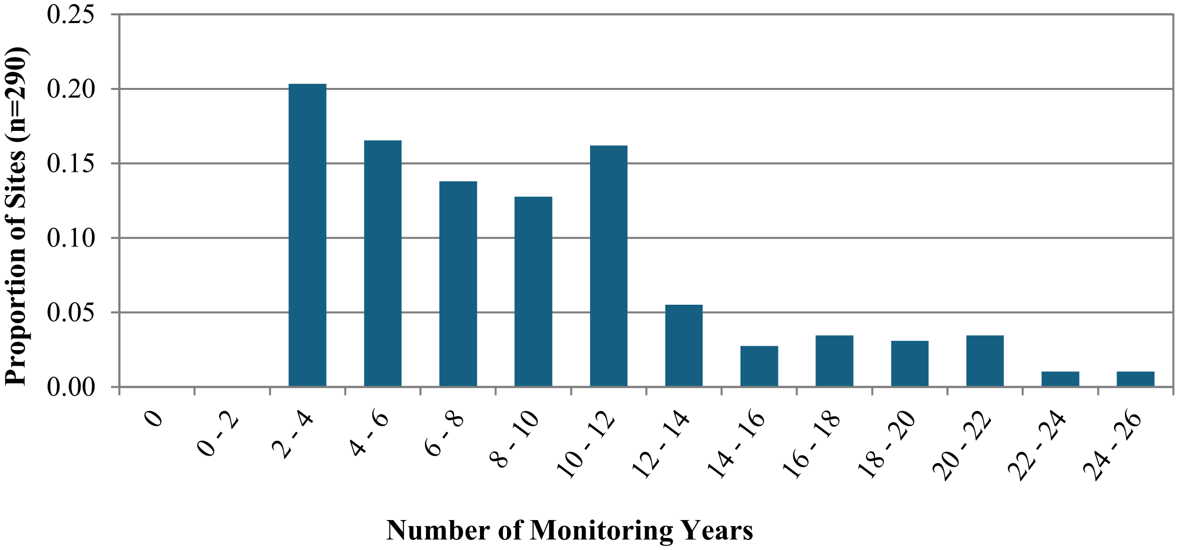

Figure 21. Proportion of wetland study sites (n=290) split by number of acoustic monitoring years

5.3.2 Generalized Additive Models

5.3.2.1 Variable Inclusion

The results of the multicollinearity test are detailed in

Table **11**. There was a high degree of correlation with the surrounding landscape composition metrics' distances. As such, only the landscape composition metrics at the 3000m distance were included in the subsequent habitat association modelling exercise. The metrics for road density were also highly correlated with the surrounding urban landcover metrics therefore only the urban landcover metric was retained for inclusion in the GAM analysis. Despite high correlations within the different distances of the juvenile dispersal and overwintering metrics, all of them were included in the GAM analysis to better understand their performance for predicting anuran species presence. Unsurprisingly, there was also a moderately strong correlation between the overwintering metrics and the landscape composition metrics for forest and wetland cover at the 3000m distance, although these correlations were not as consistently strong as for the other well-correlated variables, therefore they were also retained for inclusion in the GAM analysis. There was no consistently best performing metric in terms of deviance explained and delta AIC scores among the road crossing survival connectivity metrics at 50, 25, and 5% survival rates, therefore only the metrics at the 5% survival rate were retained for the multi-variable GAM analysis.

Table 11. Pearson correlation matrix of all connectivity and landscape composition metrics explored in this study. Pearson correlations values at or above 0.6 or at or below -0.6 are bolded

Predictor Variables	**Dispersal 1000m**	**Dispersal 2500m**	**Dispersal 5000m**	**Winter 500m**	**Winter 1000m**	**Winter 3000m**	**Survival 1000m**	**Survival 2500m**	**Survival 5000m**	**Roads 500m**	**Forests 500m**	**Urban 500m**	**Natural 500m**	**Roads 1000m**	**Forests 1000m**	**Urban 1000m**	**Natural 1000m**	**Roads 3000m**	**Forests 3000m**	**Urban 3000m**	**Natural 3000m**
Dispersal 1000m	**1.00**																				
Dispersal 2500m	**0.80**	**1.00**																			
Dispersal 5000m	**0.61**	**0.82**	**1.00**																		
Winter 500m	0.19	0.19	0.19	**1.00**																	
Winter 1000m	0.22	0.25	0.24	**0.97**	**1.00**																
Winter 3000m	0.23	0.33	0.35	**0.79**	**0.88**	**1.00**															
Survival 1000m	0.54	0.41	0.30	0.27	0.26	0.19	**1.00**														
Survival 2500m	0.52	0.44	0.37	0.18	0.18	0.18	**0.82**	**1.00**													
Survival 5000m	0.44	0.38	0.40	0.15	0.16	0.20	0.59	**0.82**	**1.00**												
Roads 500m	-0.09	-0.19	-0.22	-0.17	-0.23	-0.29	0.00	-0.06	-0.11	**1.00**											
Forests 500m	0.38	0.44	0.42	**0.66**	**0.74**	**0.77**	0.34	0.30	0.27	-0.27	**1.00**										
Urban 500m	-0.21	-0.33	-0.40	-0.29	-0.34	-0.43	-0.17	-0.22	-0.27	**0.65**	-0.48	**1.00**									
Natural 500m	0.15	0.31	0.41	0.31	0.37	0.47	0.11	0.14	0.16	-0.53	0.56	**-0.87**	**1.00**								
Roads 1000m	-0.16	-0.28	-0.35	-0.28	-0.34	-0.42	-0.16	-0.24	-0.31	0.72	-0.39	**0.85**	**-0.70**	**1.00**							
Forests 1000m	0.35	0.45	0.46	**0.60**	**0.71**	**0.86**	0.30	0.31	0.29	-0.31	**0.93**	-0.52	**0.60**	-0.46	**1.00**						
Urban 1000m	-0.17	-0.30	-0.40	-0.26	-0.33	-0.44	-0.16	-0.22	-0.29	**0.65**	-0.45	**0.96**	**-0.84**	**0.90**	-0.52	**1.00**					
Natural 1000m	0.11	0.28	0.41	0.29	0.35	0.48	0.09	0.14	0.17	-0.52	0.52	**-0.84**	**0.96**	**-0.73**	0.59	**-0.86**	**1.00**				
Roads 3000m	-0.11	-0.22	-0.32	-0.25	-0.30	-0.39	-0.17	-0.25	-0.35	**0.58**	-0.35	**0.80**	**-0.67**	**0.89**	-0.43	**0.88**	**-0.72**	**1.00**			
Forests 3000m	0.21	0.36	0.47	0.44	0.54	**0.81**	0.18	0.29	0.35	-0.33	**0.69**	-0.54	**0.60**	-0.51	**0.84**	-0.56	**0.64**	-0.53	**1.00**		
Urban 3000m	-0.12	-0.24	-0.36	-0.25	-0.30	-0.41	-0.17	-0.24	-0.33	0.58	-0.39	**0.86**	**-0.75**	**0.86**	-0.47	**0.93**	**-0.80**	**0.96**	-0.58	**1.00**	
Natural 3000m	0.04	0.21	0.36	0.21	0.28	0.45	0.05	0.14	0.19	-0.46	0.42	**-0.74**	**0.85**	**-0.68**	0.53	**-0.79**	**0.93**	**-0.75**	**0.67**	**-0.83**	**1.00**

5.3.2.2 Single Variable Models

Among single variable GAMs (Table 12), performance of the various metrics in explaining presence/absence patterns varied between species. Model performances, according to the deviance explained values were generally highest for the two Hylid species, Spring peeper and gray treefrog.

For the green frog models, surrounding landscape composition variables exhibited the highest deviance explained values, with total area of urban cover within 3000m resulting in the strongest model by AIC score. Among the three connectivity metrics, model performance was weakest when using metrics at the shortest distances (500m for overwintering; 1000m for dispersal and survival) and similar between the two longer distances (1000 and 3000m for overwintering; 2500 and 5000m for dispersal and survival).

For the wood frog models, simple surrounding landscape variables and the overwintering metrics were the top models and performed similarly in terms of explanatory strength. Among the three connectivity metrics, model performance increased as the distances increased. The survival metrics resulted in the lowest performing models. The amount of surrounding forest and wetland cover within 3000m was the top performing landscape composition variable.

For the leopard frog models, model performance was generally low across all metrics. The best performing metric was the road crossing survival metric, followed by the juvenile dispersal connectivity metric. For both the survival and dispersal metrics, models performed best at the lowest distance (1000m) and decreased in performance as distances increased. The overwintering connectivity metric and the surrounding forest and wetland landscape composition variables explained the least deviance in leopard frog presence. Among surrounding landscape composition variables, urban area within 3000m explained the most deviance.

Model performance was generally lowest for the American toad compared to the other five species. There were no observable patterns in model performance based on distance or type of connectivity metric. Urban and natural cover within 3000m were the best performing habitat metrics, but none of the connectivity or landscape composition variables resulted in significant model results at the 95% confidence level.

For both the spring peeper and gray treefrog models, the landscape composition variables performed best in the single habitat metric models. Of the three landscape composition variables, forest and wetland within 3000m explained the most variance in species presence, followed by natural area and urban cover within 3000m for both spring peeper and gray treefrog. Patterns among the connectivity metric performance were similar between the two Hylid species. The overwintering connectivity metric exhibited highest explanatory strength, followed by the survival metric and then the dispersal metric. Among all of the connectivity metrics, model performance increased as distances increased. The edf values for the road crossing survival metrics for the hylid species demonstrated a high degree of non-linearity (Table 12).

Table 12: Single variable Generalized Additive Model results for each of the six species' presence/absence. Significant models at the 95% confidence level are bolded.

Species	Variable	AIC	Δ AIC	Deviance Explained (%)	edf	Anova F	p-value
GRFR	Disp_1000	134.10	14.30	3.82	1.0000	4.2470	**0.0393**
	Disp_2500	126.90	7.10	9.56	1.1360	9.3640	**0.0026**
	Disp_5000	128.20	8.40	9.25	1.4060	10.5400	**0.0033**
	Winter_500	132.30	12.50	5.15	1.0000	4.1910	**0.0406**
	Winter_1000	130.60	10.80	6.46	1.0000	5.1480	**0.0233**
	Winter_3000	128.50	8.70	8.46	1.1600	7.6570	**0.0283**
	Surv_1000	130.80	11.00	6.23	1.0000	3.9240	**0.0477**
	Surv_2500	130.30	10.50	6.56	1.0000	4.1200	**0.0424**
	Surv_5000	127.50	7.70	8.70	1.0000	5.7340	**0.0167**
	ForWet_3000	126.40	6.60	11.80	1.9770	14.5200	**0.0023**
	Urban_3000	122.90	3.10	12.10	1.0000	16.6600	**0.0000**
	NatAgri_3000	124.30	4.50	12.60	1.6600	2.0470	**0.0169**
WOFR	Disp_1000	391.00	34.84	3.49	3.4690	9.9320	0.0532
	Disp_2500	383.70	27.54	4.07	1.0020	15.2100	**0.0001**
	Disp_5000	377.86	21.70	6.56	2.4070	22.5900	**0.0000**
	Winter_500	378.13	21.97	6.88	3.0670	23.3900	**0.0001**
	Winter_1000	371.55	15.39	8.77	3.4110	28.8100	**0.0000**
	Winter_3000	368.45	12.29	9.55	3.3570	32.0700	**0.0000**
	Surv_1000	392.08	35.92	2.23	1.9260	3.4280	0.2410
	Surv_2500	388.82	32.66	2.33	1.0000	6.9760	**0.0083**
	Surv_5000	392.37	36.21	3.01	2.5750	8.6720	**0.0353**
	ForWet_3000	367.50	11.34	8.86	1.8670	30.1700	**0.0000**
	Urban_3000	370.80	14.64	7.32	1.0000	25.4100	**0.0000**
	NatAgri_3000	372.90	16.74	6.81	1.0000	24.9100	**0.0000**
LEFR	Disp_1000	305.90	25.19	8.04	1.4100	20.7700	**0.0001**
	Disp_2500	312.80	32.09	6.67	2.3280	18.0500	**0.0004**

	Disp_5000	323.30	42.59	2.29	1.0000	7.5400	**0.0060**
	Winter_500	323.60	42.89	2.19	1.0000	5.2090	**0.0225**
	Winter_1000	321.80	41.09	2.73	1.0000	6.5470	**0.0105**
	Winter_3000	321.30	40.59	2.90	1.0000	7.7110	**0.0055**
	Surv_1000	300.20	19.49	9.62	2.7010	11.7600	0.0505
	Surv_2500	305.30	24.59	7.63	1.0000	11.9200	**0.0006**
	Surv_5000	312.50	31.79	5.58	1.0000	10.8300	**0.0010**
	ForWet_3000	322.20	41.49	2.60	1.0000	7.7600	**0.0054**
	Urban_3000	305.70	24.99	7.66	1.0000	24.1600	**0.0000**
	NatAgri_3000	320.80	40.09	4.01	2.5920	12.7200	**0.0052**
AMTO	Disp_1000	212.70	3.60	0.80	1.0000	1.5540	0.2130
	Disp_2500	214.20	5.10	0.07	1.0000	0.1390	0.7100
	Disp_5000	214.20	5.10	1.14	2.1390	1.4200	0.4840
	Winter_500	212.50	3.40	0.90	1.0000	1.4730	0.2250
	Winter_1000	212.60	3.50	3.42	3.0190	2.5040	0.4980
	Winter_3000	214.40	5.30	0.00	1.0000	0.0000	0.9970
	Surv_1000	213.05	3.95	1.72	1.7810	1.0560	0.6400
	Surv_2500	213.30	4.20	2.02	2.7360	2.0880	0.5000
	Surv_5000	213.97	4.87	0.18	1.0000	0.3510	0.5540
	ForWet_3000	214.20	5.10	0.08	1.0000	0.1670	0.6830
	Urban_3000	209.50	0.40	5.64	4.5090	8.9830	0.0912
	NatAgri_3000	209.10	0.00	4.75	2.7020	7.9570	0.0729
SPPE	Disp_1000	273.33	97.83	5.39	1.8020	13.5400	**0.0018**
	Disp_2500	259.47	83.97	9.72	1.0000	23.4600	**0.0000**
	Disp_5000	245.61	70.11	15.40	1.9320	34.7300	**0.0000**
	Winter_500	247.62	72.12	13.90	1.0000	20.9000	**0.0000**
	Winter_1000	238.27	62.77	17.20	1.0000	24.5800	**0.0000**
	Winter_3000	212.67	37.17	26.30	1.0000	30.0000	**0.0000**
	Surv_1000	270.30	94.80	6.15	2.9420	11.3700	**0.0156**
	Surv_2500	257.48	81.98	12.10	4.8200	25.7200	**0.0002**
	Surv_5000	235.67	60.17	20.50	3.7590	42.6200	**0.0000**
	ForWet_3000	181.86	6.36	37.10	1.0010	48.6300	**0.0000**
	Urban_3000	203.74	28.24	29.60	1.1600	61.5700	**0.0000**
	NatAgri_3000	193.13	17.63	34.20	1.9540	65.0700	**0.0000**
GRTR	Disp_1000	303.50	117.61	6.58	1.9800	2.4610	**0.0004**
	Disp_2500	278.70	92.81	13.50	1.0000	34.4700	**0.0000**
	Disp_5000	251.40	65.51	24.10	3.3630	44.0300	**0.0000**
	Winter_500	276.80	90.91	14.10	1.0000	24.3300	**0.0000**
	Winter_1000	260.93	75.04	19.10	1.0000	30.4600	**0.0000**
	Winter_3000	231.10	45.21	31.00	4.1290	44.2000	**0.0000**
	Surv_1000	299.15	113.26	8.20	3.4160	18.2500	**0.0017**
	Surv_2500	279.40	93.51	15.00	4.1410	35.6200	**0.0000**
	Surv_5000	255.00	69.11	23.50	4.2550	53.8400	**0.0000**
	ForWet_3000	205.55	19.66	37.20	1.6340	59.2900	**0.0000**
	Urban_3000	237.10	51.21	26.60	1.0000	61.6000	**0.0000**

	NatAgri_3000	218.30	32.41	32.90	1.3510	80.2300	**0.0000**

5.3.2.3 Multi-variable Models

Among multi-variable models, model prediction was again highest for spring peeper and gray treefrog models (See Appendix I for all model results).

The top performing model for green frog presence/absence included only two variables: Disp_2500 and Urban_3000, but 17 other models had a ΔAIC of less than 2, indicating a small or indistinguishable difference in model performance (Burnham and Anderson, 2002). Eleven of those models included Urban_3000 as an explanatory variable, and the remainder included NatAgri_3000 as an explanatory variable. Surv_1000 and Disp_2500 were also common explanatory variables. None of the models with a ΔAIC of less than 2 included four explanatory variables. Connectivity metrics at 5000m were not included in any of the top performing models. None of the explanatory variables in the top performing models had edf values higher than 1.34, indicating relationships that were close to linear. Fifty-one additional models had ΔAIC values of between 2 and 4, indicating moderate differences in model performance.

The top performing models for the wood frog explained ~14 – 15% of deviance, similar to that of the top performing green frog models. Fourteen models had ΔAIC values of less than 2, indicating a small or indistinguishable difference in model performance. Eleven of these models included Urban_3000 as an explanatory and significant ($p<0.05$) variable and with edf values of close to 1 indicating that the relationships were linear in nature. Although each of the fourteen models with ΔAIC values of less than 2 included some combination of juvenile dispersal connectivity and road crossing survival connectivity metrics, Disp_2500 occurred in only 3 models. In each case, the edf value was 1, indicating a linear relationship. A significant overwintering connectivity metric was included in each of the 14 top performing models, though there was no obvious distance that performed best. The edf values for the overwintering connectivity metrics ranged between 2.54 and 3.18, suggesting a nonlinear relationship with the presence/absence data for the wood frog.

The top performing models for the leopard frog explained ~17-18% of deviance, slightly higher than the top performing models for green frog and the wood frog. Only 3 models had ΔAIC values of less than 2, and all of them were 4-variable models that included Disp_1000, Surv_1000 and Urban_3000 as significant explanatory variables. The Disp_1000 and Urban_3000 connectivity metrics had edf values of 1, indicating linear relationships, while the Surv_1000 metric had edf values of around 2.7 indicating nonlinear relationships.

There were 25 models with ΔAIC values of 2 or less for the American toad, varying from 1 – 4 explanatory variables and an explained deviance of anywhere between 4.75-13%. Of all the explanatory variables in all the top-performing models for the American toad, only two (NatAgri_3000) were significant at 95% confidence level. The models for the American road overall explained the least variance compared to the other five anuran species models.

The top performing models for the spring peeper explained ~41-43% of variance, second highest among the six tested species. Only 4 models had ΔAIC values of less than 2, and all of them included NatAgri_3000 as a significant explanatory variable with edf values of 1. All four top performing models also included Winter_3000 as a significant explanatory variable with a linear relationship (edf of 1). The remaining explanatory variables in the top models included Disp_1000, Disp_2500, Surv_5000, and Surv_1000, with Surv_5000 significant at the 90% confidence level. A further 26 models had ΔAIC values of between 2 and 4 indicating a moderate difference in model performance. One of Urban_3000 and NatAgri_3000 explanatory variables were included in each of those 26 models.

The three top-performing models for the gray treefrog explained ~47-48% of variance, highest among the six species tested. The NatAgri_3000 explanatory variable was included in each of the 3 top models with edf values of 1, indicating linear relationships. Non-linear significant relationships were included in 2 of the top models with the Disp_1000 variable, as well as with the Winter_3000 variable. Surv_5000 was included in each of the 3 top models with edf values of between 1 and 3.22.

5.4 Discussion

5.4.1 Habitat Associations

5.4.1.1 Species Effects

The aim of this research was to design and compare a range of anuran-specific habitat connectivity and landscape composition metrics for predicting the occupancy of six anuran species in Ontario. Using Generalized Additive Models, I demonstrated a range of explained variance of anuran species presence using the connectivity and landscape composition metrics in this study. Differences between the six species were immediately notable, indicating strong species-specific responses to landscape composition and connectivity metrics. The clear differences in model performance between species indicates that species "richness" – in this case a simple count of the number of species – is a problematic response variable when modelling relationships between Ontario anuran species and landscape characteristics. Several research studies conducted in Ontario have used species richness as the sole response variable when modelling landscape relationships (Knutson et al., 1999; Burne and Griffin, 2005; Chandler et al., 2015; Collins and Fahrig, 2017) and the results should therefore be interpreted with caution.

The extent to which metric performance varied according to species was substantial. The presence/absence of the two hylid species in this study – the gray treefrog and spring peeper – resulted in the strongest performing models in this study across most habitat connectivity and landscape composition metrics. Several reasons can be posited to explain the increase in performance, including the physiology of tree frogs, habitat preferences, behavioural differences, and species detection. I posit that since they have the loudest and most distinctive breeding vocalizations of the six species included in this study and often call in large numbers, choruses of spring peeper and gray treefrog can mask quieter species and make it difficult to reliably determine the presence or absence of other species (Crouch and Paton, 2002; de Solla et al., 2005; Genet and Sargent, 2003). Even when calling individually, both of these Hylid species are loud and readily identifiable, and this characteristic is particularly important when data is collected by surveyors with a wide breadth of experience levels. Given the characteristics of their calls, the Hylids may have the most reliable and accurate record of presence in our dataset and may contribute to greater model performance.

Physiologically, the two Hylid species are smaller in size than many of the other species. At the newly-transformed juvenile stage, spring peepers and gray treefrogs are much smaller than green frogs and leopard frogs. While wood frogs and American toads are also quite small at this stage, they lack the ability to climb vertical surfaces like the Hylids. This ability may contribute to the observed differences between the study species. Small juveniles will usually have slower average movement speeds, increasing their exposure to the dangers of road mortality (Hels and Buchwald, 2001), contributing to the road crossing survival metric's higher predictive power for spring peeper and gray treefrog presence/absence. With regards to juvenile dispersal metrics, the hylids' ability to climb vertical surfaces may allow them to more closely follow their original dispersal directions instead of being funneled or redirected by physical obstacles or human infrastructure. The juvenile dispersal connectivity metric may also have performed better for the Hylid species because they favor marsh wetlands as destination breeding wetlands to a greater extent than the other four species. The American toad and green frog can generally be considered generalists in terms of habitat and breeding, while the wood frog is typically more selective of ephemeral ponds (Homan et al., 2004; Porej et al., 2004), so the juvenile dispersal connectivity metric used here may be less suitable for those species in its current format.

While the GAMs for the two Hylid species exhibited the highest explained variances, the American toad GAMs showed almost no association with any of the tested metrics for connectivity or landscape composition. Consistent with previous literature (Lehtinen et al., 1999; Houlahan and Findlay, 2003; Rubbo and Kiesecker, 2004), the American Toad is an effective generalist anuran with the ability to utilize a wide range of land covers, anthropogenic features, and remnant natural areas as habitat. Since the American Toad can effectively breed, forage, and overwinter in a wider range (and size) of features, it is no surprise that the models performed poorly.

The green frog can also be considered a habitat generalist and tolerant of disturbance given its ability to persist and sometimes even thrive in disturbed areas. The explained variances of green frog occupancy for the various metrics used in this study were generally the the highest next to the Hylid species but were still considered to be only moderately predictive. No issues with detection should be considered here as the green frog's breeding season occurs later in the summer, is easily distinguishable, and is reliably identifiable. Curiously, green frogs and other ranids are heavily impacted by road mortality and the habitat fragmentation that exacerbates it (Ashley and Robinson, 1996; Glista et al., 2008) but seem to have a higher tolerance to this component of fragmentation as evidenced by the poor associations with the road crossing survival metric. The difference with the green frog compared to the two hylids and some other anuran species like wood frogs and American toads, is that the green frog overwinters in permanent ponds, oftentimes the same ponds where they breed. Despite the large numbers of road fatalities amongst newly-transformed juvenile green frogs, there may be many cases where enough individuals stay in their natal ponds, overwinter, and survive to the next years to breed and replenish juvenile numbers.

Although the green frog is able to persist in many developed areas, it may not be able to do so in cases of sustained habitat disturbance and may respond more slowly to habitat degradation than some other species like the spring peeper and gray treefrog. It is difficult to know with certainty the degree of response on a species-by-species basis, but there is some evidence to suggest a lag effect for some anuran species (Hamer and McDonnell, 2008; Metzger et al., 2009). Logically, the slow but cumulative pressures of increased human disturbance would result in a similarly slow but inevitable decline in species abundance not captured by presence/absence data if the disturbance in question was more recent, and if the green frog is indeed more resilient to these pressures, it may take up to several decades for true species extirpation in any particular wetland to take place. With regards to the metrics tested in this study, they may remain useful for the green frog if applied with that consideration in place. Concerns of vehicle-induced mass mortality and reductions in safe avenues for population replenishment remain valid for the green frog if long-term persistence is desired.

The wood frog is a frequently studied species (Porej et al., 2004; Coster et al., 2014) because of its relatively strong preference for forested ephemeral ponds. Unsurprisingly, the best-performing connectivity metric was associated with forest cover (overwintering habitat) though these metrics explained less than 10% of variance as single variables. The wood frog has a relatively quiet call and is an explosive early breeder which may lead to reductions in detectability, particularly when populations are small, far away from the survey point, or in remote areas which make quick response spring surveys more logistically challenging. These issues may also explain why the wood frog was the least frequently recorded species among the six included in this study. Assuming the detectability amongst the sites was reliable, the wood frog's model performance may have been compromised by the focus on marsh habitat in the juvenile dispersal and road crossing survival metrics and the exclusion of swamps which may contain suitable ephemeral breeding ponds. Furthermore, most of the wetlands surveyed in this study – and by the Birds Canada protocol in general – tend to be larger, permanent wetlands favored by other anuran species, whereas wood frogs are commonly found to prefer ephemeral ponds. To more accurately explore the relationships between wood frogs and landscape characteristics, a more targeted site selection approach may be required.

Most of the top performing models for the wood frog also used urban cover within 3000m as an explanatory variable, indicating a strong response to human disturbance at a wider radial extent. Metrics at smaller spatial scales (e.g. 1000m) were also common in the top models, remaining consistent with our current understanding of the maximum movement distances of wood frog which have been recorded in the 430-2530m range (Patrick et al., 2012).

The sixth species analyzed in this study was the Northern leopard frog. Visually striking and among the largest ranids in Ontario, the leopard frog nonetheless has one of the quietest breeding calls, a rumbling low call which overlaps with the higher-pitched spring peeper calls in early and mid-spring (Birds Canada, 2012). The leopard frog was the second least frequently recorded species among the six included in this study. The top leopard frog models performed better than the other ranid species, but not nearly as well as the models for the hylids. The leopard frog is well known for its affinity for grassy and meadow areas surrounding their breeding habitat, and with its strong hind legs is a capable jumper. Curiously, despite the leopard frog's physiological advantages for overland travel and long-ranging maximum dispersal distances (Carr and Fahrig, 2001; Patrick et al., 2012), the variables included in the top performing models suggest that connectivity measures at shorter distances are better predictors for presence/absence.

Metrics associated with forest cover were also weak for the leopard frog, but this is consistent with our understanding of the leopard frog's habitat preferences. Like the green frog, the leopard frog overwinters at the bottom of permanent ponds, and forages in surrounding meadows, grassy areas, or agricultural areas (Knutson et al., 2018), suggesting limited life history needs for forested areas. Short distance juvenile dispersal, road crossing survival, and surrounding urban cover performed well in the top leopard frog models, but other factors such as hydroperiod, predatory presence, and foraging habitat (i.e. local vs landscape variables) may be more important for determining presence/absence (Houlahan and Findlay, 2003; Weyrauch and Grubb, 2004).

Regardless of species, model performance was consistently improved when multiple variables were included in a single model, suggesting that the specific mechanisms modelled by the connectivity metrics are contributing to improved model predictivity when combined with general landscape characteristics. Up to 50% of variance was explained for the hylids when combining connectivity metrics with landscape composition variables compared to a maximum of 37% of variance with single-variable models.

5.4.1.2 Local vs Landscape Predictors

Additional variance in anuran species presence and absence can be attributed to local conditions that were not accounted for in this analysis, including hydroperiod, water quality, water depth, and presence of predators. The six species included in this study have different habitat preferences for both landscape and local variables. Water depth and hydroperiod in particular are important determinants of whether a wetland is suitable for breeding habitat. The wood frog, for instance, prefers wetlands with shorter hydroperiod partly as a way to avoid predation by fish that could not otherwise survive in bodies of water that are not inundated for the full year (Rubbo and Kiesecker, 2004; Weyrauch and Grubb, 2004; Hermann et al., 2005). Species like the green frog and leopard frog, on the other hand favour wetlands with longer hydroperiods or those that are deeper and reliably hold water the whole year round because they can remain as tadpoles over the winter, transforming into adult frogs by the early summer for dispersal (Houlahan and Findlay, 2003; Weyrauch and Grubb, 2004). Details about these local hydrological characteristics were not provided in the Birds Canada dataset so they could not be included in the analysis, challenging the ability of the connectivity metrics to perform at their best. Performing separate analyses on short hydroperiod wetlands vs longer hydroperiod wetlands would have likely garnered some additional interesting results, particularly at the species level.

Human disturbances of equal spatial footprint can also vary in terms of their intensity and pressure on adjacent natural spaces. One such example is the impact that heavy industrial or commercial activity can have on neighbouring wetlands because of excessive noise pollution. Since successful anuran breeding is reliant on auditory cues, if male breeding calls are obscured by anthropogenic noise, then breeding success may be reduced resulting in smaller populations and compromised population resilience (Lengagne, 2008; Grenat et al., 2023; Zaffaroni-Caorsi et al., 2023). With all of this in mind, a general landscape composition metric such as the proportion of urban cover within a certain distance of wetland edge may not account for the types of urban cover in question which can vary from low-density residential to heavy industrial uses. Smaller-scale anuran population modelling exercises that are not constrained by the limitations of a wide geographic area should aim to account for both the direct (footprint) and indirect (e.g. noise, pollution, activity) impacts of human-altered land covers within the anuran species' habitat ranges.

5.4.1.3 Wetland Selection and Characteristics

In constructing these models and selecting sites from the existing Birds Canada database, I found what I expected - the size, location, hydrology, and history of the wetlands varied substantially from one survey site to another. As with any ecological models, controlling for this type of complexity was not possible nor practical and as such was anticipated to lead to reductions in model predictability of anuran species presence. Examination of the 290 wetlands selected for inclusion in this analysis did, however, reveal some high-level groupings of wetland characteristics that are hypothesized to contribute to the variable performance of many of the tested connectivity metrics.

The wetlands in this study spanned from the tip of southwestern Ontario in Windsor up to the border of Quebec along the St. Lawrence River. With the abundance of waterbodies in this area of Canada, many of the surveyed wetlands occurred along the coast of lakes or along the edges of large rivers. In such cases, the interpretability of certain metrics is compromised without understanding and/or accommodating the landscape context. For example, the juvenile dispersal metric's output is a value between 0 and 12 representing how many directions of initial travel were likely to result in access to other suitable wetland habitats. If a wetland was situated on the edge of a large lake, then immediately, 5-6 initial directions are removed from contention, and even if the remaining inland terrestrial land cover is ideal habitat for anuran species, the most the metric can report is 6/12 for juvenile dispersal connectivity. Contextually, one would have to account for the fact that dispersing anurans simply would not disperse out into a major body of water or for those that try, would be swept back to shore.

With regards to wetland selection, it must be noted that because the survey data was taken from a repository of anuran acoustic survey data which, in many cases, was collected using citizen science or targeted for certain conservation objectives, then the selection of study sites could not be considered random. It is likely there was an overrepresentation of wetlands that were favourable for anuran species presence with the goal of monitoring changes in population abundance or composition as opposed to presence or absence entirely. Accordingly, there were many large wetlands and wetland complexes included in the dataset, and smaller wetlands or those in urban areas with historical habitat degradation were generally less represented. Efforts at sub sampling to avoid over representation or certain characteristics could be an avenue for future modelling and research, but it is my assertion here that the sheer size and temporal coverage of survey data provided sufficient strength to the underlying model data so as to dilute any effects induced by wetland selection or bias. Furthermore, I applied my own set of filters to the thousands of survey stations from the original dataset to remove problematic, unreliable, or data-deficient sites.

5.4.1.4 Variable Distance Effects

The role of maximum movement distance remains unclear for most of the species, but there is some evidence in the GAMs results to suggest that connectivity metrics at certain maximum distances and for certain species provided greater predictive power than others. Part of the reason that the role of maximum movement distance may remain uncertain is that our understanding of the movement patterns of juvenile and hylid species is incomplete. As discussed in Section 2.1.1, each of the six anuran species included in this study has been reported with varying maximum movement extents, which also vary according to life stage. These figures are also maximum values as opposed to most likely or common movement extents. Maximum movement extents can be subject to individual anomalies or movement events assisted by other features (e.g. a fast-flowing river may conceivably carry a dispersing juvenile a long distance with minimal energy expenditure of the anuran individuals' end). In addition, hylids such as the spring peeper and gray treefrog are notoriously difficult to track given their size and tendencies to climb trees, making recovery of tracking equipment challenging.

Among the two elusive hylid species, the top performing models consistently included an overwintering connectivity metric at the 3000m maximum movement extent, a road crossing survival metric at the 5000m maximum movement extent, and a juvenile dispersal metric at the 1000m maximum movement extent. These results are somewhat confounding given the range of distance effects, but as a whole, the picture that is painted points to hylid species responding strongly and positively to a large and wide-reaching vegetated landscape. With regards to dispersal, I hypothesize that since juvenile hylids are exceptionally small, they require suitable destination habitats and wetlands within shorter distances (e.g. 1000m vs 5000m) for newly transformed juveniles to stop over at or settle into.

The top performing presence/absence models for the green frog, on the other hand, included no connectivity metrics at the 5000m extent. The most commonly included road crossing survival metric in the top models was at the 1000m extent, while the juvenile dispersal metric was most commonly included at the 2500m distance. These results would suggest that green frogs are less impacted by wider landscape effects compared to the two hylid species. The top performing model did not include any significant overwintering metric at any distance. Indeed, this is fairly consistent with our understanding of green frog life history dynamics since they can overwinter in the same ponds that they breed in and forage in adjacent areas, allowing them to persist in relatively isolated wetland habitat for longer periods of time. This may explain their relative resilience to surrounding landscape disturbance and why they are so often present in disturbed landscapes.

Consistent with the wood frog’s preference for wooded land covers, the top performing models all included an overwintering connectivity metric, although there was no one distance that performed better than the others. Curiously, despite being recorded with the farthest maximum movement distance among all the species at 5200m (Patrick et al., 2012), the top performing models for the leopard frog included road crossing survival and dispersal metrics at the 1000m extent. Although the leopard frog may be able to move quickly and jump farther than the other species, this might be an adaptation to its preference for grassy areas, meadows, and even agricultural fields, and might have less to do with its ability to disperse and migrate across the landscape. Furthermore, a maximum movement distance is not necessarily indicative of average dispersal distance. The models in this study suggest that the leopard frog is quite sensitive to nearby habitat disturbance and therefore may require greater buffers around wetland habitat.

Overall, the results suggest that each species has a different preference for landscape composition and connectivity to survive and thrive. This result also reiterates that anuran richness as a response variable cannot be reliably used to guide anuran conservation as species-specific habitat needs will become diluted.

5.4.2 Connectivity Metric Performance and Improvement

5.4.2.1 Juvenile Dispersal Metric

Dispersal as a movement mechanism in anurans has rarely been incorporated into anuran habitat modelling. My attempt at creating a metric that could capture characteristic movement patterns of dispersing juveniles is rudimentary and exploratory in nature given the lack of previous work to build on. Regardless, there were some promising results, as well as plenty of opportunities to improve based on the experiences in the development and implementation of the metric presented in this study.

The dispersal metrics' performance was variable across the six species, but generally explained the lowest or among the lowest variance compared to the other metrics. It was, however, included as a significant habitat metric in the top-performing hylid models, leaving room for improvement, refinement, and scrutiny with regards to its ability to model juvenile anuran dispersal. Two major challenges were encountered while developing this metric: 1) deciding the radial width of movement for a dispersing individual, and 2) deciding the type and size of wetlands that qualify as appropriate destination areas.

When deciding the number of "wedges" to include in the juvenile dispersal metric models, there were several important considerations, including the amount of leeway to provide for side-to-side movements and diversion due to physical barriers (e.g. buildings, steep slopes, coastlines). These considerations needed to be balanced with the labour and computational capacity of including more wedges. For example, increasing the number of wedges from twelve to twenty (thus decreasing the radial width from 60 degrees to 36 degrees) could have provided some greater resolution for this metric, emphasizing the directional characteristics of dispersal, but increasing the computational time by at least 67% for a metric which in its current format required hundreds of hours to compute. The metric used in this study used a 60-degree radial width, which provided a substantial margin for side-to-side deviations in movement but may have assumed that lateral movement was too wide. Deciding upon the radial width was additionally complicated by the lack of tracking data for newly transformed juvenile anurans.

Newly transformed juveniles are typically much smaller than adults, particularly in wood frogs, American toads, gray treefrogs, and spring peepers, which are usually about the size of a small coin. Organisms of this size are extremely difficult to reliably track through telemetric techniques due to the weight and size of the transmitters required. Additionally, as juvenile anurans disperse, they are often victim to predation, vehicle-induced mortality, or other causes of mortality, reducing the efficacy of telemetry and increasing equipment cost.

Deciding upon what constitutes a suitable destination wetland was also a challenging component of crafting the juvenile dispersal metric. The SOLRIS dataset and the provincial wetland layer dataset classified wetlands into 4 categories: marsh, swamp, bog, and fen. The majority of wetland classifications across the study area were swamp, a land cover where all species of anurans can often be found depending on the hydrological characteristics of each area. However, they do not reliably have standing water long enough to facilitate anuran breeding, therefore it was omitted from the dispersal metric as a suitable destination area. Omitting the swamps from the destination pixels was deemed necessary due to their inconsistent hydrological regimes, but it may have led to an underestimation of juvenile dispersal connectivity, particularly in swamp-dominated landscapes. Fortunately, if applied on a smaller scale, this limitation may be far less important, as all wetlands within a small region can be surveyed to determine hydrological suitability of anuran wetland habitat before the connectivity models are executed. On the scale of analysis in this study, this level of field validation was not viable.

5.4.2.2 Road Crossing Survival Metric

Similar to the juvenile dispersal connectivity metric, the road crossing survival metric generally explained less deviance of anuran species presence compared to the surrounding landscape composition metrics but was included in many of the top-performing multi-variable models. With this connectivity metric, there is also an opportunity for improvement and further research as the pressures associated with road-induced mortality persist and expand in large areas of Southern Ontario.

The road crossing survival metric shared a fundamental challenge with the dispersal metric: determining appropriate destination cells. In this metric, marsh was designated as suitable destination habitat while swamp was omitted because its classification is not a reliable enough indicator of standing water suitable for anuran breeding. Nevertheless, anurans that cross over roads may be doing so to reach destinations other than breeding ponds. For instance, fall migration would involve movement of anurans from wetlands or adjacent non-breeding habitat (e.g. forests, meadows) to overwintering areas such as permanent ponds, forests with appropriate ground cover, or even streams. For simplicity in this exploratory analysis, the road crossing survival metric was designed to capture movement behaviours more aligned with juvenile dispersal (i.e. movement from a breeding pond to another breeding pond) so as to keep the source areas as the wetlands where acoustic surveying took place and the destinations as nearby suitable wetlands. Fortunately, this metric need not be restricted to modelling dispersal; it can just as easily be applied to regional or local analyses focused on other types of movements and destinations, just as it can also be adapted to model the movement of other terrestrial species.

Focusing these kinds of analyses on more localized contexts can also improve the realism of the traffic rates that are required to determine road crossing survival rates. In this study, road traffic rates needed to be generalized across the thousands of road segments across the 290 study areas. Realistically, roads of the same provincial classification will vary dramatically in terms of traffic intensity based on local conditions, urban context, or function as commuting corridors, and these site-to-site details are important for improving model accuracy on a smaller scale.

A third area of improvement is our understanding and implementation of road crossing survival rates. Although empirically sourced data from a limited number of published literature was available to determine the relationship between traffic intensity and road crossing success, there was a clear lack of research in this particular area. Validating anuran road crossing survival rates is extremely difficult since they are small, challenging to track, and typically move around at night and in the rain when visual observation is compromised. Mazerolle et al. (2005), among others, have conducted controlled road crossing experiments, but they may be compromised by the removal of the individuals from their natural habitat and disruption of their natural movement cues. Other attempts at determining road crossing survival rates have focused on crafting formulas which take into account anuran physiology such as movement speed and body size, along with traffic frequency, road width, and vehicle footprint (Hels and Buchwald, 2001). In this case, detailed species-specific data is required, which wasn't available at the time this metric was developed. Interestingly, the road crossing survival rates that were inferred from previous field observations in Joly et al. (2003) matched up fairly well with the calculated survival rates outlined in Hels and Buchwald (2001).

5.4.2.3 Overwintering Habitat Metric

The overwintering metric used in this analysis was the least altered from traditional connectivity metrics, using a similar resistance-based approach to quantify the accessibility of forest habitat in areas surrounding breeding wetlands. Two significant changes to traditional resistance models included altering resistance values to be consistent with movement during ideal conditions (i.e. at night during periods of increased moisture such as rain or high humidity) and including buildings as absolute barriers. The overwintering metric was a significant contributor to the top-performing models for the wood frog, spring peeper, and gray treefrog, all of which are dependent on forest for overwintering habitat. Minimal challenges were encountered when developing or using this metric, but several improvements and considerations can be implemented.

There was little emphasis on including punishing resistance values in this connectivity metric in response to the assertion throughout this study that anuran movement occurs during times of the day when hostile land cover resistance is minimized or entirely mitigated. There was a meaningful focus, however, on including some additional realism with regards to the maze of absolute barriers introduced in human landscapes in the form of buildings and other structures. Curiously, building footprints are often not included in amphibian connectivity models, but certainly most amphibians can not pass through or over, a vast majority of anthropogenic structures. Even for the hylids, successfully climbing over any larger human structure like a house would be a unnecessarily complicated, energy-intensive, and rare undertaking during movements such as migration and dispersal. While the inclusion of these obstacles was important, it was difficult to accumulate and compile data from such a wide geographic area. The Provincial datasets with the greatest geographic extent only include buildings of a certain size, so additional resolution was needed in the form of municipal and regional building footprint datasets. Ultimately, a sufficient degree of geographic coverage was attained and included in the model, but there are a couple of considerations to note.

The first consideration is that of resolution. When converting the vector building footprint layers to a raster format compatible with the rest of the modelling process (15x15m pixels), a significant amount of detail is lost. This is particularly pertinent because buildings were assigned resistance values consistent with being absolute barriers, so small spaces between buildings that could otherwise act as avenues for movement through residential developments or other clusters of structures in urban areas may have been lost when resampling to a raster format. The consequence of this is that there may have been instances in which shorter travel routes were not available when the cost distance functions were executed for the overwintering connectivity metric. Nevertheless, the rasterized layers were examined in some detail and for the most part major discrepancies were not noted.

The second consideration is that of other human infrastructure barriers. In addition to buildings, there are many other structures that can interrupt anuran movement enough to consider them absolute barriers. One example is solid wood fences in residential areas, which due to their sprawling nature may create major obstacles for even the smaller hylid species, although this particular interaction has not been studied in any amount of detail. Other infrastructure such as canals, highway dividers, and industrial activities can present similar barriers to movement. However, even natural barriers that impede movement are common across the study, save perhaps the sprawling agricultural areas of southwestern Ontario. In all of these cases, such finer details are not available and as such may present some additional uncertainty with regards to the accuracy of the modelling results in this study in other such connectivity modelling efforts. One exception to this is the wide availability of topographical data which provides some insight into the presence of steep and difficult to traverse areas. Future improvements to overwintering habitat metrics could seek to incorporate such topographical detail to address variations in natural cover resistance.

5.5 Implications and Conclusions

The motivation behind exploring new anuran connectivity metrics was to address the failure of existing anuran connectivity modelling to adequately incorporate the differing movement behaviours characteristic of migration and juvenile dispersal in anthropogenically disturbed landscapes. Furthermore, anuran movement dynamics are complex and multi-faceted, and attempts to include that complexity into a single land cover resistance value are difficult to reconcile with those complexities. Instead of focusing this research on refining anuran land cover resistance values, I aimed to deconstruct the resistance modelling approach and address each known anuran movement mechanism on its own. As such, refinements to each metric could be made individually to examine the effects on a species-by-species basis. Using GAMs to examine the explanatory power of each metric individually and combined with other metrics, interesting patterns were uncovered, many of which are consistent with our a priori understanding of each species' behaviours.

As expected, general landscape composition characteristics such as the amount of surrounding urban cover or forest cover performed well across most of the species and have long been identified as general explanatory variables for anuran species presence and abundance in the region of study. The connectivity metrics that were constructed and tested added additional explanatory strength to the models. Many avenues for refinement and improvement were identified for the connectivity metrics, providing opportunities for future research and model exploration.

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6.0 Exploring Landscape and Habitat Thresholds

6.1 Introduction and Objectives

Species' responses to disturbances such as habitat loss are rarely expected to be arithmetically linear in nature given the compounding effects and pressures of these changes on their life history and physiological requirements. When considering a gradient of disturbance, the strength of species' responses can change gradually or abruptly (Toms and Lesperance, 2003). In cases where the species response occurs abruptly, the point at which the change occurs is the critical breakpoint, commonly referred to as an "ecological threshold" in ecological research and plays an important role in species management (Huggett, 2005; Groffman et al., 2006). The presence and identification of these thresholds is challenging due to the complex environmental interactions at play between species and their habitats (Suding and Hobbs, 2009). Ecological thresholds are likely to be dependent on the broader context of the landscape on interest, the quality of the land covers, and the spatial interaction of heterogeneous land cover matrices (Olden, 2007; Ficetola and Denoel, 2009; Hillibrand et al., 2023). Nonetheless, if and when identified, they may provide an understanding of species' tolerances to disturbance that can be used to guide protections, craft mitigation measures, and work towards long-term conservation (Ficetola and Denoel, 2009).

This theory of thresholds in biological systems and the potential for its complimentary implementation in regulatory natural heritage management has contributed to the widespread adoption of minimum habitat or land cover protections. In the context of anurans conservation, existing regulations in Ontario and in many other North American jurisdictions require minimum natural cover buffers or other minimum protections for wetlands (Lee et al., 2004; Schulte-Hostedde et al., 2007; Sawatzky and Fahrig, 2019), suggesting a fundamental understanding that loss of habitat in a surrounding habitat beyond a certain point will lead to accelerated species decline and possible extirpation. Whether these minimums are actually addressing the minimum habitat needs of Ontario's anuran species is an important question as development, urban expansion, and fragmentation continue to occur across Ontario's landscape. With regards to habitat connectivity, references to preserving movement corridors do not include any suggestions of minimum land cover amount, quality, or placement details. This is despite a wealth of existing literature regarding habitat connectivity, suggesting a concerning and extended lag in the regulatory adoption of natural heritage recommendations that hinders the effectiveness of such regulations for species that are dependent on connected habitat to persist long-term (Schulte-Hostedde et al., 2007; Sawatzky and Fahrig, 2019).

In addition to the shortcomings of current regulatory minimums for natural heritage management in Ontario, there is the wider and more recent contention that threshold-type relationships are poorly evidenced quantitatively (Hillibrand et al., 2020). They are enticing to policymakers and those tasked with crafting regulatory objectives because they provide a relatively easy to understand and quantifiable goal (Pimm et al., 2019), but they may also vary according to local context with the same jurisdictional area, follow more gradual responses, and be less effective without considering interaction with other pressures (Carrier-Bellaeu et al., 2022). Nevertheless, there is no indication that natural heritage regulations in relation to species management will shift away from the minimum habitat requirement approach, therefore it is important to refine current policies to be consistent with evidence-based biological minimums.

Relationships between Ontario anuran species presence and habitat metrics have been established both in the published literature detailed in Section 2.1.2 and results presented in Section 5.3. Several studies have also explored threshold-type relationships among the habitat metrics, identifying such critical breakpoints as 44% of habitat cover within 1000m for wood frogs (Homan et al., 2004) and 40% of forest cover within 1000m for overall amphibian richness (Hermann et al., 2005). These ecological thresholds commonly relate to the amount of suitable land cover or habitat within a certain distance of the anurans' breeding pond. A critical component often unexplored is that of connectivity thresholds, and the extent to which configurations, accessibilities, and barriers can lead to critical thresholds. The work detailed in Section 5 aimed to craft metrics that could quantitatively communicate components of connectivity that are informed by anuran movement timing, behaviour, and dynamics. In this section, I will explore whether these connectivity metrics and habitat composition metrics demonstrate ecological thresholds and discuss what these thresholds mean for broader anuran conservation in Ontario.

6.2 Methods

6.2.1 Study Area

The area of interest for this study was Southern Ontario, an area spanning a wide geographic area from Windsor to Ottawa. The area is characterized by a wide range of land covers, both natural and anthropogenic, including historical heavily urban areas and remnant natural wetlands and forests. Most of the population of Ontario lives within a small area along Lake Ontario which included the Toronto metropolitan area, although a variety of large and small communities are spread out across the breadth of the Southern Ontario region. As such, the area has a sprawling and heavily used road network that has fragmented large swaths of the landscape. For more information on the area of study, refer to Section 5.2.1.

6.2.2 Study species

This area of Ontario is habitat to the highest amphibian richness in Canada, which includes eleven anuran species that occur widely in notable numbers. Six anuran species were selected for analysis due to their widespread distribution and auditory recognition amongst the general citizen science community. The six species are the green frog, wood frog, Northern leopard frog, American toad, spring peeper, and gray treefrog. Reasons for excluding certain other species from this analysis are discussed in Section 5.2.2.

6.2.3 Response Variable and Dataset

Wetland occupancy (presence/absence) was used as a response variable in this analysis. Data regarding the presence or absence of breeding anurans was derived from the Birds Canada Great Lakes Marsh Monitoring Program database. This repository includes anuran auditory survey data from thousands of wetlands across Ontario collected over more than 25 years using the standardized survey protocol detailed in the Marsh Monitoring Protocol document (Bird Canada, 2008). Details regarding the collection of this data is included in Section 5.2.3. The data was accessed in 2019 and therefore any additional data from 2020 onwards was not included in this analysis. Presence of any of the six anuran species included in this study was confirmed at a wetland site if at least 2 individuals were recorded calling. A single calling individual across all monitoring years was deemed insufficient to warrant a confirmed species presence.

Wetlands were determined to be appropriate for inclusion in this analysis based on several criteria. The first requirement was that the wetland needed to be surveyed for at least three years (even if non-consecutive) to ensure that issues related to population turnover, variable calling timing, and detectability were minimized. The second requirement was for the wetland to be naturally occurring and not an anthropogenic feature such as a stormwater pond. The third requirement was that the wetlands have clear and defined boundaries such that those that were part of larger hydrological features or unusual environmental contexts were omitted. After the application of these criteria, 290 wetlands were deemed suitable for inclusion in the analysis.

6.2.4 Predictor variables

Three connectivity metrics were constructed to model anuran movement processes and life histories. The first metric addressed the dispersal mechanism which occurs when a newly transformed juvenile anuran leaves its natal pond and searches for new habitat. The metric quantified the number of directions (out of twelve) that included suitable wetland habitat after accounting for three maximum dispersal movement distances, and theoretical nighttime land cover resistance values for each species. Details on the construction and workflow for this metric are included in Section 5.2.7.1.

The second metric addressed the availability of overwintering forest habitat available for anurans in the area surrounding each wetland study site. This metric quantified the accessibility of adjacent forest habitat after accounting for maximum migration movement distance and theoretical nighttime land cover resistance values. Details on the construction and execution of this metric are included in Section 5.2.7.2.

The third metric addressed the mechanisms of road crossing mortality by applying a multiplicative penalty to survival when crossing over a road, proportional to the probability of survival of crossing that road. Road crossing mortality is applicable to both dispersal and migration movement for anurans. The road crossing survival metric quantified the amount of wetland that is accessible by at least 5% of initial moving individuals from the source wetland after accounting for several maximum movement distance, theoretical nighttime land cover resistance values, and variable road crossing mortality rates depending on traffic intensity. Details on the construction and execution of this metric are included in Section 5.2.7.3.

The final groups of metrics were more general in nature and characterized the surrounding land use composition. The proportion of 1) forest and wetland, 2) urban cover, including low and high density, and 3) vegetated land cover including agricultural land cover, were calculated for each survey site within a surrounding area of 500, 1000, and 3000 metres. Table 13 summarizes the naming conventions for the connectivity and landscape connectivity metrics used in the threshold analysis.

Table 13: Naming conventions and descriptions of connectivity and landscape composition metrics used in the threshold analysis

Variable Name	Description
Surv1000	Road crossing survival metric with a maximum movement distance of 1000 metres
Surv2500	Road crossing survival metric with a maximum movement distance of 2500 metres
Surv5000	Road crossing survival metric with a maximum movement distance of 5000 metres
Overwinter500	Overwintering habitat connectivity metric with a maximum movement distance of 500 metres
Overwinter1000	Overwintering habitat connectivity metric with a maximum movement distance of 1000 metres
Overwinter3000	Overwintering habitat connectivity metric with a maximum movement distance of 3000 metres
Disp1000	Juvenile dispersal connectivity metric with a maximum movement distance of 1000 metres
Disp2500	Juvenile dispersal connectivity metric with a maximum movement distance of 2500 metres
Disp5000	Juvenile dispersal connectivity metric with a maximum movement distance of 5000 metres
ForWet500	Proportion of forest and wetland land cover within 500 metres
ForWet1000	Proportion of forest and wetland land cover within 1000 metres
ForWet3000	Proportion of forest and wetland land cover within 3000 metres
Urban500	Proportion of urban land cover within 500 metres
Urban1000	Proportion of urban land cover within 1000 metres
Urban3000	Proportion of urban land cover within 3000 metres
NatAgri500	Proportion of vegetated land cover within 500 metres
NatAgri1000	Proportion of vegetated land cover within 1000 metres
NatAgri3000	Proportion of vegetated land cover within 3000 metres

6.2.5 Statistical Analysis

For each variable in the analysis, bins of an equal number of data points were created. Both deciles and 20-bin quantiles were calculated so that the proportion of sites within each division with confirmed anuran species presence could be determined. Since the dataset was large (N = 290) and many variables' values spanned a wide range, 20-bin quantiles were included and tested to add additional resolution to the threshold analysis. Only thirteen values were possible for the dispersal metric so in lieu of determining deciles or 20-bin quantiles, each value was treated as its own quantile. The road crossing survival metric at the 1000 m distance was limited to 17 bins for the 20 bin quantile analysis because there was a high number of values that were exactly zero.

A piecewise regression analysis was performed for each species and each variable/distance combination. Piecewise regression has been previously shown to correctly identify breakpoint positions (Ficetola and Denoel, 2009) so it was selected for use in this analysis. The r.segmented package was used to run the analysis. Breakpoints were first estimated visually and inputted into the r.segmented analyses for use in guiding breakpoint estimation by the piecewise regression software. Since each decile and 20 bin-quantile division was a range of values (except the dispersal metric), many of which did not increase linearly, the deciles and 20-bin quantiles were assigned numbers corresponding to the order of their bins. Davies p-value ($p = 0.05$) was calculated to determine the significant of the breakpoint by testing for a non-zero difference between the slope parameters of the two linear models.

6.3 Results

All breakpoint analysis results are graphically presented in Appendix II.

Green frog

For the decile analysis (Table 14), only one significant breakpoint was identified amongst the connectivity metrics (Overwinter3000) at the 1764 – 2680 range, indicating that when the forest habitat accessibility score was less than 1764 at a 3000m maximum movement distance, the proportion of green frog presence drops at an accelerated rate, although the proportion of presence remained high at 76% in the lowest decile representing sites with 0 – 751 accessible forest habitat scores. A breakpoint was identified for the 20-bin quantile analysis as well (Table 15), but it was insignificant at the 95% confidence level ($p = 0.081$). The only significant breakpoint identified amongst the connectivity metrics in the 20-bin quantile analysis was with Surv5000 at the 2671 – 3320 range indicating that at less than 2671 pixels (equivalent to about 150 acres) of accessible wetland reachable with a minimum 5% survival rate with a maximum movement distance of 5000m, rates of green frog presence decreased at a quicker rate.

Further significant breakpoints in the decile analysis were identified in all of the landscape composition metrics except ForWet1000. For the urban landscape composition metrics, breakpoints at which green frog presence decreased at a faster rate occurred when urban cover was greater than 10.4% of 500m radius surrounding land cover, 20% of 1000m radius surrounding land cover, and 24% of 3000m radius surrounding land cover. Presence rates were never lower than 78% at the lowest deciles across the three distances. In the 20-bin quantile analysis, these breakpoints occurred at 55%, 71%, and 74% respectively, with the lowest presence rates at 64%.

Table 14: Results of the decile breakpoint analysis for the green frog using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level

Decile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	-	-	-	-
Surv2500	6	7.709	-23.902	1.000
Surv5000	4	1.269	-33.797	0.051
Overwinter500	-	-	-	-
Overwinter1000	4	1.929	-25.282	0.684
Overwinter3000	**3**	**0.538**	**-33.898**	**< 0.001**
ForWet500	**4**	**0.930**	**-34.080**	**0.003**
ForWet1000	-	-	-	-
ForWet3000	**3**	**0.330**	**-36.662**	**< 0.001**
Urban500	**6**	**0.493**	**-43.585**	**< 0.001**
Urban1000	**7**	**1.307**	**-29.401**	**0.048**
Urban3000	**7**	**0.937**	**-36.332**	**0.002**
NatAgri500	**4**	**0.420**	**-39.394**	**< 0.001**
NatAgri1000	**4**	**0.670**	**-34.874**	**< 0.001**
NatAgri3000	**2**	**0.195**	**-38.347**	**< 0.001**

Table 15: Results of the 20-bin quantile breakpoint analysis for the green frog using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level

20-bin quantile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	13	7.461	-49.962	1.000
Surv2500	-	-	-	-
Surv5000	**7**	**1.494**	**-67.979**	**0.016**
Disp1000	-	-	-	-
Disp2500	5	2.228	-16.752	0.355

Disp5000	4	2.121	-18.877	0.239
Overwinter500	3	6.015	-47.220	1.000
Overwinter1000	8	3.516	-48.526	0.414
Overwinter3000	6	1.881	-47.734	0.081
ForWet500	7	2.031	-43.583	0.095
ForWet1000	**4**	**1.436**	**-42.418**	**0.014**
ForWet3000	**6**	**0.979**	**-57.829**	**< 0.001**
Urban500	**18**	**0.597**	**-53.937**	**< 0.001**
Urban1000	**19**	**0.502**	**-55.714**	**0.009**
Urban3000	**19**	**0.477**	**-58.416**	**0.004**
NatAgri500	**8**	**0.877**	**-68.283**	**< 0.001**
NatAgri1000	**4**	**1.256**	**-41.811**	**< 0.001**
NatAgri3000	**3**	**0.408**	**-59.702**	**< 0.001**

Wood Frog

Many breakpoints were identified overall for the wood frog, but only a few of these were identified as significant. For the decile analysis (Table 16), a significant threshold was identified for the Urban3000 metric at the 6.3 – 9.0% range, indicating that at sites with greater than 9% urban cover within 3000m, wood frog presence decreased at a faster rate to a low of 25% presence at the highest decile. Additional breakpoints in the decile analysis were identified at 98% and 92% natural landcover for the NatAgri500 and NatAgri3000 metrics.

Table 16: Results of the decile breakpoint analysis for the wood frog using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level

Decile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	5	2.488	-8.043	0.617
Surv2500	4	1.697	-14.997	0.251
Surv5000	-	-	-	-
Overwinter500	4	1.640	-14.747	0.431
Overwinter1000	3	1.505	-19.345	0.509
Overwinter3000	9	1.115	-13.570	0.257
ForWet500	4	2.065	-12.264	0.522
ForWet1000	8	3.967	-18.652	1.000
ForWet3000	4	3.096	-8.393	0.441
Urban500	4	1.712	-17.270	0.366
Urban1000	5	1.329	-15.835	0.075
Urban3000	**5**	**0.894**	**-15.639**	**0.005**
NatAgri500	**9**	**0.266**	**-44.583**	**< 0.001**
NatAgri1000	7	1.690	-22.502	0.058

NatAgri3000	**7**	**1.009**	**-18.590**	**0.045**

For the 20-bin quantile analysis (Table 17), only two significant breakpoints were identified. The first was for the Surv2500 metric, at which below 1739 pixels of accessible wetland reachable with at least 5% survival rate with a maximum movement distance of 2500m, rates of wood frog presence decreased at a faster rate. The other significant threshold was identified for the Urban3000 metric at the 7.5 – 9.2 % range.

Table 17: Results of the 20-bin quantile breakpoint analysis for the wood frog using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level.

20-bin quantile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	16	3.405	-8.635	0.803
Surv2500	**7**	**2.019**	**-32.944**	**0.039**
Surv5000	11	2.914	-18.490	0.273
Disp1000	11	1.547	-0.899	0.766
Disp2500	-	-	-	-
Disp5000	11	1.425	-17.531	0.082
Overwinter500	6	3.931	-17.051	0.732
Overwinter1000	19	0.917	-28.543	0.201
Overwinter3000	18	1.909	-20.132	0.178
ForWet500	8	3.668	-19.180	0.784
ForWet1000	16	4.603	-27.850	1.000
ForWet3000	16	3.393	-15.604	0.477
Urban500	4	2.497	-21.505	0.230
Urban1000	12	2.202	-28.153	0.072
Urban3000	**10**	**1.602**	**-24.572**	**0.001**
NatAgri500	17	3.675	-34.483	0.798
NatAgri1000	18	3.537	-27.855	0.714
NatAgri3000	9	2.581	-18.797	0.100

Leopard Frog

Significant thresholds were identified for the leopard frog with all urban and natural land cover metrics in both the decile and 20-bin quantile analyses. For the decile analysis (Table 18), breakpoints at which leopard frog presence decreased at a faster rate occurred when urban cover was greater than 18.6% of 500m radius surrounding land cover, 20% of 1000m radius surrounding land cover, and 24% of 3000m radius surrounding land cover. Presence rates for the leopard frog were 44% at their lowest decile across the three distances. In the 20-bin quantile analysis (Table 19), these breakpoints occurred at 23%, 20% and 24% respectively, with the lowest presence rate at 21%.

Table 18: Results of the decile breakpoint analysis for the leopard frog using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level.

Decile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	7	0.468	-28.757	< 0.001
Surv2500	9	1.429	-12.882	0.610
Surv5000	-	-	-	-
Overwinter500	3	1.164	-12.189	0.403
Overwinter1000	4	2.446	-19.218	0.594
Overwinter3000	-	-	-	-
ForWet500	-	-	-	-
ForWet1000	2	1.937	-16.290	1.000
ForWet3000	9	1.240	-25.937	0.842
Urban500	**7**	**0.749**	**-16.640**	**0.003**
Urban1000	**7**	**0.460**	**-25.905**	**< 0.001**
Urban3000	**7**	**0.355**	**-30.995**	**< 0.001**
NatAgri500	**6**	**0.892**	**-17.385**	**0.006**
NatAgri1000	**5**	**0.386**	**-28.507**	**< 0.001**
NatAgri3000	**4**	**0.376**	**-32.502**	**< 0.001**

For the decile analysis, breakpoints at which leopard frog presence decreased at a faster rate occurred when natural land cover was less than 85% of 500m radius surrounding land cover, 70% of 1000m radius surrounding land cover, and 56% of 3000m radius surrounding land cover. In the 20-bin quantile analysis, these breakpoints occurred at 74%, 70%, and 69% respectively. The only connectivity metric with a significant threshold identified was the Surv1000 metric. For the decile analysis, a significant threshold was identified at which below 442 pixels of accessible wetland habitat reachable with at least 5% survival rate with a maximum movement distance of 1000m, rates of leopard frog presence remained stable. For the 20-bin quantile analysis, this threshold occurred at 360 pixels with a similar pattern of presence.

Table 19: Results of the 20-bin quantile breakpoint analysis for the leopard frog using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level.

20-bin quantile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	**12**	**1.431**	**-26.229**	**0.009**
Surv2500	17	1.841	-20.641	0.521
Surv5000	-	-	-	-
Disp1000	4	2.196	-12.810	0.821
DIsp2500	4	1.734	-11.067	0.353
Disp5000	3	1.591	-14.467	0.065
Overwinter500	-	-	-	-
Overwinter1000	7	3.878	-39.523	0.602
Overwinter3000	-	-	-	-
ForWet500	4	2.381	-21.197	0.277
ForWet1000	4	3.244	-18.912	0.964
ForWet3000	-	-	-	-
Urban500	**15**	**1.030**	**-33.617**	**< 0.001**
Urban1000	**14**	**1.427**	**-26.927**	**0.002**
Urban3000	**14**	**0.949**	**-35.929**	**< 0.001**
NatAgri500	**9**	**1.739**	**-20.862**	**0.007**
NatAgri1000	**9**	**1.090**	**-30.007**	**< 0.001**
NatAgri3000	**9**	**1.792**	**-25.474**	**0.017**

American Toad

Among the six species in this study, the threshold analysis identified the second fewest significant breakpoints for the American Toad. In the decile analysis (Table 20), three significant thresholds were identified in the landscape composition metrics. The first was at the 9-13% range for urban land cover at the 3000m distance. Upon visual inspection, toad presence generally increases in proportion from 0 – 9% urban land cover and then starts generally decreasing when urban land cover exceeds 13%. The other two significant thresholds were identified for NatAgri1000 and NatAgri3000 at the 26 – 42% range and 80 – 87% range respectively. Visually, the relationships between American toad presence and NatAgri3000 followed a similar pattern of increase and decrease past the breakpoint as the Urban3000 metric.

Table 20: Results of the decile breakpoint analysis for the American toad using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level.

Decile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	4	1.416	-36.536	0.254
Surv2500	-	-	-	-
Surv5000	-	-	-	-
Overwinter500	3	1.395	-19.009	0.302
Overwinter1000	3	1.374	-27.737	0.075
Overwinter3000	4	3.637	-21.374	0.966
ForWet500	5	1.494	-22.876	0.213
ForWet1000	-	-	-	-
ForWet3000	9	1.024	-22.323	0.318
Urban500	8	1.364	-27.202	0.055
Urban1000	8	1.369	-20.922	0.250
Urban3000	**6**	**0.512**	**-40.213**	**< 0.001**
NatAgri500	-	-	-	-
NatAgri1000	**2**	**0.714**	**-27.754**	**0.045**
NatAgri3000	**6**	**0.702**	**-25.808**	**< 0.001**

In the 20-bin quantile analysis (Table 21), three significant thresholds were identified. The first was in the Disp2500 variable (and the only significant threshold identified for a connectivity metric), in which a significantly faster decrease in American toad presence was noted at sites with less than 3 connected directions. The other two significant thresholds were identified in the Urban3000 and NatAgri3000 variables at the 11.4 – 12.8 % range and 60.8 – 69.0% range respectively. Visual inspections revealed weak threshold relationships, although there is some indication that American toad presence is accelerated with more than 92% vegetated land cover within 3000m (NatAgri3000).

Table 21: Results of the 20-bin quantile breakpoint analysis for the American toad using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level.

20-bin quantile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	5	2.432	-48.247	0.094
Surv2500	3	1.592	-35.628	0.200
Surv5000	2	0.621	-48.199	0.115
Disp1000	7	1.973	-27.505	0.228
Disp2500	**3**	**0.691**	**-38.739**	**0.005**
Disp5000	3	1.591	-14.467	0.065
Overwinter500	7	4.182	-28.293	0.687

Overwinter1000	5	2.462	-37.661	0.441
Overwinter3000	4	5.205	-33.651	1.000
ForWet500	10	2.596	-42.826	0.173
ForWet1000	4	2.067	-46.789	0.187
ForWet3000	10	7.408	-28.287	1.000
Urban500	19	0.672	-41.099	0.121
Urban1000	15	2.910	-28.813	0.470
Urban3000	**12**	**1.434**	**-55.838**	**0.001**
NatAgri500	3	1.618	-36.942	0.305
NatAgri1000	10	2.236	-46.157	0.052
NatAgri3000	**8**	**1.840**	**-30.483**	**0.021**

Spring Peeper

For the decile analysis (Table 22), only one breakpoint was estimated for the spring peeper among the connectivity metrics, which was also identified as significant via the Davies Test. This threshold was identified in the Surv5000 connectivity metric at the 2671 – 4052 decile. Visual inspection confirmed that with less than 2671 pixels of connected marsh reachable with at least 5% survival rate within 5000m, the rate of spring peeper presence drops precipitously to 37% in the lowest decile. All of the landscape compositions variables had significant breakpoints identified. For the ForWet variables, breakpoints at which spring peeper presence decreased at a faster rate occurred when forest and wetland cover was lower than 16.3%, 22.4%, and 12.1% of total land cover within 500, 1000, and 3000m respectively. For the Urban variables, breakpoints at which presence decreased at a faster rate occurred when urban cover was greater than 18.6%, 20.0%, and 23.5% of total land cover within 500, 1000, and 3000m respectively. For the NatAgri variables, significant breakpoints at which spring peeper presence decreased at a faster rate occurred when natural cover was less than 62.1%, 42.2%, and 41.3% of total land cover within 500, 1000, and 3000m respectively. Spring peeper presence was lowest at 17.2% in the lowest decile for NatAgri3000m.

Table 22: Results of the decile breakpoint analysis for the spring peeper using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level.

Decile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	-	-	-	-
Surv2500	-	-	-	-

Surv5000	**4**	**0.462**	**-25.086**	**< 0.001**
Overwinter500	-	-	-	-
Overwinter1000	-	-	-	-
Overwinter3000	-	-	-	-
ForWet500	**3**	**0.704**	**-31.189**	**< 0.001**
ForWet1000	**4**	**0.797**	**-20.592**	**< 0.001**
ForWet3000	**3**	**0.225**	**-31.409**	**< 0.001**
Urban500	**7**	**0.366**	**-29.378**	**< 0.001**
Urban1000	**7**	**0.483**	**-20.873**	**< 0.001**
Urban3000	**7**	**0.084**	**-56.750**	**< 0.001**
NatAgri500	**4**	**0.225**	**-42.182**	**< 0.001**
NatAgri1000	**3**	**0.312**	**-25.296**	**< 0.001**
NatAgri3000	**3**	**0.227**	**-25.549**	**< 0.001**

For the 20-bin quantile analysis (Table 23), four significant breakpoints were identified for the Spring pepper among the connectivity metrics. Two of these thresholds were with the road crossing survival metrics at which spring peeper presence decreased faster when the amount of accessible marsh habitat at a minimum 5% survival rate was less than 442 pixels at the 1000m maximum movement distance and 2671 pixels at the 5000m maximum movement distance. Additional significant breakpoints were identified for the Disp5000 variable in which spring peeper presence decreased faster when fewer than 3 directions were connected to marsh habitat at the 5000m maximum movement distance. Visual inspection of this variable revealed that this breakpoint is likely an artifact of no sites with 2 connected directions and likely occurs at 7 directions instead. The last connectivity metric with a significant threshold identified was the Overwitner3000 variable in which presence decreased faster when the accessible forest habitat score was less than 1800 pixels.

Table 23: Results of the 20-bin quantile analysis for the spring peeper using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level.

20-bin quantile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	**11**	**3.204**	**-37.824**	**0.449**
Surv2500	11	2.219	-28.510	0.058
Surv5000	**7**	**0.693**	**-49.826**	**< 0.001**
Disp1000	5	2.643	4.144	0.804
Disp2500	-	-	-	-

Disp5000	**3**	**0.805**	**-29.474**	**0.038**
Overwinter500	3	0.887	-50.866	0.062
Overwinter1000	4	3.279	-32.369	0.460
Overwinter3000	**5**	**1.323**	**-35.701**	**< 0.001**
ForWet500	**2**	**0.464**	**-35.888**	**0.011**
ForWet1000	**4**	**0.622**	**-36.860**	**< 0.001**
ForWet3000	**5**	**0.676**	**-33.656**	**< 0.001**
Urban500	**14**	**0.841**	**-40.562**	**< 0.001**
Urban1000	**13**	**0.960**	**-33.848**	**< 0.001**
Urban3000	**14**	**0.666**	**-46.511**	**< 0.001**
NatAgri500	**8**	**1.290**	**-36.271**	**< 0.001**
NatAgri1000	**6**	**0.793**	**-33.976**	**< 0.001**
NatAgri3000	**5**	**0.287**	**-59.210**	**< 0.001**

For the 20-bin quantile analysis, all of the landscape compositions variables had significant breakpoints identified. For the ForWet variables, breakpoints at which spring peeper presence decreased at a faster rate occurred when forest and wetland cover was lower than 5.1%, 10.9%, and 12.2% of total land cover within 500, 1000, and 3000m respectively. For the Urban variables, breakpoints at which presence decreased at a faster rate occurred when urban cover was greater than 18.6%, 15.8%, and 17.0% of total land cover within 500, 1000, and 3000m respectively. For the NatAgri variables, significant breakpoints at which spring peeper presence decreased at a faster rate occurred when natural cover was less than 68.6%, 49.3%, and 41.3% of total land cover within 500, 1000, and 3000m respectively. Spring peeper presence was lowest at 6.7% in the lowest decile for NatAgri3000 and ForWet3000.

Gray Treefrog

For the decile analysis (Table 24), three significant breakpoints were identified for the gray treefrog among the connectivity metrics. Two of these significant thresholds were with the road crossing survival metrics at which gray treefrog presence decreased faster when the amount of accessible marsh habitat at a minimum 5% survival rate was less than 1452 pixels at the 2500m maximum movement distance and 4052 pixels at the 5000m maximum movement distance. The third significant breakpoint was identified for the Overwinter3000 variable in which gray treefrog presence decreased faster when the accessible forest habitat score was less than 7264 at a maximum movement distance of 3000m.

Table 24: Results of the decile breakpoint analysis for the gray treefrog using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level.

Decile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	-	-	-	-
Surv2500	**6**	**0.926**	**-21.783**	**0.006**
Surv5000	**5**	**0.681**	**-16.411**	**< 0.001**
Overwinter500	2	0.796	-22.827	0.085
Overwinter1000	8	3.071	-20.306	0.631
Overwinter3000	**7**	**0.998**	**-21.968**	**0.005**
ForWet500	7	1.372	-23.174	0.059
ForWet1000	**7**	**0.841**	**-15.526**	**0.008**
ForWet3000	**5**	**0.632**	**-17.610**	**< 0.001**
Urban500	**9**	**0.321**	**-23.239**	**< 0.001**
Urban1000	**7**	**0.351**	**-29.816**	**< 0.001**
Urban3000	**6**	**0.520**	**-23.349**	**< 0.001**
NatAgri500	**4**	**0.450**	**-24.339**	**< 0.001**
NatAgri1000	**3**	**0.153**	**-38.175**	**< 0.001**
NatAgri3000	**4**	**0.389**	**-24.700**	**< 0.001**

Also for the decile analysis, 9 out of 10 landscape composition variables had significant breakpoints identified. For the ForWet variables, breakpoints at which gray treefrog presence decreased at a faster rate occurred when forest and wetland cover was lower than 34.7% and 21.2% of total land cover within 1000 and 3000m respectively. For the Urban variables, breakpoints at which presence decreased at a faster rate occurred when urban cover was greater than 54.8%, 20.0%, and 12.6% of total land cover within 500, 1000, and 3000m respectively. For the NatAgri variables, significant breakpoints at which gray treefrog presence decreased at a faster rate occurred when natural cover was less than 62.1%, 42.1%, and 55.8% of total land cover within 500, 1000, and 3000m respectively.

For the 20-bin quantile analysis (Table 25), four significant breakpoints were identified for the gray treefrog among the connectivity metrics. Two of these significant thresholds were with the road crossing survival metrics at which gray treefrog presence decreased faster when the amount of accessible marsh habitat at a minimum 5% survival rate was less than 1452 pixels at the 2500m maximum movement distance and 4052 pixels at the 5000m maximum movement distance. The other two significant breakpoints were identified for the overwintering habitat variables in which gray treefrog presence decreased faster when the accessible forest habitat score was less than 38 at a maximum movement distance of 500m and less than 7258 at a maximum movement distance of 3000m.

Table 25: Results of the 20-bin quantile breakpoint analysis for the gray treefrog using the r.segmented package (n=290). Bold values indicate significance at the 95% confidence level.

20-bin quantile Variable	r.seg Est	St.Error	AIC	Davies p
Surv1000	11	3.809	-22.917	0.606
Surv2500	**11**	**1.808**	**-29.048**	**0.010**
Surv5000	**9**	**0.913**	**-37.362**	**< 0.001**
Disp1000	6	3.285	2.674	0.867
Disp2500	6	2.114	-22.259	0.052
Disp5000	5	1.415	-30.178	0.111
Overwinter500	**3**	**0.931**	**-39.322**	**0.048**
Overwinter1000	4	3.627	-19.336	0.229
Overwinter3000	**13**	**1.733**	**-29.501**	**0.010**
ForWet500	**2**	**0.319**	**-37.749**	**0.002**
ForWet1000	**13**	**1.707**	**-27.049**	**0.005**
ForWet3000	**9**	**0.919**	**-37.852**	**< 0.001**
Urban500	**17**	**0.945**	**-23.985**	**< 0.001**
Urban1000	**15**	**0.855**	**-34.550**	**< 0.001**
Urban3000	**14**	**1.049**	**-33.483**	**< 0.001**
NatAgri500	**7**	**0.866**	**-35.602**	**< 0.001**
NatAgri1000	**6**	**0.672**	**-31.207**	**< 0.001**
NatAgri3000	**7**	**0.474**	**-49.673**	**< 0.001**

Also for the 20-bin quantile analysis, all of the landscape composition variables had significant breakpoints identified. For the ForWet variables, breakpoints at which gray treefrog presence decreased at a faster rate occurred when forest and wetland cover was lower than 5.1%, 34.4%, and 21.2% of total land cover within 500, 1000, and 3000m respectively. For the urban variables, breakpoints at which presence decreased at a faster rate occurred when urban cover was great than 45.7%, 30.8%, and 23.6% of total land cover within 500, 1000, and 3000m respectively. For the NatAgri variables, significant breakpoints at which gray treefrog presence decreased at a faster rate occurred when natural cover was less than 62.0%, 49.3%, and 55.2% of total land cover within 500, 1000, and 3000m respectively.

6.4 Discussion

Using a piecewise regression statistical approach to breakpoint estimation, many breakpoints were identified amongst the connectivity and landscape composition metrics included in this study. The six anuran species of interest in this research exhibited a range of threshold-types responses to habitat composition, configuration, and effect distance, suggesting fundamental differences between species-habitat relationships. Several statistical shortcomings were also identified in this analysis, highlighting the importance of visual examination, critical interpretation of piecewise regression results, and an understanding of the nature of the data being used to describe wildlife habitat. The following sections will discuss these topics in greater detail as they relate to this research and the implications for research moving forward.

Statistical analysis and interpretation

The large sample size of this study allowed for both deciles and 20-bin quantiles (i.e. twenty bins of equal number of observations) to be investigated. Given the sample size of this study (N = 290), 14 – 15 samples were able to be included in each 20-bin quantile, which was deemed a sufficiently large of a sample size for each bin to minimize the impact of one or more outliers/discrepancies. In some cases, the greater resolution of the 20-bin quantile analysis led to a "smoothing" of the relationship curve, with the result of changing the estimated breakpoint, a change which was sometimes slight, but other times quite dramatic. This smoothing phenomenon, however, was not consistent across all variables, and in several cases the added resolution of the 20-bin quantile analysis also led to the introduction of local maxima or minima and breakpoints estimates which were visually not as accurate (e.g. Overwinter_3000, ForWet_3000, and ForWet_1000 for Spring Peeper). In either case, one of the shortcomings of a simple breakpoint analysis of this sort is that when prompted to only identify one breakpoint, it can wrongly identify local maxima or minima as overall breakpoints. In each case, it is important to examine the visual quantiles before confirming whether breakpoint estimates are accurate.

It is also worth commenting on the extent to which the species included in this study were frequently present in the chosen wetland sites. The least commonly observed species – the wood frog – was still present at 60% of study sites. This skewness of the data towards presence may be something to be wary of when interpreting the results because as much as presence of the anuran species is required to determine which landscapes are suitable for long-term persistence, absence of these same species would provide a similar utility by giving examples of landscapes which are unsuitable for anuran persistence. Rarely did the relationships in question result in decile or 20-bin quantile values (i.e. proportion of anuran presence) of zero or close to zero. Conversely, there were many instances where decile or 20-bin quantile values were at or close to 1, consistent with the skewness of the data towards anuran presence. If there was a more equal distribution of sites with presence and those with absence, greater resolution could be achieved towards the other end of the relationship and identification of breakpoints may have been improved. Restricting suitable wetlands for analysis to those with at least three years of monitoring data provided confidence that absence of any species from a wetland wasn't due to a lack of data.

Although the piecewise regression analysis identifies significant breakpoints, it is also important to look at the shape of the relationships of interest. Some of the relationships were linearly positive and then flat after the identified threshold (e.g. Spring peeper and gray treefrog with the Surv_5000 metric in both decile and 20-bin quantile analyses). In other cases, relationships started flat, and following an identified significant threshold, increased linearly and positively (e.g. Wood frog with Overwinter_1000 and Gray treefrog with Disp_5000 and Leopard frog with Surv_1000). In a few cases, the relationships increased linearly and positively, then decreased linearly following an identified threshold (Wood frog with Urban_3000 in the 20-bin quantile analysis, and Leopard frog with NatAgri_1000 in the decile and 20-bin quantile analysis). Given the variability in the relationships, it is critical to interpret the thresholds carefully when applying them to management, landscape design, and planning. Since there were no breakpoints identified across all the variables in which anuran species presence plateaued at zero, this may not necessarily provide answers to the question of what is the bare minimum of land cover/distribution that is needed to avoid complete habitat degradation and associated population extirpation.

As explicated in Spake et al. (2022), the observational scale of the underlying data plays a significant role in the detection of ecological thresholds. Relevant to this research, the organizational level of the data, the study extent, and the analytical scale may all have played a role in whether thresholds are detected and where. For example, if species richness was used instead of individuals species presence/absence as a response variables, thresholds may have not been detected visually or statistically, particularly when clear species-specific relationships had been noted. The analytical scale of this research may also be pertinent to the detection of thresholds as discussed earlier with the skewness of the data towards species presence, and the division of the data into quantiles. Finally, the temporal context of, and focus on, the last 25 years may limit the ability of the analysis to detect larger scale responses. For example, whereas the last 20 to 30 years has been characterized by widespread urban expansion in Southern Ontario, similarly disruptive land change patterns from 50-100 years ago may have similarly imparted pressures that can change the distribution of anuran species across the landscape.

Interpretation of Thresholds

Regardless of whether the deciles or 20-bin quantiles were used in the analysis, there were many cases where there was agreement on where there were significant breakpoints/thresholds. The landscape compositions variables were consistently identified as having critical breakpoints for many of the individual anuran species, and in many cases they were statistically significant. Previous studies in Eastern North America have identified thresholds related to the simple proportion of forest cover and urban cover within a range of distances from source wetlands (Gibbs, 1998; Homan et al., 2004; Hermann et al., 2005). Here too, I have identified significant breakpoints at all three distances of forest/wetland and urban cover (500m, 1000m, and 3000m) for several species, including the spring peeper and gray treefrog, which also tested strongest in the GAM analysis in Section 5. These minimum thresholds of forest covers were identified to be around the 14 – 16% range for the Spring Peeper and 23 – 25% range for the gray treefrog at the 3000m radius. For urban land cover, the maximum coverage was estimated at 23 – 24% for the spring peeper and 12 – 14% for the gray treefrog at the 3000m radius. These statistically identified thresholds hold well to visual confirmation, and it seems clear that there is a certain level of forest/wetland cover and urban cover that is integral for maintaining stable and thriving hylid populations. Reductions of those land covers beyond a certain amount threaten a steep drop in the likelihood of persistence and should therefore be considered as target landscape composition amounts while conducting larger regional planning exercises.

Consistent with one of the guiding assumptions of this study that otherwise hostile landcovers can be suitable or even conducive to anuran movement patterns at night, I included a landscape composition variable that is often not considered in published habitat association analyses in the form of NatAgri, which includes all vegetated land covers including agriculture. With the understanding that anurans execute their migrational and dispersal movements at night in favourable weather conditions (i.e. rain, high humidity, and low wind), agricultural land cover should be an important consideration in landscape conservation modelling.

In this research's study area in particular, agricultural land often the most commonly occurring land cover. In addition to its potential benefit for anuran movement, if the forest/wetland thresholds occurred at 14 – 25% of land cover for the two hylid species, and the urban land cover thresholds occurred at 12 – 24% of land cover, then there is about 50% of remaining land cover that must certainly play a role in the overall anuran habitat matrix, and the majority of this 50% for many of the study sites was agricultural land. In the threshold analyses, significant thresholds at 49 – 56% of vegetated land cover for the spring peeper and 61 – 69% of vegetated land cover for the gray treefrog (3000m radius) were identified, under which hylid presence decreased steeply. Not only do planners need to consider a limit to how much urban cover is appropriate for the continued presence of these species, but they must consider an upper limit of how much vegetated land can be removed. The presence of these statistically significant and visually notable thresholds for the NatAgri variables suggests that agricultural lands are important contributors to the habitat and life history functions of these species, likely in the form of allowing for relatively safe and unobstructed movement for migration and dispersal.

The connectivity metrics had generally fewer significant thresholds associated with them. For the road crossing survival metric, several significant thresholds were identified for the hylids, particularly at the 5000m distance. These thresholds occurred at 2671 pixels of accessible marsh for the spring peeper and 4052 pixels of accessible marsh for the gray treefrog. Both of these thresholds used a minimum survival cutoff of 5%, meaning that an accessible unit of marsh habitat is one in which there is at least a 5% chance of successfully reaching it when accounting for road-induced mortality. In planning terms, 60 and 91 hectares of marsh habitat reachable with a 5% survival rate for the spring peeper and gray treefrog respectively must be distributed within 5000m of accessible land cover for these species to persist without steep declines in persistence rates. Connecting habitat amount with a component of accessibility and accounting for major barriers to movement and survival probability brings us another step closer to including species-specific landscape connectivity functions in landscape planning.

The threshold analyses for the overwintering metric generally resulted in fewer significant breakpoints identified, at least by the r.segmented program. Visually, obvious breakpoints were also difficult to distinguish for many species in both the decile and 20-bin quantile analyses. However, the lack of thresholds does not necessarily indicate insignificance or unsuitability as a connectivity metric. For a species that is well-known to thrive and require upland forest like the wood frog, clear relationships were visible at all three distances and both quantile analyses. A strong association between accessible forest and wood frog presence is therefore reasonably present even with the lack of a defined breakpoint at which presence declines more steeply. For the two hylid species, near 100 percent presence occurs when sites have overwintering habitat values of over 6,160. Visually, such a plateau would indicate a threshold, and a significant one at that, but the exact placements of the significant breakpoint by the r.segmented program (2,308) was much lower for the spring peeper due to a local maxima.

The overwintering metric was slightly different from the others in that each accessible cell was scaled based on the remaining energy an anuran would have after reaching it. For the other connectivity and landscape metrics, such a scaling did not occur, so this should be considered when interpreting not only the metric results, but the thresholds relationships. It also distinguishes it from the ForWet landscape composition metrics to a greater extent by providing some additional context about accessible forest proximity. Unfortunately, this scaling could also introduce some difficulties in that two or more different scenarios could be true for a single overwintering metric value. When it comes to interpreting any potential threshold values associated with overwintering habitat using this metric, therefore, this could involuntarily lead to unintended outcomes for habitat management. It is therefore important to consider all connectivity and landscape metrics and thresholds in habitat management so that all components of anuran life history are considered.

Although a few significant thresholds were also identified for the dispersal metrics, these were the least well defined visually among all of the metrics. Many local maxima and minima in the 13 quantiles likely contributed to some debatable breakpoints being identified by the r.segmented program. Reasons for why the juvenile dispersal metrics ended up with less smooth relationships compared to the other variables is subject to some discussion. Since the dispersal metric only allowed for a total of 13 possible values, corresponding to how many directions contained accessible marsh habitat (including 0), there was less of an opportunity for smoothing to take place, unlike in the other metrics which had a greater range of possible values. For this same reason, 20-bin quantiles could not be created or tested because there was a maximum of 13 possible values. Furthermore, this characteristic of the metric did not allow for the equal distribution of data points across each quantile, and for this reason the dispersal metric could not be said to have been processed as a quantile analysis at all. The consequence of this unequal distribution is that some dispersal values had very few sites associated with them, while other had more than 50. In the case of the 5000m dispersal metrics, several dispersal value categories had 0 sites associated with them, leading to some visual and statistical anomalies.

The juvenile dispersal metric was also the most experimental of the three connectivity metrics and so was subject to the greatest degree of uncertainty, contributing to its overall weak performance for many species in the GAM analyses in Section 0 and in the threshold analyses performed here. Refinements of this metric in ways that are discussed in Section 5.4.2.1, including increasing the number of wedges (i.e. movement directions) would likely be beneficial for both habitat association and thresholds analyses performed in the future. This metric is also among the most important to continue developing as it is the only one that attempts to take into account the selection of non-optimal land covers during movement and auto-correlated movement (see Unnithan Kumar et al., 2022). Most resistance-based connectivity analyses fail in this one crucial component, oftentimes outputting “optimal” movement routes that anurans would be unlikely to discover and utilize according to their movement behaviours, which can lead to concentrations of necessary habitat in a small radial width. For anurans which are known to disperse in all directions from a breeding pond and frequently travel across hostile land covers, this can result in mass mortality of newly transformed juveniles whose survival is crucial for the distribution of genetic diversity and replenishment of depleted populations in other habitats.

With these dynamics in mind and the results presented in this research, it is likely that there are many examples of wetlands in the Ontario region where the necessary amounts of forest or vegetated habitat are present within a certain distance from an anuran breeding wetland but are present in such an orientation that long-term presence is compromised. Petrovan and Schmidt (2019) have previously noted that amphibian juveniles and their crucial role in population integrity through dispersal is neglected not only in the policy realm, but also in the academic literature and research. The consideration of the role of habitat distribution is one that needs to be critically examined, modelled, and applied to conservation practices if vulnerable terrestrial organisms whose movement dynamics are threatened are to be protected in the long-term. Although relatively simple in its application of directionality, my dispersal metric does allow for the rudimentary identification of breakpoints in the presence/absence relationship and the communication of tangible targets for habitat orientation in the landscape.

6.5 Implications and Conclusions

The research presented in this chapter demonstrated that ecological thresholds for anuran species in Southern Ontario are common across various types and scales of habitat and connectivity metrics. The widespread presence of these breakpoints suggests that on spatial scales ranging from 500m to 5000m from breeding pond edge, anuran species exhibit varying levels of threshold-type responses to changes in habitat composition and connectivity. The identification of these thresholds, particularly for metrics that were previously identified as explaining notable amounts of variance in species presence/absence relationships, has important implications for species habitat management and regulatory planning in Ontario. Current wetland regulations are focused on preserving small buffers of natural greenspace in the wetlands' immediate radius. The relationships demonstrated here show widespread and significant relationships on much wider scales, meaning that conservation planning should consider a wider landscape context for a group of species that demonstrate frequent and long-range movement. Furthermore, many significant thresholds were identified for connectivity metrics which aimed to incorporate components of habitat distribution and arrangement, which can provide a more meaningful basis for habitat management in fragmented landscapes.

Nevertheless, caution must be taken when interpreting these critical breakpoints by confirming relationships visually and understanding the underlying spatio-temporal and analytical scale of the analysis. By continuing to explore and refine our understanding of ecological thresholds with regards to anuran species, we can develop ecologically meaningful conservation targets that address the complex and heterogeneous habitat needs of these often-overlooked species. As important indicators of ecological health and users of both aquatic and terrestrial habitats, anurans can be used as a blanket target species for protection, and if their habitat is adequately protected for long-term persistence, a similar long-term protection can be simultaneously achieved for a wide range of other species.

6.6 References

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7.0 Conclusion

In the face of the ongoing desire to improve, expand, and densify human infrastructure, considerations for ecological connectivity are typically secondary in nature. This is neither surprising nor insidious, as our social systems strive to improve the conditions and standards of living for our own species. In the urban and suburban context, areas are planned with primary objectives such as transportation connectivity, housing, and economic optimization in mind. Existing regulatory minimums – including those related to natural heritage – are generally treated as barriers to those primary objectives and are implemented in a piecemeal fashion, making it challenging for regional or larger scale objectives of landscape connectivity to be achieved (Schulte-Hostedde et al., 2007). Consequently, if ecological considerations such as connectivity are finally confronted, they are challenging to address. In most cases, landscape matrices cannot be restored to their previous permeability once human infrastructure is already in place. Wildlife corridor networks, when prioritized and properly crafted with science-based ecological thresholds in mind, can provide effective movement networks, and habitat for foraging, breeding, and overwintering. The benefits of a robust natural corridor network extend in many ways to adjacent human systems as well by providing ecosystem services that contribute to positive social, economic, and health outcomes. In this concluding chapter, I will summarize the implications of the previous sections and discuss the benefits to human system outcomes of implementing science-based ecological thresholds for anuran habitat.

Anurans were selected as a study species due to their potential for consideration as an umbrella species for conservation and the availability of a spatially and temporally robust monitoring dataset. In section 3.0, I determined that a minimum of 3 years of acoustic data is required to reliably determine presence for anuran species in Ontario. I applied this result to craft a series of habitat composition and connectivity metrics, detailed in Sections 4.0 and 5.0, which were tested for performance in predicting individual species occupancy, and identified landscape characteristics of importance for Ontario anuran species. In Section 6.0, I identified significant breakpoints in the relationships between individual anuran species presence and the habitat and connectivity metrics. The ecological thresholds identified generally point to a corridor network that has large core areas, permeable, low-mortality-risk movement corridors in many directions from source breeding wetlands, and accessibility between woodlands and wetlands. In general, these characteristics are consistent with the requirements for other species groups. While the exact arrangement and quality of habitat can vary according to geographical and species context, the implementation of these characteristics would generally result in more vegetated land covers (whether natural or agricultural).

With a robust and connected wildlife corridor network in place, human land uses would need to be concentrated in the remaining areas, catalyzing a number of planning approaches with a suite of resulting economic benefits. An urban matrix with a greater focus on density and concentration of development around wildlife connectivity networks could likely contribute to lowered costs for infrastructure construction and maintenance (Burchell et al., 1998; Savitch, 2003; Trubka et al., 2010). With wildlife corridors restricting unnecessary sprawl, naturally forming human corridors would be more likely to emerge, which favours high quality, high frequency, and functional public transit opportunities (Dagonzo, 2010; Trubka et al., 2010). By maintaining accessible and functional connections between habitats, wildlife is also less likely to be forced into negative interactions with urban areas (Soulsbury and White, 2015).

Evidence of increased health benefits and outcomes for humans in areas with higher natural land cover is also widespread and far-reaching. By maintaining the natural land covers necessary to facilitate a robust and ecologically connected landscape, individuals have a greater opportunity of interacting with, being exposed to, and benefitting from the many direct and indirect effects of adjacent natural spaces (James et al., 2015; Van den Bosch and Sang, 2017). From a biophysical perspective, adjacent natural spaces perform a number of valuable ecosystem services including thermal regulation (McPhearson 1994; Bowler et al., 2010) and air quality purification (Nowak, 1994; Escobedo et al., 2008). Negative outcomes from urban heat island effects and air pollution, if unaddressed or inadequately addressed. include higher mortality rates, health degradation, and lower education outcomes stemming from compromised development in children (Clifford et al., 2016). The cost to address these issues once they are prevalent in any given society are high and can restrict the availability of funds to other policies that can improve quality of life (Landrigan and Fuller, 2015). If robust wildlife corridors are identified and retained before intensive development takes place, the associated natural land covers can be well worth the opportunity costs of not developing them.

From the policy standpoint, setting aside the necessary natural land covers in strategic places to preserve wildlife corridors can have secondary benefits by contributing to fulfilling commitments related to pollutant control, greenhouse gas reductions, and biodiversity protection. Greenspaces, particularly those that are well established and have a strong native plant composition, can contribute to enhancing and improving stormwater retention systems by filtering out pollutants (Karanathasis et al., 2003; Vauramo and Setälä, 2011). Other hydrological processes that planners and policy makers consistently consider when development takes place include flooding and groundwater recharge. Both of these processes can be concurrently addressed by the same natural land covers that are providing connectivity for wildlife (McPhearson et al., 2005; Pataki et al., 2013). From a biodiversity standpoint, many levels of government have objectives regarding the protection and recovery of species at risk. Unsurprisingly, many such species in Ontario are at risk from urban expansion-induced mortality and habitat loss (Gunson et al., 2016). Reserving natural land cover to meet the minimum habitat requirements for an umbrella group of species such as anurans can strategically address the recovery of many at risk species which have been threatened by the encroachment of hostile land uses and sprawling road networks.

In the Southern Ontario context, natural land cover has long been absent from much of the landscape, replaced in large part with agriculture. From the anuran perspective, relatively isolated wetlands – given adequate size and quality – can facilitate strong populations, suggesting that agricultural land can be suitable for long–range movement and dispersal processes (Koumaris and Fahrig, 2016). Indeed, when grouping forest, wetland, and agricultural land use together, strong associations with anuran presence were demonstrated in this research (See Section 5.3.2). Furthermore, the landscape composition metrics which included agricultural land exhibited some of the strongest threshold-like relationships among all connectivity and land use metrics (See Section 6.3). Unfortunately, agricultural land is generally disregarded in the literature and in planning as a valuable land cover for terrestrial wildlife populations and is usually the first land use to be converted to more intensive urban land covers with little consideration of how, or if, it can facilitate movement of anurans (or other wildlife) from one habitat patch to another (Clucas et al., 2018). Agricultural areas are also characterized by lower road density, lower traffic volumes, and reduced noise and light pollution. As such, there needs to be a re-evaluation of the role of agricultural land in mapping, implementing, and maintaining landscape connectivity for wildlife (Kremen and Merenlender, 2018).

Ontario is a province rich in natural spaces but is challenged to continue its expansion of urban spaces as its population increases. With fragmentation and habitat loss one of the greatest threats to wildlife in this landscape, maintaining and planning for landscape connectivity is critical. From a regional planning perspective, there are long-standing efforts to identify, protect, and steward the remaining forests, wetlands, and other natural habitats scattered across Southern Ontario. Many large municipalities and regional authorities have identified natural heritage systems in their jurisdictions. Protection for these systems varies to some extent but in general restricts development in significant woodlands, wetlands, and watercourses. This in itself contributes to some extent to maintaining remnant wildlife habitat and the connections between them, though thresholds related to habitat and connectivity are largely absent from planning guidelines and poorly represented in literature. The landscape composition and habitat connectivity thresholds identified in this thesis can contribute to an increased understanding of how much, what kind, and in what orientation, habitat for anurans is required for stable persistence in landscapes slated for imminent alteration.

Our approach to understanding wildlife habitat connectivity on a regional scale needs improvement, and more importantly, requires an incentive for improvement. The lure of low-cost greenfield areas for development has proliferated sprawl in Ontario and elsewhere, and increased pressure on wildlife through habitat loss, increased matrix impermeability, and higher road mortality. There is, however, a financial and societal case for exercising restraint and reserving land for wildlife corridors. A robust wildlife corridor network built around data-driven ecological minimums can have long-term and wide-reaching positive impacts on society and individuals, with minimal cost for maintenance or stewardship. This thesis aimed to garner a greater understanding of what constitutes a reasonably connected landscape for an umbrella group of species whose effective long-term conservation can indirectly protect a wider range of wildlife threatened by habitat loss and land alteration pressures. By applying these minimum habitat requirements earlier on in the expansion and development process can encourage planning bodies to produce a denser, more efficient, and more equitable landscape for both humans and the wildlife populations living alongside them.

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Appendices

Appendix A – Generalized Additive Model Results

Table 1: Generalized Additive Results for Green Frog

Variable 1	Variable 2	Variable 3	Variable 4	AIC	Delta	% Variance Explaine	R^2	edf 1	edf 2	edf 3	edf 4	ANOVA F 1	ANOVA F 2	ANOVA F 3	ANOVA F 4	p-value 1	p-value 2	p-value 3	p-value 4
Disp_2500	Urban_3000	-	-	119.80	0.00	15.9	0.0951	1.00	1.00	-	-	4.67	8.60	-	-	0.03	0.00	-	-
Surv_1000	Urban_3000	-	-	120.00	0.20	15.6	0.0815	1.00	1.00	-	-	2.36	12.67	-	-	0.12	0.00	-	-
Winter_1000	Surv_1000	Urban_3000	-	120.06	0.26	17.1	0.0981	1.00	1.00	1.00	-	1.49	1.96	8.70	-	0.22	0.16	0.00	-
Winter_3000	Surv_1000	Urban_3000	-	120.19	0.39	17.0	0.0984	1.00	1.00	1.00	-	1.43	2.00	6.50	-	0.23	0.16	0.01	-
Winter_500	Surv_1000	Urban_3000	-	120.25	0.45	17.0	0.0918	1.00	1.00	1.00	-	1.36	1.97	9.94	-	0.24	0.16	0.00	-
Surv_1000	NatAgri_3000	-	-	120.40	0.60	15.4	0.0884	1.00	1.00	-	-	2.82	11.27	-	-	0.09	0.00	-	-
Disp_2500	Winter_500	Urban_3000	-	120.67	0.87	16.8	0.1000	1.00	1.00	1.00	-	3.49	0.88	7.33	-	0.06	0.35	0.01	-
Disp_2500	NatAgri_3000	-	-	120.70	0.90	16.1	0.1080	1.31	1.00	-	-	4.39	7.58	-	-	0.04	0.01	-	-
Disp_2500	Winter_1000	Urban_3000	-	120.76	0.96	16.9	0.1040	1.09	1.00	1.00	-	2.98	0.89	6.66	-	0.08	0.35	0.01	-
Disp_2500	Winter_3000	Urban_3000	-	121.02	1.22	16.9	0.1060	1.17	1.00	1.00	-	2.75	0.85	5.39	-	0.10	0.36	0.02	-
Winter_1000	Surv_1000	NatAgri_3000	-	121.07	1.27	16.4	0.0937	1.00	1.00	1.00	-	0.97	2.30	7.14	-	0.32	0.13	0.01	-
Winter_500	Surv_1000	NatAgri_3000	-	121.09	1.29	16.3	0.0919	1.00	1.00	1.00	-	0.97	2.31	8.43	-	0.32	0.13	0.00	-
Winter_3000	Surv_1000	NatAgri_3000	-	121.29	1.49	16.2	0.0900	1.00	1.00	1.00	-	0.89	2.37	5.20	-	0.34	0.12	0.02	-
Winter_1000	Surv_2500	Urban_3000	-	121.56	1.76	16.0	0.0888	1.00	1.00	1.00	-	1.53	1.27	7.12	-	0.21	0.26	0.01	-
Surv_2500	Urban_3000	-	-	121.60	1.80	14.5	0.0775	1.00	1.00	-	-	1.54	10.56	-	-	0.21	0.00	-	-
Disp_2500	Winter_500	NatAgri_3000	-	121.72	1.92	16.8	0.1100	1.34	1.00	1.00	-	3.36	0.68	6.28	-	0.08	0.41	0.01	-
Winter_3000	Surv_2500	Urban_3000	-	121.76	1.96	15.8	0.0902	1.00	1.00	1.00	-	1.43	1.27	5.49	-	0.23	0.26	0.02	-
Winter_500	Surv_2500	Urban_3000	-	121.78	1.98	15.8	0.0827	1.00	1.00	1.00	-	1.39	1.27	8.17	-	0.23	0.26	0.00	-
Disp_2500	Winter_1000	NatAgri_3000	-	121.81	2.01	16.9	0.1110	1.39	1.00	1.00		3.34	0.64	5.61	-	0.09	0.43	0.02	-
Disp_5000	Winter_3000	Surv_1000	Urban_3000	121.83	2.03	17.3	0.0979	1.00	1.00	1.00	1.00	0.36	0.98	1.24	5.37	0.55	0.32	0.26	0.02
Disp_5000	Urban_3000	-	-	121.90	2.10	14.3	0.0880	1.00	1.00	-	-	3.15	7.35	-	-	0.08	0.01	-	-
Disp_1000	Winter_1000	Surv_1000	Urban_3000	121.99	2.19	17.2	0.0961	1.00	1.00	1.00	1.00	0.06	1.53	1.40	8.63	0.80	0.22	0.24	0.00
Disp_2500	Winter_3000	NatAgri_3000	-	122.08	2.28	16.7	0.1110	1.41	1.00	1.00	-	3.42	0.53	4.35	-	0.09	0.47	0.04	-
Disp_1000	Winter_3000	Surv_1000	Urban_3000	122.15	2.35	17.0	0.0959	1.00	1.00	1.00	1.00	0.04	1.46	1.35	6.52	0.84	0.23	0.25	0.01
Winter_1000	Surv_5000	Urban_3000	-	122.16	2.36	15.6	0.0885	1.00	1.00	1.00	-	1.61	1.25	4.78	-	0.20	0.26	0.03	-
Disp_1000	Winter_500	Surv_1000	Urban_3000	122.19	2.39	17.0	0.0897	1.00	1.00	1.00	1.00	0.06	1.39	1.38	9.92	0.81	0.23	0.23	0.00
Winter_1000	Urban_3000	-	-	122.20	2.40	14.1	0.0908	1.00	1.00	-	-	1.92	10.23	-	-	0.17	0.00	-	-
Surv_5000	Urban_3000	-	-	122.30	2.50	14.0	0.0782	1.00	1.00	-	-	1.55	6.92	-	-	0.21	0.01	-	-
Winter_500	Surv_5000	Urban_3000	-	122.31	2.51	15.5	0.0824	1.00	1.00	1.00	-	1.52	1.29	5.37	-	0.22	0.26	0.02	-
Winter_3000	Surv_5000	Urban_3000	-	122.34	2.54	15.5	0.0901	1.00	1.00	1.00	-	1.53	1.24	3.75	-	0.21	0.26	0.05	-
Disp_5000	Winter_1000	Urban_3000	-	122.36	2.56	15.5	0.0947	1.00	1.00	1.00	-	1.93	1.10	5.79	-	0.17	0.29	0.02	-
Disp_5000	Winter_500	Urban_3000	-	122.37	2.57	15.5	0.0907	1.00	1.00	1.00	-	2.17	1.11	6.26	-	0.14	0.29	0.01	-
Winter_3000	Urban_3000	-	-	122.40	2.60	14.0	0.0922	1.00	1.00	-	-	1.87	7.71	-	-	0.17	0.01	-	-
Disp_2500	Winter_500	Surv_1000	NatAgri_3000	122.45	2.65	20.8	0.1120	1.81	1.00	2.01	1.00	3.68	0.54	0.47	6.40	0.18	0.46	0.79	0.01
Disp_2500	Winter_1000	Surv_1000	Urban_3000	122.49	2.69	20.1	0.1080	1.49	1.00	1.94	1.00	1.68	0.82	0.36	6.24	0.29	0.37	0.85	0.01
Disp_2500	Winter_1000	Surv_1000	NatAgri_3000	122.49	2.69	20.9	0.1140	1.85	1.00	2.01	1.00	3.80	0.51	0.46	5.78	0.19	0.47	0.80	0.02
Winter_500	Urban_3000	-	-	122.50	2.70	13.9	0.0840	1.00	1.00	-	-	1.76	11.89	-	-	0.18	0.00	-	-
Surv_2500	NatAgri_3000	-	-	122.50	2.70	14.1	0.0811	1.00	1.10	-	-	1.77	9.70	-	-	0.18	0.00	-	-
Disp_2500	Winter_500	Surv_1000	Urban_3000	122.51	2.71	19.9	0.1050	1.42	1.00	1.95	1.00	1.57	0.77	0.36	6.85	0.28	0.38	0.85	0.01
Disp_2500	Winter_3000	Surv_1000	Urban_3000	122.54	2.74	20.3	0.1110	1.60	1.00	1.95	1.00	2.47	0.83	0.37	4.91	0.26	0.36	0.85	0.03
Disp_2500	Winter_3000	Surv_1000	NatAgri_3000	122.57	2.77	20.8	0.1140	1.88	1.00	2.00	1.00	3.91	0.45	0.47	4.47	0.18	0.50	0.79	0.03
Surv_5000	NatAgri_3000	-	-	122.60	2.80	14.3	0.0818	1.00	1.20	-	-	1.95	7.69	-	-	0.16	0.02	-	-
Winter_1000	Surv_2500	NatAgri_3000	-	122.66	2.86	15.2	0.0848	1.00	1.00	1.00	-	1.19	1.53	5.65	-	0.28	0.22	0.02	-
Disp_5000	Winter_3000	Urban_3000	-	122.67	2.87	15.3	0.0956	1.00	1.00	1.00	-	1.79	0.97	4.96	-	0.18	0.32	0.03	-
Winter_500	Surv_2500	NatAgri_3000	-	122.71	2.91	15.1	0.0826	1.00	1.00	1.00	-	1.18	1.52	6.71	-	0.27	0.22	0.01	-

Winter_500	Surv_5000	NatAgri_3000	-	122.78	2.98	15.4	0.0819	1.00	1.00	1.07	-	1.24	1.66	5.19	-	0.27	0.20	0.03	-
Winter_1000	Surv_5000	NatAgri_3000	-	122.81	3.01	15.4	0.0845	1.00	1.00	1.00	-	1.21	1.60	4.48	-	0.27	0.20	0.05	-
Disp_5000	Winter_1000	Surv_1000	Urban_3000	122.89	3.09	18.1	0.1000	1.00	1.00	1.67	1.00	0.71	1.02	0.65	5.97	0.40	0.31	0.78	0.01
Urban_3000	-	-	-	122.90	3.10	12.1	0.0787	1.00	-	-	-	16.66	-	-	-	0.00	-	-	-
Disp_5000	Winter_500	Surv_1000	Urban_3000	122.96	3.16	18.1	0.0964	1.00	1.00	1.71	1.00	0.83	1.00	0.63	6.37	0.35	0.32	0.80	0.01
Disp_1000	Urban_3000	-	-	122.97	3.17	13.6	0.0716	1.00	1.00	-	-	1.77	13.06	-	-	0.18	0.00	-	-
Disp_1000	Winter_1000	Surv_1000	NatAgri_3000	122.99	3.19	16.4	0.0911	1.00	1.00	1.00	1.00	0.08	1.02	1.64	7.09	0.77	0.31	0.20	0.01
Disp_1000	Winter_500	Surv_1000	NatAgri_3000	123.00	3.20	16.4	0.0892	1.00	1.00	1.00	1.00	0.08	1.01	1.64	8.40	0.78	0.31	0.20	0.00
Disp_2500	Winter_1000	Surv_2500	Urban_3000	123.06	3.26	20.0	0.1170	1.61	1.00	1.94	1.00	3.89	0.82	0.42	6.70	0.14	0.37	0.82	0.01
Disp_1000	Winter_1000	Urban_3000	-	123.09	3.29	14.9	0.0861	1.00	1.00	1.00	-	1.06	1.38	9.06	-	0.30	0.24	0.00	-
Disp_1000	Winter_3000	Urban_3000	-	123.13	3.33	14.9	0.0880	1.00	1.00	1.00	-	1.19	1.42	6.90	-	0.28	0.23	0.01	-
Disp_2500	Winter_500	Surv_2500	Urban_3000	123.18	3.38	19.8	0.1130	1.55	1.00	1.94	1.00	3.13	0.73	0.40	7.42	0.15	0.39	0.83	0.01
Winter_3000	Surv_2500	NatAgri_3000	-	123.19	3.39	15.3	0.0868	1.00	1.00	1.19	-	1.11	1.47	4.90	-	0.29	0.22	0.07	-
Disp_2500	Winter_3000	Surv_2500	Urban_3000	123.20	3.40	20.0	0.1200	1.66	1.00	1.95	1.00	4.04	0.78	0.41	5.39	0.14	0.38	0.83	0.02
Disp_1000	Winter_500	Urban_3000	-	123.28	3.48	14.8	0.0799	1.00	1.00	1.00	-	1.10	1.24	10.19	-	0.29	0.26	0.00	-
Winter_3000	Surv_5000	NatAgri_3000	-	123.28	3.48	15.5	0.0869	1.00	1.00	1.27	-	1.12	1.61	4.03	-	0.29	0.21	0.13	-
Disp_1000	Winter_3000	Surv_1000	NatAgri_3000	123.34	3.54	16.4	0.0913	1.00	1.00	1.00	1.07	0.06	0.94	1.61	5.52	0.80	0.33	0.20	0.03
Disp_1000	Winter_1000	Surv_2500	Urban_3000	123.39	3.59	16.1	0.0845	1.00	1.00	1.00	1.00	0.17	1.31	0.75	7.32	0.68	0.25	0.39	0.01
Disp_5000	NatAgri_3000	-	-	123.40	3.60	13.6	0.0885	1.00	1.12	-	-	3.03	6.33	-	-	0.08	0.02	-	-
Disp_2500	Winter_1000	Surv_2500	NatAgri_3000	123.48	3.68	20.4	0.1240	1.92	1.00	2.00	1.00	5.09	0.63	0.51	5.99	0.11	0.43	0.80	0.01
Disp_1000	Winter_3000	Surv_2500	Urban_3000	123.51	3.71	16.0	0.0860	1.00	1.00	1.00	1.00	0.23	1.27	0.71	5.69	0.63	0.26	0.40	0.02
Disp_2500	Winter_500	Surv_2500	NatAgri_3000	123.54	3.74	20.3	0.1230	1.88	1.00	1.99	1.00	5.07	0.62	0.49	6.74	0.11	0.43	0.80	0.01
Disp_1000	Winter_500	Surv_2500	Urban_3000	123.59	3.79	16.0	0.0785	1.00	1.00	1.00	1.00	0.18	1.18	0.74	8.36	0.67	0.27	0.39	0.00
Disp_2500	Winter_3000	Surv_2500	NatAgri_3000	123.76	3.96	20.2	0.1250	1.92	1.00	1.99	1.00	5.16	0.50	0.49	4.63	0.11	0.48	0.80	0.03
Disp_1000	NatAgri_3000	-	-	123.80	4.00	13.3	0.0813	1.00	1.12	-	-	2.19	12.35	-	-	0.14	0.00	-	-
Disp_5000	Winter_500	NatAgri_3000	-	123.83	4.03	14.6	0.0891	1.00	1.00	1.09	-	2.23	1.00	5.10	-	0.14	0.32	0.04	-
Disp_1000	Winter_1000	Surv_5000	Urban_3000	123.87	4.07	15.8	0.0831	1.00	1.00	1.00	1.00	0.28	1.37	0.82	5.02	0.60	0.24	0.36	0.03
Disp_5000	Winter_500	Surv_1000	NatAgri_3000	123.88	4.08	17.6	0.0922	1.00	1.00	1.80	1.00	0.73	0.80	0.72	5.15	0.39	0.37	0.81	0.02
Disp_1000	Winter_3000	Surv_5000	Urban_3000	123.90	4.10	15.8	0.0848	1.00	1.00	1.00	1.00	0.37	1.35	0.79	3.99	0.54	0.25	0.38	0.45
Disp_5000	Winter_1000	Surv_1000	NatAgri_3000	123.93	4.13	17.5	0.9340	1.00	1.00	1.78	1.00	0.65	0.74	0.74	4.68	0.42	0.39	0.80	0.03
Disp_5000	Winter_1000	NatAgri_3000	-	123.95	4.15	14.7	0.0912	1.00	1.00	1.13	-	2.05	0.96	4.81	-	0.15	0.33	0.05	-
Winter_1000	NatAgri_3000	-	-	123.99	4.19	14.2	0.0903	1.00	1.58	-	-	1.53	10.59	-	-	0.22	0.01	-	-
Disp_1000	Winter_500	Surv_5000	Urban_3000	124.02	4.22	15.7	0.0772	1.00	1.00	1.00	1.00	0.28	1.27	0.84	5.63	0.60	0.26	0.36	0.02
Winter_500	NatAgri_3000	-	-	124.10	4.30	14.1	0.0879	1.00	1.57	-	-	1.48	12.54	-	-	0.22	0.00	-	-
Surv_1000	ForWet_3000	-	-	124.10	4.30	14.4	0.0780	1.00	1.77	-	-	2.14	9.62	-	-	0.14	0.01	-	-
Disp_5000	Winter_3000	Surv_1000	NatAgri_3000	124.16	4.36	17.3	0.0929	1.00	1.00	1.79	1.00	0.60	0.62	0.79	3.79	0.44	0.43	0.79	0.05
Disp_2500	Winter_1000	Surv_5000	Urban_3000	124.19	4.39	18.8	0.1040	1.35	1.00	2.00	1.00	1.93	0.92	0.49	5.11	0.20	0.34	0.87	0.02
Winter_3000	NatAgri_3000	-	-	124.20	4.40	14.3	0.0920	1.00	1.68	-	-	1.59	7.39	-	-	0.21	0.03	-	-
Disp_2500	Winter_500	Surv_5000	Urban_3000	124.22	4.42	18.6	0.1000	1.29	1.00	2.00	1.00	1.98	0.87	0.48	5.61	0.18	0.35	0.87	0.02
Disp_5000	Winter_1000	Surv_2500	Urban_3000	124.26	4.46	17.3	0.0973	1.00	1.00	1.78	1.00	1.20	1.03	0.39	5.64	0.27	0.31	0.85	0.02
NatAgri_3000	-	-	-	124.30	4.50	12.6	0.0003	1.66	-	-	-	2.05	-	-	-	16.59	-	-	-
Disp_2500	ForWet_3000	-	-	124.30	4.50	14.6	0.0938	1.23	1.56	-	-	3.38	4.55	-	-	0.07	0.07	-	-
Winter_3000	Surv_5000	-	-	124.30	4.50	12.6	0.0613	1.00	1.00	-	-	3.39	3.01	-	-	0.07	0.08	-	-
Disp_2500	Winter_3000	Surv_5000	Urban_3000	124.32	4.52	18.9	0.1070	1.43	1.00	2.02	1.00	2.12	0.91	0.50	4.20	0.20	0.34	0.86	0.04
Disp_5000	Winter_500	Surv_2500	Urban_3000	124.34	4.54	17.3	0.0934	1.00	1.00	1.79	1.00	1.38	1.01	0.38	6.10	0.24	0.32	0.86	0.01
Disp_1000	Winter_500	Surv_5000	NatAgri_3000	124.41	4.61	15.4	0.0781	1.00	1.00	1.00	1.00	0.27	1.00	1.13	5.09	0.60	0.31	0.28	0.02
Disp_1000	Winter_1000	Surv_5000	NatAgri_3000	124.41	4.61	15.4	0.0803	1.00	1.00	1.00	1.00	0.28	0.98	1.12	4.34	0.59	0.32	0.28	0.04
Disp_2500	Winter_500	Surv_5000	NatAgri_3000	124.46	4.66	19.3	0.1110	1.65	1.00	2.03	1.00	3.80	0.72	0.53	5.53	0.15	0.39	0.86	0.02

Disp_2500	Winter_1000	Surv_5000	NatAgri_3000	124.47	4.67	19.4	0.1120	1.69	1.00	2.03	1.00	3.86	0.69	0.54	4.94	0.16	0.41	0.85	0.03
Disp_1000	Winter_1000	Surv_2500	NatAgri_3000	124.48	4.68	15.3	0.0818	1.00	1.00	1.00	1.00	0.18	0.96	0.89	5.82	0.67	0.32	0.34	0.02
Disp_1000	Winter_500	NatAgri_3000	-	124.49	4.69	14.3	0.0842	1.00	1.00	1.15	-	1.38	0.95	9.50	-	0.23	0.33	0.01	-
Disp_1000	Winter_1000	NatAgri_3000	-	124.49	4.69	14.4	0.0862	1.00	1.00	1.17	-	1.32	0.96	8.38	-	0.25	0.33	0.01	-
Disp_5000	Winter_3000	NatAgri_3000	-	124.50	4.70	14.7	0.0934	1.00	1.00	1.32	-	1.80	0.87	4.55	-	0.18	0.35	0.11	-
Disp_1000	Winter_500	Surv_2500	NatAgri_3000	124.51	4.71	15.3	0.0798	1.00	1.00	1.00	1.00	0.19	0.95	0.86	6.91	0.66	0.32	0.35	0.01
Disp_5000	Winter_3000	Surv_2500	Urban_3000	124.57	4.77	17.1	0.0973	1.00	1.00	1.77	1.00	1.08	0.87	0.40	4.79	0.30	0.35	0.85	0.03
Disp_2500	Winter_3000	Surv_5000	-	124.63	4.83	15.0	0.0744	1.47	1.00	1.00	-	1.72	2.56	1.26	-	0.27	0.11	0.26	-
Disp_2500	Winter_3000	Surv_5000	NatAgri_3000	124.69	4.89	19.2	0.1120	1.70	1.00	2.02	1.00	3.94	0.59	0.53	3.89	0.15	0.44	0.85	0.05
Disp_2500	Winter_3000	-	-	124.70	4.90	13.0	0.0774	1.29	1.00	-	-	4.25	2.94	-	-	0.05	0.87	-	-
Disp_1000	Winter_3000	NatAgri_3000	-	124.77	4.97	14.5	0.0884	1.00	1.00	1.31	-	1.34	0.99	6.82	-	0.25	0.32	0.04	-
Disp_1000	Winter_3000	Surv_5000	NatAgri_3000	124.79	4.99	15.5	0.0818	1.00	1.00	1.00	1.11	0.34	0.92	1.09	3.65	0.56	0.34	0.29	0.09
Disp_1000	Winter_3000	Surv_2500	NatAgri_3000	124.80	5.00	15.2	0.0827	1.00	1.00	1.00	1.06	0.24	0.91	0.85	4.56	0.62	0.34	0.36	0.05
Winter_3000	Surv_1000	-	-	124.99	5.19	12.0	0.0562	1.00	1.00	-	-	4.71	2.58	-	-	0.03	0.11	-	-
Disp_5000	Winter_1000	Surv_5000	Urban_3000	125.18	5.38	17.0	0.0906	1.00	1.00	1.89	1.00	1.09	1.10	0.47	4.55	0.30	0.29	0.86	0.03
Winter_1000	Surv_5000	-	-	125.20	5.40	12.0	0.0535	1.00	1.00	-	-	2.94	3.70	-	-	0.09	0.05	-	-
Winter_3000	Surv_5000	ForWet_3000	-	125.22	5.42	15.7	0.0751	1.00	1.00	2.04	-	1.77	1.93	3.57	-	0.18	0.16	0.35	-
Disp_5000	Winter_500	Surv_5000	Urban_3000	125.25	5.45	17.0	0.0870	1.00	1.00	1.91	1.00	1.25	1.12	0.46	4.96	0.26	0.29	0.86	0.03
Surv_5000	ForWet_3000	-	-	125.30	5.50	13.2	0.0695	1.00	1.56	-	-	1.82	4.25	-	-	0.18	0.09	-	-
Winter_1000	Surv_1000	ForWet_3000	-	125.35	5.55	15.1	0.0789	1.00	1.00	1.80	-	0.65	1.97	5.12	-	0.42	0.16	0.12	-
Disp_2500	Winter_1000	Surv_5000	-	125.38	5.58	14.2	0.0620	1.37	1.00	1.00	-	1.49	2.00	1.43	-	0.27	0.16	0.23	-
Disp_5000	Winter_3000	Surv_5000	Urban_3000	125.42	5.62	16.8	0.0911	1.00	1.00	1.88	1.00	0.97	0.98	0.47	3.81	0.32	0.32	0.86	0.05
Disp_2500	Winter_3000	Surv_1000	-	125.44	5.64	17.2	0.0819	1.85	1.00	2.04	-	4.66	2.69	0.56	-	0.12	0.10	0.73	-
Winter_500	Surv_1000	ForWet_3000	-	125.45	5.65	14.9	0.0755	1.00	1.00	1.77	-	0.58	1.96	6.18	-	0.44	0.16	0.07	-
Disp_5000	Winter_3000	Surv_5000	-	125.46	5.66	13.2	0.0614	1.00	1.00	1.00	-	0.83	2.38	1.33	-	0.36	0.12	0.25	-
Disp_5000	Winter_500	Surv_2500	NatAgri_3000	125.49	5.69	16.4	0.0882	1.00	1.00	1.78	1.00	1.18	0.96	0.43	4.75	0.28	0.33	0.85	0.03
Disp_5000	Winter_1000	Surv_2500	NatAgri_3000	125.49	5.69	16.4	0.0896	1.00	1.00	1.77	1.00	1.09	0.91	0.45	4.25	0.29	0.34	0.84	0.04
Winter_3000	Surv_2500	-	-	125.50	5.70	11.6	0.0536	1.00	1.00	-	-	4.20	2.38	-	-	0.04	0.12	-	-
Surv_2500	ForWet_3000	-	-	125.50	5.70	13.2	0.0694	1.00	1.69	-	-	1.52	7.66	-	-	0.22	0.03	-	-
Disp_2500	Winter_3000	ForWet_3000	-	125.54	5.74	15.8	0.0970	1.23	1.00	1.89	-	2.85	0.67	3.23	-	0.10	0.41	0.34	-
Disp_2500	Winter_1000	-	-	125.70	5.90	12.0	0.0632	1.17	1.00	-	-	5.26	2.12	-	-	0.02	0.15	-	-
Disp_5000	Winter_500	Surv_5000	NatAgri_3000	125.72	5.92	16.3	0.0842	1.00	1.00	1.75	1.00	0.84	1.02	0.63	4.15	0.36	0.31	0.77	0.04
Disp_2500	Winter_500	ForWet_3000	-	125.75	5.95	14.9	0.0911	1.21	1.00	1.55	-	3.08	0.44	2.91	-	0.08	0.51	0.17	-
Disp_5000	Winter_1000	Surv_5000	NatAgri_3000	125.76	5.96	16.2	0.0857	1.00	1.00	1.73	1.00	0.77	0.94	0.64	3.68	0.38	0.33	0.76	0.06
Disp_2500	Winter_1000	ForWet_3000	-	125.77	5.97	15.1	0.0919	1.26	1.00	1.58	-	2.98	0.45	2.59	-	0.09	0.50	0.23	-
Winter_3000	Surv_2500	ForWet_3000	-	125.77	5.97	15.4	0.0732	1.00	1.00	2.13	-	1.45	1.59	4.39	-	0.23	0.21	0.27	-
Disp_2500	Winter_3000	Surv_1000	ForWet_3000	125.86	6.06	20.9	0.1050	1.86	1.00	2.06	2.10	3.62	0.86	0.59	4.22	0.19	0.35	0.72	0.27
Winter_3000	Surv_1000	ForWet_3000	-	125.88	6.08	17.2	0.0824	1.00	1.70	2.27	-	1.26	1.24	5.49	-	0.26	0.63	0.18	-
Disp_5000	Winter_3000	-	-	125.90	6.10	11.4	0.0567	1.00	1.00	-	-	4.51	2.50	-	-	0.03	0.11	-	-
Winter_500	Surv_5000	-	-	125.90	6.10	11.4	0.0458	1.00	1.00	-	-	2.50	4.15	-	-	0.11	0.04	-	-
Disp_5000	Winter_1000	Surv_5000	-	125.92	6.12	12.8	0.0538	1.00	1.00	1.00	-	1.22	2.01	1.36	-	0.27	0.16	0.24	-
Disp_2500	Winter_500	Surv_5000	-	125.93	6.13	13.6	0.0550	1.27	1.00	1.00	-	1.56	1.60	1.48	-	0.23	0.21	0.22	-
Disp_5000	Winter_3000	Surv_2500	NatAgri_3000	125.97	6.17	16.1	0.0893	1.00	1.00	1.74	1.04	0.98	0.76	0.46	3.55	0.32	0.38	0.84	0.07
Winter_1000	Surv_5000	ForWet_3000	-	126.08	6.28	14.2	0.0692	1.00	1.00	1.60	-	0.98	1.85	1.86	-	0.32	0.17	0.37	-
Disp_2500	Winter_3000	Surv_5000	ForWet_3000	126.11	6.31	17.3	0.0887	1.45	1.00	1.00	1.85	1.38	1.10	0.91	2.47	0.33	0.29	0.34	0.43
Disp_1000	Winter_3000	Surv_5000	-	126.12	6.32	12.7	0.0575	1.00	1.00	1.00	-	0.16	3.31	2.33	-	0.69	0.07	0.13	-
Disp_2500	Surv_5000	-	-	126.20	6.40	11.9	0.0485	1.28	1.00	-	-	2.62	1.65	-	-	0.12	0.20	-	-
Winter_500	Surv_5000	ForWet_3000	-	126.25	6.45	14.0	0.0670	1.00	1.00	1.55	-	0.87	1.82	2.03	-	0.35	0.18	0.28	-

Disp_2500	Winter_500	-	-	126.30	6.50	11.2	0.0578	1.05	1.00	-	-	6.67	1.66	-	-	0.01	0.20	-	-
Disp_5000	ForWet_3000	-	-	126.30	6.50	12.4	0.0696	1.00	1.49	-	-	2.46	3.21	-	-	0.12	0.13	-	-
Disp_5000	Winter_3000	Surv_5000	NatAgri_3000	126.35	6.55	16.2	0.0874	1.00	1.00	1.71	1.18	0.64	0.83	0.66	3.51	0.42	0.36	0.75	0.12
Disp_5000	Winter_500	Surv_5000	-	126.38	6.58	12.5	0.0477	1.00	1.00	1.00	-	1.53	1.74	1.37	-	0.22	0.19	0.24	-
Disp_5000	Winter_3000	Surv_1000	-	126.38	6.58	14.4	0.0587	1.00	1.00	1.89	-	2.33	2.30	0.52	-	0.13	0.13	0.85	-
ForWet_3000	-	-	-	126.40	6.60	11.8	0.0686	1.98	-	-	-	14.52	-	-	-	0.00	-	-	-
Winter_1000	Surv_2500	ForWet_3000	-	126.49	6.69	14.0	0.0685	1.00	1.00	1.72	-	0.83	1.52	3.70	-	0.36	0.22	0.20	-
Disp_2500	Winter_1000	Surv_1000	ForWet_3000	126.49	6.69	19.7	0.0989	1.80	1.00	2.05	1.77	3.75	0.34	0.58	3.85	0.18	0.55	0.72	0.20
Disp_2500	Winter_500	Surv_1000	ForWet_3000	126.54	6.74	19.5	0.0978	1.76	1.00	2.05	1.75	3.73	0.31	0.60	4.31	0.17	0.58	0.71	0.16
Disp_2500	Winter_1000	Surv_5000	ForWet_3000	126.58	6.78	16.1	0.0822	1.44	1.00	1.00	1.43	1.57	0.59	0.81	0.94	0.29	0.44	0.37	0.44
Disp_2500	Winter_500	Surv_5000	ForWet_3000	126.65	6.85	15.8	0.0808	1.39	1.00	1.00	1.39	1.48	0.53	0.78	1.23	0.28	0.47	0.38	0.34
Winter_500	Surv_2500	ForWet_3000	-	126.66	6.86	13.8	0.0672	1.00	1.00	1.68	-	0.72	1.47	4.59	-	0.40	0.23	0.12	-
Disp_5000	Winter_1000	-	-	126.70	6.90	11.2	0.0494	1.18	1.00	-	-	5.73	1.99	-	-	0.02	0.16	-	-
Disp_2500	Winter_3000	Surv_2500	-	126.70	6.90	16.1	0.0844	1.80	1.00	1.86	-	4.31	3.01	0.44	-	0.13	0.08	0.85	-
Disp_2500	Winter_1000	Surv_1000	-	126.78	6.98	16.1	0.0681	1.75	1.00	2.06	-	5.24	1.80	0.53	-	0.08	0.18	0.70	-
Disp_2500	-	-	-	126.90	7.10	9.6	0.0533	1.14	-	-	-	9.36	-	-	-	0.00	-	-	-
Disp_5000	Surv_5000	-	-	126.90	7.10	10.6	0.0414	1.00	1.00	-	-	2.64	1.51	-	-	0.10	0.22	-	-
Winter_1000	Surv_1000	-	-	126.90	7.10	10.6	0.0437	1.00	1.00	-	-	3.79	2.76	-	-	0.05	0.10	-	-
Winter_1000	Surv_2500	-	-	126.90	7.10	10.6	0.0409	1.00	1.00	-	-	3.54	2.79	-	-	0.06	0.10	-	-
Winter_3000	ForWet_3000	-	-	126.90	7.10	13.6	0.0720	1.00	2.35	-	-	1.19	6.26	-	-	0.28	0.12	-	-
Disp_5000	Winter_3000	Surv_5000	ForWet_3000	126.95	7.15	15.8	0.0732	1.00	1.00	1.00	1.97	0.39	1.49	1.17	2.82	0.53	0.22	0.28	0.43
Disp_1000	ForWet_3000	-	-	127.00	7.20	12.3	0.0723	1.00	1.75	-	-	1.30	9.90	-	-	0.26	0.01	-	-
Disp_2500	Surv_1000	-	-	127.00	7.20	14.4	0.0599	1.76	2.08	-	-	8.42	0.91	-	-	0.02	0.58	-	-
Disp_1000	Winter_3000	Surv_1000	-	127.03	7.23	12.3	0.0543	1.12	1.02	1.00	-	0.25	4.90	1.83	-	0.81	0.03	0.18	-
Disp_1000	Winter_1000	Surv_5000	-	127.04	7.24	12.0	0.0494	1.00	1.00	1.00	-	0.08	2.79	2.99	-	0.78	0.10	0.08	-
Disp_5000	Winter_1000	Surv_1000	-	127.12	7.32	13.9	0.0506	1.00	1.00	1.93	-	3.59	1.79	0.46	-	0.06	0.18	0.85	-
Disp_1000	Winter_1000	Surv_1000	ForWet_3000	127.16	7.36	15.4	0.0752	1.00	1.00	1.00	1.88	0.16	0.72	1.56	5.40	0.69	0.40	0.21	0.12
Disp_1000	Winter_3000	Surv_5000	ForWet_3000	127.19	7.39	15.7	0.0724	1.00	1.00	1.00	2.21	0.05	1.60	1.52	3.38	0.82	0.21	0.22	0.36
Disp_5000	Winter_3000	ForWet_3000	-	127.24	7.44	14.0	0.0730	1.00	1.00	1.92	-	2.05	0.94	2.82	-	0.15	0.33	0.42	-
Disp_5000	Winter_3000	Surv_1000	ForWet_3000	127.26	7.46	17.8	0.0795	1.00	1.00	1.91	2.13	0.86	1.09	0.53	3.80	0.35	0.30	0.85	0.33
Disp_1000	Winter_500	Surv_1000	ForWet_3000	127.29	7.49	15.2	0.0737	1.00	1.00	1.00	1.83	0.14	0.63	1.52	6.40	0.71	0.43	0.22	0.07
Winter_1000	ForWet_3000	-	-	127.30	7.50	12.7	0.0689	1.00	2.05	-	-	0.83	7.54	-	-	0.36	0.06	-	-
Disp_5000	Winter_1000	ForWet_3000	-	127.39	7.59	13.1	0.0681	1.00	1.00	1.53	-	2.33	0.69	1.49	-	0.13	0.41	0.37	-
Disp_5000	Winter_500	-	-	127.40	7.60	11.1	0.0454	1.33	1.00	-	-	6.69	1.71	-	-	0.02	0.19	-	-
Winter_500	ForWet_3000	-	-	127.40	7.60	12.5	0.0674	1.00	1.99	-	-	0.77	8.92	-	-	0.38	0.03	-	-
Disp_1000	Winter_3000	Surv_2500	-	127.40	7.60	11.7	0.0503	1.00	1.00	1.00	-	0.07	4.10	1.59	-	0.80	0.04	0.21	-
Disp_2500	Winter_500	Surv_1000	-	127.40	7.60	15.5	0.0627	1.67	1.00	2.08	-	5.85	1.34	0.74	-	0.06	0.25	0.66	-
Surv_5000	-	-	-	127.50	7.70	8.7	0.0368	1.00	-	-	-	5.73	-	-	-	0.02	-	-	-
Disp_5000	Winter_3000	Surv_2500	-	127.50	7.70	13.3	0.0565	1.00	1.00	1.70	-	1.88	2.49	0.50	-	0.17	0.12	0.82	-
Disp_5000	Winter_1000	Surv_5000	ForWet_3000	127.51	7.71	14.3	0.0667	1.00	1.00	1.00	1.46	0.66	0.85	1.05	0.75	0.42	0.36	0.31	0.54
Disp_5000	Winter_500	ForWet_3000	-	127.55	7.75	13.1	0.0673	1.08	1.00	1.49	-	2.27	0.68	1.69	-	0.14	0.41	0.30	-
Disp_5000	Winter_500	Surv_5000	ForWet_3000	127.61	7.81	14.1	0.0647	1.00	1.00	1.00	1.40	0.71	0.78	1.02	0.89	0.40	0.38	0.31	0.45
Disp_1000	Winter_3000	Surv_1000	ForWet_3000	127.66	7.86	17.3	0.0789	1.04	1.00	1.58	2.31	0.14	1.36	1.08	5.48	0.81	0.24	0.62	0.17
Disp_2500	Winter_3000	Surv_2500	ForWet_3000	127.66	7.86	19.4	0.1090	1.86	1.00	1.98	1.98	3.91	0.88	0.47	3.52	0.17	0.35	0.82	0.31
Disp_1000	Winter_3000	Surv_2500	ForWet_3000	127.77	7.97	15.4	0.0704	1.00	1.00	1.00	2.15	0.01	1.37	1.13	4.36	0.94	0.24	0.29	0.27
Disp_5000	Surv_1000	-	-	127.80	8.00	12.5	0.0420	1.21	1.97	-	-	6.51	0.50	-	-	0.02	0.80	-	-
Disp_1000	Winter_500	Surv_5000	-	127.80	8.00	11.5	0.0417	1.00	1.00	1.00	-	0.08	2.34	3.32	-	0.78	0.13	0.07	-
Disp_5000	Winter_1000	Surv_1000	ForWet_3000	127.84	8.04	16.5	0.0740	1.00	1.00	1.88	1.74	1.07	0.56	0.51	2.75	0.30	0.45	0.86	0.32

Disp_2500	Winter_1000	Surv_2500	-	127.88	8.08	14.9	0.0683	1.72	1.00	1.82	-	4.36	2.17	0.44	-	0.12	0.14	0.85	-
Disp_5000	Winter_500	Surv_1000	-	127.88	8.08	13.9	0.0476	1.20	1.00	1.96	-	4.26	1.51	0.44	-	0.05	0.22	0.84	-
Disp_5000	Winter_500	Surv_1000	ForWet_3000	127.88	8.08	16.4	0.0727	1.00	1.00	1.89	1.70	1.12	0.53	0.51	3.00	0.29	0.47	0.86	0.27
Disp_1000	Winter_3000	ForWet_3000	-	127.90	8.10	13.9	0.0765	1.00	1.00	2.10	-	0.97	0.92	5.00	-	0.32	0.34	0.20	-
Disp_1000	Winter_1000	Surv_5000	ForWet_3000	127.98	8.18	14.2	0.0664	1.00	1.00	1.00	1.57	0.11	0.83	1.40	1.70	0.74	0.36	0.24	0.36
Disp_5000	Winter_1000	Surv_2500	-	128.08	8.28	13.0	0.0482	1.00	1.00	1.75	-	2.76	2.01	0.49	-	0.10	0.16	0.83	-
Disp_2500	Winter_1000	Surv_2500	ForWet_3000	128.08	8.28	18.3	0.1030	1.83	1.00	1.97	1.64	4.18	0.48	0.45	3.22	0.15	0.49	0.82	0.22
Winter_500	Surv_2500	-	-	128.10	8.30	9.7	0.0323	1.00	1.00	-	-	2.83	2.94	-	-	0.09	0.09	-	-
Disp_1000	Winter_500	Surv_5000	ForWet_3000	128.13	8.33	14.0	0.0643	1.00	1.00	1.00	1.55	0.13	0.73	1.36	1.93	0.72	0.39	0.24	0.28
Disp_5000	-	-	-	128.20	8.40	9.3	0.0384	1.41	-	-	-	10.54	-	-	-	0.00	-	-	-
Disp_2500	Winter_500	Surv_2500	ForWet_3000	128.21	8.41	16.0	0.1020	1.78	1.00	1.96	1.60	4.15	0.39	0.43	3.77	0.14	0.53	0.82	0.15
Disp_1000	Winter_1000	ForWet_3000	-	128.27	8.47	13.0	0.0722	1.00	1.00	1.80	-	1.00	0.58	5.57	-	0.32	0.44	0.10	-
Disp_1000	Winter_3000	-	-	128.30	8.50	9.6	0.0510	1.00	1.00	-	-	1.87	4.80	-	-	0.17	0.03	-	-
Winter_500	Surv_1000	-	-	128.30	8.50	9.5	0.0342	1.00	1.00	-	-	2.98	2.89	-	-	0.08	0.09	-	-
Disp_1000	Winter_500	ForWet_3000	-	128.33	8.53	12.9	0.0710	1.00	1.00	1.75	-	1.03	0.56	6.53	-	0.31	0.46	0.06	-
Disp_1000	Winter_1000	Surv_2500	ForWet_3000	128.46	8.66	14.1	0.0659	1.00	1.00	1.00	1.72	0.04	0.73	1.01	3.76	0.85	0.39	0.32	0.20
Winter_3000	-	-	-	128.50	8.70	8.5	0.0413	1.16	-	-	-	7.66	-	-	-	0.03	-	-	-
Disp_1000	Winter_500	Surv_2500	ForWet_3000	128.61	8.81	13.9	0.0646	1.00	1.00	1.00	1.67	0.06	0.63	0.95	4.60	0.81	0.43	0.33	0.11
Disp_5000	Winter_500	Surv_2500	-	128.67	8.87	12.6	0.0428	1.00	1.00	1.77	-	3.45	1.70	0.45	-	0.06	0.19	0.84	-
Disp_2500	Winter_500	Surv_2500	-	128.79	8.99	14.0	0.0611	1.61	1.00	1.80	-	4.38	1.59	0.40	-	0.10	0.21	0.86	-
Disp_1000	Winter_1000	Surv_2500	-	128.84	9.04	10.6	0.0374	1.00	1.00	1.00	-	0.02	3.38	1.98	-	0.90	0.07	0.16	-
Disp_5000	Winter_3000	Surv_2500	ForWet_3000	128.89	9.09	16.2	0.0725	1.00	1.00	1.74	2.20	0.94	1.24	0.48	3.15	0.33	0.27	0.83	0.39
Disp_1000	Winter_1000	Surv_1000	-	128.95	9.15	11.2	0.0428	1.24	1.00	1.00	-	0.52	3.91	2.04	-	0.75	0.05	0.15	-
Disp_2500	Surv_2500	-	-	129.00	9.20	12.4	0.0577	1.63	1.80	-	-	6.51	0.43	-	-	0.04	0.85	-	-
Disp_1000	Surv_5000	-	-	129.20	9.40	8.9	0.0294	1.00	1.00	-	-	0.31	3.96	-	-	0.58	0.05	-	-
Disp_5000	Surv_2500	-	-	129.30	9.50	10.6	0.0357	1.00	1.72	-	-	4.94	0.52	-	-	0.03	0.82	-	-
Disp_5000	Winter_1000	Surv_2500	ForWet_3000	129.30	9.50	15.0	0.0670	1.00	1.00	1.74	1.57	1.25	0.76	0.43	1.56	0.26	0.39	0.85	0.40
Disp_5000	Winter_500	Surv_2500	ForWet_3000	129.41	9.61	14.8	0.0655	1.00	1.00	1.74	1.52	1.31	0.69	0.42	1.66	0.25	0.41	0.85	0.33
Disp_1000	Winter_500	Surv_2500	-	130.08	10.28	9.7	0.0289	1.00	1.00	1.00	-	0.03	2.66	1.99	-	0.85	0.10	0.16	-
Surv_2500	-	-	-	130.30	10.50	6.6	0.0220	1.00	-	-	-	4.12	-	-	-	0.04	-	-	-
Disp_1000	Winter_1000	-	-	130.30	10.50	8.1	0.0390	1.00	1.00	-	-	1.98	3.70	-	-	0.16	0.05	-	-
Disp_1000	Winter_500	Surv_1000	-	130.38	10.58	10.0	0.0319	1.18	1.00	1.00	-	0.29	3.04	1.92	-	0.83	0.08	0.16	-
Winter_1000	-	-	-	130.60	10.80	6.5	0.0274	1.00	-	-	-	5.15	-	-	-	0.02	-	-	-
Surv_1000	-	-	-	130.80	11.00	6.2	0.0172	1.00	-	-	-	3.92	-	-	-	0.05	-	-	-
Disp_1000	Winter_500	-	-	131.60	11.80	7.2	0.0310	1.00	1.00	-	-	2.38	2.91	-	-	0.12	0.09	-	-
Disp_1000	Surv_2500	-	-	132.00	12.20	6.8	0.0167	1.00	1.00	-	-	0.28	2.28	-	-	0.59	0.13	-	-
Winter_500	-	-	-	132.30	12.50	5.2	0.0174	1.00	-	-	-	4.19	-	-	-	0.04	-	-	-
Disp_1000	Surv_1000	-	-	132.80	13.00	6.2	0.0139	1.00	1.00	-	-	0.01	1.91	-	-	0.95	0.17	-	-
Disp_1000	-	-	-	134.10	14.30	3.8	0.0152	1.00	-	-	-	4.25	-	-	-	0.04	-	-	-

Table 2: Generalized Additive Model Results for Wood Frog

Variable 1	Variable 2	Variable 3	Variable 4	AIC	Delta	% Variance Explained	R^2	edf 1	edf 2	edf 3	edf 4	ANOVA F 1	ANOVA F 2	ANOVA F 3	ANOVA F 4	p-value 1	p-value 2	p-value 3	p-value 4
Disp_2500	Winter_1000	Surv_1000	Urban_3000	356.16	0.00	14.60	0.15	1.00	2.70	2.67	1.00	4.37	10.48	5.60	10.65	0.04	0.02	0.18	0.00
Disp_1000	Winter_1000	Surv_2500	Urban_3000	356.29	0.13	15.10	0.16	3.33	3.08	1.00	1.00	8.01	15.92	1.50	10.21	0.10	0.00	0.22	0.00
Disp_1000	Winter_3000	Surv_5000	NatAgri_3000	361.21	0.13	14.30	0.16	3.50	2.94	1.00	1.00	9.21	11.86	0.61	6.02	0.07	0.02	0.44	0.01
Disp_2500	Winter_500	Surv_1000	Urban_3000	356.39	0.23	14.40	0.15	1.00	2.54	2.73	1.00	5.57	9.72	6.36	12.79	0.02	0.03	0.14	0.00
Disp_1000	Winter_1000	Urban_3000	-	356.56	0.40	15.00	0.16	3.43	3.09	1.00	-	8.42	15.08	13.39	-	0.09	0.01	0.00	-
Disp_1000	Winter_1000	Surv_2500	NatAgri_3000	357.18	1.02	14.90	0.16	3.38	3.00	1.00	1.00	8.19	13.99	2.10	9.68	0.10	0.01	0.15	0.00
Disp_2500	Winter_3000	Surv_1000	Urban_3000	357.62	1.46	14.20	0.15	1.00	2.65	2.70	1.00	4.50	9.22	6.11	7.07	0.03	0.04	0.15	0.01
Disp_1000	Winter_3000	Urban_3000	-	357.64	1.48	14.90	0.16	3.51	3.18	1.00	-	9.39	13.95	8.39	-	0.07	0.01	0.00	-
Disp_1000	Winter_1000	Surv_1000	Urban_3000	357.65	1.49	15.70	0.16	3.16	3.09	2.36	1.00	4.85	15.50	1.28	12.07	0.23	0.00	0.73	0.00
Disp_1000	Winter_500	Surv_2500	Urban_3000	357.74	1.58	14.60	0.16	3.39	2.86	1.00	1.00	8.37	14.05	1.51	13.20	0.09	0.01	0.22	0.00
Disp_5000	Winter_500	Surv_1000	Urban_3000	357.89	1.73	14.60	0.16	1.87	2.57	2.59	1.00	6.15	10.13	4.55	9.57	0.07	0.02	0.25	0.00
Disp_5000	Winter_1000	Surv_1000	Urban_3000	357.92	1.76	14.60	0.16	1.60	2.74	2.56	1.00	3.61	10.63	4.04	8.27	0.14	0.02	0.31	0.00
Disp_1000	Winter_500	Urban_3000	-	358.06	1.90	14.50	0.16	3.48	2.83	1.00	-	8.96	13.10	16.77	-	0.08	0.01	0.00	-
Disp_1000	Winter_500	Surv_2500	NatAgri_3000	358.06	1.90	14.50	0.16	3.44	2.70	1.00	1.00	8.62	12.34	2.14	13.43	0.09	0.01	0.14	0.00
Disp_1000	Winter_3000	Surv_2500	Urban_3000	358.22	2.06	14.90	0.16	3.43	3.10	1.22	1.00	8.55	14.60	1.30	6.34	0.09	0.01	0.47	0.01
Winter_1000	Surv_1000	Urban_3000	-	358.27	2.11	13.60	0.15	3.08	2.46	1.00	-	16.24	2.39	11.98	-	0.00	0.53	0.00	-
Disp_1000	Winter_1000	NatAgri_3000	-	358.40	2.24	14.50	0.16	3.49	3.03	1.00	-	9.03	13.18	12.13	-	0.08	0.01	0.00	-
Disp_1000	Winter_1000	Surv_5000	Urban_3000	358.41	2.25	15.00	0.16	3.41	1.07	1.00	1.00	8.25	15.24	0.18	11.27	0.10	0.01	0.67	0.00
Disp_1000	Winter_3000	Surv_1000	Urban_3000	358.60	2.44	15.60	0.16	3.25	3.19	2.44	1.00	6.16	14.56	1.55	7.46	0.17	0.01	0.69	0.01
Disp_2500	Winter_1000	Surv_1000	NatAgri_3000	358.60	2.44	13.80	0.15	1.00	2.61	2.62	1.00	3.79	9.41	4.53	8.79	0.05	0.03	0.27	0.00
Disp_2500	Winter_500	Surv_1000	NatAgri_3000	358.83	2.67	13.70	0.15	1.00	2.40	2.66	1.00	4.72	8.97	4.97	11.17	0.03	0.03	0.23	0.00
Disp_1000	Winter_1000	Surv_1000	NatAgri_3000	358.86	2.70	15.20	0.16	3.27	3.01	2.08	1.00	6.28	13.47	1.58	11.24	0.18	0.01	0.60	0.00
Disp_1000	Winter_500	Surv_1000	Urban_3000	358.94	2.78	15.20	0.16	3.21	2.83	2.38	1.00	5.39	13.70	1.44	15.37	0.21	0.01	0.70	0.00
Disp_1000	Winter_3000	Surv_2500	NatAgri_3000	359.09	2.93	14.40	0.16	3.46	2.87	1.00	1.00	8.75	12.07	1.56	5.42	0.09	0.02	0.21	0.02
Disp_1000	Winter_500	NatAgri_3000	-	359.40	3.24	14.10	0.15	3.54	2.63	1.00	-	9.76	11.23	16.28	-	0.06	0.02	0.00	-
Disp_1000	Winter_3000	Surv_5000	Urban_3000	359.56	3.40	14.90	0.16	3.49	3.16	1.00	1.00	9.18	14.09	0.08	7.18	0.07	0.00	0.77	0.01
Disp_1000	Winter_1000	Surv_5000	NatAgri_3000	359.58	3.42	14.70	0.16	3.44	2.98	1.00	1.00	8.49	13.39	0.89	10.58	0.09	0.01	0.34	0.00
Disp_1000	Winter_500	Surv_1000	NatAgri_3000	359.72	3.56	14.80	0.16	3.33	2.66	2.11	1.00	6.73	11.81	1.63	15.18	0.16	0.01	0.49	0.00
Winter_1000	Surv_2500	Urban_3000	-	359.74	3.58	12.70	0.14	3.00	1.70	1.00	-	15.54	2.33	10.31	-	0.00	0.33	0.00	-
Disp_1000	Winter_3000	NatAgri_3000	-	359.77	3.61	14.20	0.16	3.55	3.03	1.00	-	9.82	11.93	6.77	-	0.06	0.02	0.01	-
Disp_1000	Winter_500	Surv_5000	Urban_3000	359.89	3.73	14.50	0.15	3.46	2.83	1.00	1.00	8.74	13.25	0.19	14.25	0.09	0.01	0.67	0.00
Winter_1000	Urban_3000	-	-	359.90	3.74	12.00	0.14	3.06	1.00	-	-	16.01	13.04	-	-	0.00	0.00	-	-
Disp_2500	Winter_1000	Urban_3000	-	359.92	3.76	12.40	0.14	1.00	2.80	1.00	-	2.27	10.97	11.29	-	0.13	0.02	0.01	-
Winter_500	Surv_1000	Urban_3000	-	359.92	3.76	13.00	0.14	2.86	2.46	1.00	-	14.36	2.51	15.27	-	0.01	0.51	0.00	-
Disp_2500	Winter_3000	Surv_1000	NatAgri_3000	360.03	3.87	13.40	0.14	1.00	2.37	2.64	1.00	4.09	7.77	5.02	5.25	0.04	0.05	0.22	0.02
Winter_1000	Surv_1000	NatAgri_3000	-	360.12	3.96	13.00	0.14	2.99	2.33	1.00	-	14.09	2.27	10.75	-	0.01	0.53	0.00	-
Winter_3000	Surv_1000	Urban_3000	-	360.16	4.00	13.10	0.14	2.90	2.49	1.00	-	14.55	2.75	7.37	-	0.01	0.48	0.01	-
Disp_5000	Winter_3000	Surv_1000	Urban_3000	360.20	4.04	13.70	0.15	1.51	2.31	2.57	1.00	2.76	7.90	4.26	5.90	0.17	0.05	0.28	0.01
Disp_5000	Winter_1000	Surv_1000	NatAgri_3000	360.30	4.14	13.80	0.15	1.45	2.68	2.49	1.00	2.51	10.02	3.33	5.24	0.19	0.29	0.39	0.01
Disp_1000	Winter_3000	Surv_1000	NatAgri_3000	360.35	4.19	15.00	0.16	3.31	2.95	2.24	1.00	6.81	12.25	1.54	6.16	0.16	0.02	0.65	0.01
Disp_5000	Winter_500	Surv_1000	NatAgri_3000	360.37	4.21	13.90	0.15	1.77	2.47	2.53	1.00	4.88	9.46	3.62	7.60	0.22	0.02	0.34	0.01
Disp_5000	Winter_1000	Urban_3000	-	360.40	4.24	12.80	0.15	1.74	2.75	1.00	-	3.48	10.22	9.27	-	0.22	0.03	0.00	-
Disp_1000	Winter_500	Surv_5000	NatAgri_3000	360.47	4.31	14.30	0.15	3.50	2.65	1.00	1.00	9.06	11.67	0.98	14.35	0.08	0.01	0.32	0.00
Winter_1000	Surv_2500	NatAgri_3000	-	360.74	4.58	12.30	0.14	2.92	1.54	1.00	-	13.83	3.70	9.58	-	0.01	0.19	0.00	-

Disp_2500	Winter_500	Surv_1000	ForWet_3000	360.77	4.61	13.10	0.14	1.00	2.29	2.67	1.00	3.96	5.77	5.50	9.01	0.05	0.13	0.19	0.00
Disp_2500	Winter_1000	Surv_2500	Urban_3000	360.77	4.61	13.10	0.14	1.00	2.83	2.03	1.00	1.37	11.48	2.04	10.45	0.24	0.02	0.45	0.00
Disp_5000	Winter_1000	Surv_2500	Urban_3000	360.95	4.79	13.40	0.15	1.54	2.70	2.00	1.00	1.91	10.76	2.14	8.56	0.29	0.02	0.43	0.00
Disp_5000	Winter_500	Urban_3000	-	361.03	4.87	12.70	0.15	2.00	2.55	1.00	-	5.60	8.91	10.74	-	0.12	0.04	0.00	-
Disp_5000	Winter_500	Surv_2500	Urban_3000	361.20	5.04	13.50	0.15	1.82	2.61	2.16	1.00	4.34	10.02	2.46	10.04	0.16	0.03	0.40	0.00
Winter_500	Surv_2500	Urban_3000	-	361.32	5.16	12.30	0.13	2.84	1.85	1.00	-	13.92	2.57	13.22	-	0.01	0.31	0.00	-
Disp_2500	Winter_1000	Surv_1000	ForWet_3000	361.37	5.21	13.10	0.14	1.00	2.44	2.64	1.00	3.66	4.99	5.07	6.19	0.06	0.19	0.22	0.01
Winter_500	Surv_1000	NatAgri_3000	-	361.39	5.23	12.50	0.14	2.68	2.33	1.00	-	12.33	2.41	14.65	-	0.01	0.50	0.00	-
Winter_500	Urban_3000	-	-	361.40	5.24	11.30	0.13	2.86	1.00	-	-	13.70	16.73	-	-	0.01	0.00	-	-
Winter_1000	Surv_5000	Urban_3000	-	361.46	5.30	12.10	0.14	2.86	2.46	1.00	-	14.36	2.51	15.27	-	0.01	0.51	0.00	-
Disp_1000	Winter_500	Surv_2500	ForWet_3000	361.47	5.31	13.90	0.15	3.37	2.54	1.00	1.49	8.28	7.32	1.57	10.06	0.09	0.07	0.21	0.00
Disp_1000	Winter_1000	Surv_2500	ForWet_3000	361.51	5.35	14.00	0.15	3.32	2.82	1.00	1.43	7.78	8.03	1.64	5.59	0.11	0.08	0.21	0.03
Disp_2500	Winter_500	Urban_3000	-	361.53	5.37	11.90	0.14	1.16	2.58	1.00	-	2.69	9.17	13.72	-	0.11	0.04	0.00	-
Disp_2500	Winter_500	Surv_2500	Urban_3000	361.61	5.45	12.80	0.14	1.00	2.66	2.16	1.00	2.06	10.31	2.44	12.93	0.15	0.02	0.40	0.00
Winter_3000	Surv_2500	Urban_3000	-	361.72	5.56	12.30	0.14	2.89	1.87	1.00	-	14.00	2.31	6.50	-	0.01	0.36	0.01	-
Disp_2500	Winter_3000	Urban_3000	-	361.79	5.63	11.80	0.14	1.00	2.55	1.00	-	2.35	8.93	7.80	-	0.13	0.04	0.01	-
Disp_5000	Winter_500	Surv_1000	ForWet_3000	361.89	5.73	13.40	0.15	1.74	2.35	2.57	1.00	4.47	6.55	4.27	5.98	0.13	0.10	0.28	0.01
Winter_500	Surv_2500	NatAgri_3000	-	361.99	5.83	11.90	0.13	2.67	1.70	1.00	-	12.35	3.58	13.12	-	0.01	0.18	0.00	-
Winter_3000	Urban_3000	-	-	362.00	5.84	11.40	0.13	2.85	1.00	-	-	13.98	8.48	-	-	0.01	0.00	-	-
Disp_2500	Winter_1000	NatAgri_3000	-	362.03	5.87	11.80	0.14	1.00	2.71	1.00	-	2.85	9.72	9.79	-	0.09	0.03	0.00	-
Winter_3000	Surv_1000	NatAgri_3000	-	362.11	5.95	12.40	0.14	2.66	2.39	1.00	-	11.94	2.48	5.99	-	0.01	0.50	0.01	-
Disp_1000	Winter_3000	Surv_2500	-	362.15	5.99	13.40	0.14	3.38	3.41	1.00	-	8.44	29.13	2.28	-	0.09	0.00	0.13	-
Disp_2500	Winter_1000	Surv_2500	NatAgri_3000	362.16	6.00	12.60	0.14	1.00	2.75	1.92	1.00	1.09	10.43	2.24	9.51	0.29	0.03	0.39	0.00
Disp_2500	Winter_3000	Surv_2500	Urban_3000	362.29	6.13	12.80	0.14	1.00	2.82	2.14	1.00	1.59	10.31	2.35	6.89	0.21	0.03	0.42	0.01
Disp_5000	Winter_3000	Surv_1000	NatAgri_3000	362.33	6.17	12.90	0.14	1.42	2.09	2.51	1.00	2.29	7.36	3.59	4.14	0.20	0.05	0.36	0.04
Disp_2500	Winter_1000	Surv_5000	Urban_3000	362.50	6.34	12.60	0.14	1.00	2.80	1.43	1.00	2.05	11.05	0.37	10.68	0.15	0.02	0.79	0.00
Disp_1000	Winter_500	ForWet_3000	-	362.53	6.37	13.70	0.15	3.47	2.42	1.71	-	8.68	5.90	15.13	-	0.09	0.12	0.00	-
Disp_5000	Winter_1000	Surv_2500	NatAgri_3000	362.53	6.37	12.80	0.14	1.41	2.73	1.92	1.00	1.70	10.42	2.42	7.20	0.41	0.03	0.36	0.01
Disp_5000	Winter_500	Surv_5000	Urban_3000	362.56	6.40	13.10	0.15	2.02	2.54	1.75	1.00	5.70	8.99	1.15	10.88	0.11	0.04	0.62	0.00
Disp_1000	Winter_1000	ForWet_3000	-	362.60	6.44	13.80	0.15	3.43	2.74	1.66	-	8.25	6.63	10.08	-	0.10	0.14	0.01	-
Disp_2500	Winter_3000	Surv_1000	-	362.61	6.45	12.80	0.13	1.00	3.19	2.70	-	4.77	20.35	5.89	-	0.03	0.00	0.17	-
Disp_5000	Winter_1000	Surv_1000	ForWet_3000	362.64	6.48	13.20	0.14	1.56	2.51	2.54	1.00	3.06	5.61	3.91	4.05	0.16	0.16	0.32	0.04
Disp_2500	Winter_500	Surv_2500	NatAgri_3000	362.76	6.60	12.40	0.14	1.00	2.51	2.05	1.00	1.64	9.37	2.52	12.47	0.20	0.03	0.37	0.00
Disp_1000	Winter_500	Surv_1000	ForWet_3000	362.79	6.63	14.30	0.15	3.17	2.47	2.27	1.46	4.83	6.56	1.49	11.75	0.24	0.10	0.67	0.00
Winter_1000	Surv_5000	NatAgri_3000	-	362.83	6.67	11.70	0.14	2.92	1.00	1.00	-	14.04	1.71	9.67	-	0.01	0.19	0.00	-
Disp_5000	Winter_3000	Urban_3000	-	362.85	6.69	11.90	0.14	1.68	2.32	1.00	-	2.91	7.33	7.10	-	0.26	0.06	0.01	-
Disp_5000	Winter_500	Surv_2500	NatAgri_3000	362.86	6.70	12.90	0.14	1.70	2.51	2.05	1.00	3.06	9.61	2.62	8.88	0.25	0.03	0.35	0.00
Disp_5000	Winter_1000	NatAgri_3000	-	362.93	6.77	12.10	0.14	1.67	2.71	1.00	-	3.42	9.82	7.17	-	0.20	0.03	0.01	-
Disp_1000	Winter_3000	Surv_2500	ForWet_3000	362.95	6.79	13.60	0.15	3.41	3.17	1.00	1.00	8.37	7.29	1.34	1.39	0.10	0.12	0.25	0.23
Disp_2500	Winter_3000	Surv_1000	ForWet_3000	362.99	6.83	12.90	0.13	1.00	2.81	2.60	1.00	4.18	4.70	5.56	1.91	0.04	0.31	0.18	0.17
Disp_2500	Winter_3000	Surv_2500	NatAgri_3000	362.99	6.83	12.10	0.13	1.00	2.57	2.03	1.00	1.39	8.65	2.33	5.70	0.24	0.05	0.40	0.02
Disp_5000	Winter_1000	Surv_5000	Urban_3000	363.00	6.84	13.20	0.15	1.76	2.73	1.67	1.00	3.63	10.18	0.95	9.29	0.21	0.03	0.65	0.00
Disp_1000	Winter_1000	Surv_1000	ForWet_3000	363.03	6.87	14.40	0.15	3.15	2.77	2.22	1.43	4.62	7.05	1.41	7.24	0.25	0.12	0.67	0.01
Winter_500	Surv_1000	ForWet_3000	-	363.05	6.89	12.30	0.14	2.49	2.47	1.25	-	6.96	2.60	11.93	-	0.08	0.50	0.00	-
Disp_5000	Winter_3000	Surv_2500	Urban_3000	363.06	6.90	12.80	0.14	1.43	2.61	2.10	1.00	1.28	8.80	2.29	6.02	0.36	0.04	0.41	0.01
Winter_3000	Surv_2500	NatAgri_3000	-	363.10	6.94	11.70	0.13	2.66	1.70	1.00	-	11.66	2.07	5.46	-	0.01	0.23	0.02	-
Winter_1000	Surv_1000	ForWet_3000	-	363.18	7.02	12.40	0.14	2.75	2.44	1.21	-	7.36	2.41	7.45	-	0.10	0.52	0.01	-
Disp_2500	Winter_500	NatAgri_3000	-	363.19	7.03	11.30	0.13	1.08	2.40	1.00	-	3.54	8.29	12.74	-	0.06	0.05	0.00	-

Winter_500	Surv_5000	Urban_3000	-	363.42	7.26	11.50	0.13	2.81	1.00	1.00	-	13.40	0.62	13.35	-	0.00	0.43	0.00	-
Winter_3000	Surv_5000	Urban_3000	-	363.50	7.34	11.50	0.13	2.79	1.00	1.00	-	13.64	0.48	6.80	-	0.01	0.49	0.01	-
Disp_5000	Winter_500	NatAgri_3000	-	363.52	7.36	11.90	0.14	1.92	2.42	1.00	-	5.34	8.56	8.89	-	0.11	0.04	0.00	-
Disp_2500	Winter_1000	Surv_5000	NatAgri_3000	363.87	7.71	12.00	0.14	1.00	2.71	1.19	1.00	1.62	9.98	0.72	9.37	0.20	0.03	0.64	0.00
Disp_2500	Winter_3000	NatAgri_3000	-	363.94	7.78	11.10	0.13	1.00	2.34	1.00	-	3.07	7.28	6.27	-	0.08	0.06	0.01	-
Disp_1000	ForWet_3000	-	-	363.98	7.82	11.90	0.14	3.47	1.96	-	-	8.43	27.74	-	-	0.10	0.00	-	-
Disp_2500	Winter_500	Surv_5000	Urban_3000	363.98	7.82	12.20	0.14	1.08	2.59	1.46	1.00	2.59	9.28	0.41	13.02	0.11	0.03	0.77	0.00
Winter_500	NatAgri_3000	-	-	364.00	7.84	10.60	0.13	2.69	1.00	-	-	12.79	15.36	-	-	0.01	0.00	-	-
Disp_1000	Winter_3000	ForWet_3000	-	364.02	7.86	13.40	0.15	3.50	3.18	1.20	-	8.96	6.11	2.24	-	0.08	0.19	0.14	-
Disp_1000	Winter_500	Surv_5000	ForWet_3000	364.07	7.91	13.70	0.15	3.44	2.46	1.00	1.59	8.52	6.35	0.41	12.02	0.09	0.10	0.52	0.00
Disp_5000	Winter_3000	Surv_1000	-	364.09	7.93	12.50	0.13	1.49	2.84	2.59	-	4.05	15.94	4.54	-	0.08	0.00	0.26	-
Disp_1000	Winter_3000	-	-	364.10	7.94	12.90	0.14	3.50	3.59	-	-	9.24	30.32	-	-	0.07	0.00	-	-
Disp_1000	Winter_1000	Surv_5000	ForWet_3000	364.10	7.94	13.80	0.15	3.40	2.76	1.00	1.53	8.06	7.16	0.46	6.81	0.10	0.11	0.50	0.02
Disp_1000	Winter_3000	Surv_1000	-	364.20	8.04	13.90	0.14	3.25	3.53	2.39	-	5.99	30.04	1.52	-	0.18	0.00	0.69	-
Disp_1000	Winter_3000	Surv_1000	ForWet_3000	364.25	8.09	14.10	0.15	3.26	3.23	2.32	1.00	5.56	6.85	1.47	2.16	0.20	0.15	0.68	0.14
Winter_500	Surv_5000	NatAgri_3000	-	364.33	8.17	11.10	0.13	2.62	1.00	1.00	-	12.00	2.11	13.20	-	0.01	0.14	0.00	-
Winter_3000	NatAgri_3000	-	-	364.40	8.24	10.50	0.13	2.76	1.00	-	-	13.01	6.19	-	-	0.01	0.01	-	-
Disp_2500	Winter_3000	Surv_5000	Urban_3000	364.40	8.24	12.20	0.14	1.00	2.68	1.63	1.00	2.29	9.50	0.91	7.55	0.13	0.04	0.65	0.01
Disp_5000	Winter_1000	Surv_1000	-	364.49	8.33	12.60	0.13	1.69	2.88	2.59	-	8.19	15.10	4.55	-	0.02	0.00	0.26	-
Winter_1000	Surv_2500	ForWet_3000	-	364.62	8.46	11.40	0.13	2.73	1.58	1.22	-	7.59	2.60	5.65	-	0.09	0.31	0.02	-
Disp_5000	Winter_3000	Surv_2500	NatAgri_3000	364.70	8.54	12.10	0.13	1.32	2.42	1.98	1.00	0.92	8.02	2.48	4.60	0.42	0.05	0.36	0.03
Disp_1000	Winter_3000	Surv_5000	-	364.87	8.71	13.20	0.14	3.44	3.48	1.00	-	8.65	29.12	1.33	-	0.09	0.00	0.25	-
Disp_5000	Winter_1000	Surv_5000	NatAgri_3000	364.88	8.72	12.40	0.14	1.61	2.70	1.34	1.00	2.05	10.09	1.00	7.33	0.33	0.03	0.64	0.01
Disp_2500	Winter_500	Surv_5000	NatAgri_3000	364.94	8.78	11.60	0.13	1.00	2.43	1.27	1.00	2.23	8.45	0.88	12.30	0.14	0.04	0.64	0.00
Winter_500	Surv_2500	ForWet_3000	-	364.96	8.80	11.40	0.13	2.49	1.77	1.33	-	6.87	2.35	9.67	-	0.09	0.33	0.00	-
Disp_5000	Winter_3000	Surv_1000	ForWet_3000	365.01	8.85	12.60	0.13	1.54	2.50	2.50	1.00	3.01	3.70	4.08	1.32	0.16	0.35	0.30	0.25
Disp_1000	Winter_1000	Surv_2500	-	365.06	8.90	12.50	0.13	3.22	3.33	1.00	-	6.93	26.18	3.55	-	0.12	0.00	0.06	-
Disp_2500	Winter_1000	Surv_1000	-	365.13	8.97	11.90	0.12	1.00	3.00	2.67	-	5.78	17.66	5.47	-	0.02	0.00	0.19	-
Winter_3000	Surv_5000	NatAgri_3000	-	365.16	9.00	10.90	0.13	2.62	1.00	1.00	-	11.59	1.57	5.58	-	0.01	0.21	0.02	-
Winter_3000	Surv_1000	ForWet_3000	-	365.26	9.10	11.80	0.13	2.96	2.45	1.00	-	6.16	2.56	2.57	-	0.19	0.50	0.11	-
Disp_5000	Urban_3000	-	-	365.30	9.14	10.10	0.12	2.23	1.00	-	-	9.95	13.52	-	-	0.02	0.00	-	-
Disp_1000	Winter_3000	Surv_5000	ForWet_3000	365.31	9.15	13.40	0.14	3.47	3.22	1.00	1.00	8.67	7.04	0.43	0.18	0.09	0.14	0.51	0.19
Disp_5000	Winter_3000	NatAgri_3000	-	365.32	9.16	11.10	0.13	1.63	2.15	1.00	-	3.16	6.83	4.96	-	0.21	0.07	0.03	-
Disp_5000	Winter_3000	Surv_5000	Urban_3000	365.35	9.19	12.50	0.14	1.70	2.45	1.70	1.00	3.00	7.70	1.09	6.95	0.26	0.06	0.61	0.01
Winter_3000	Surv_1000	-	-	365.51	9.35	11.40	0.12	3.31	2.48	-	-	29.80	2.67	-	-	0.00	0.50	-	-
Disp_5000	Winter_500	Surv_2500	ForWet_3000	365.52	9.36	12.20	0.13	1.71	2.38	2.04	1.03	2.93	6.36	2.05	6.18	0.27	0.11	0.43	0.01
Disp_5000	Winter_500	Surv_5000	NatAgri_3000	365.55	9.39	12.30	0.14	1.88	2.44	1.46	1.00	3.90	8.81	1.19	9.15	0.21	0.03	0.59	0.00
Winter_1000	ForWet_3000	-	-	365.60	9.44	10.80	0.13	2.72	1.47	-	-	6.86	8.08	-	-	0.12	0.01	-	-
Surv_1000	ForWet_3000	-	-	365.60	9.44	10.30	0.12	2.37	1.71	-	-	2.34	26.72	-	-	0.51	0.00	-	-
Disp_2500	Winter_1000	ForWet_3000	-	365.60	9.44	10.90	0.13	1.00	2.51	1.18	-	2.04	5.28	6.10	-	0.15	0.18	0.02	-
Disp_1000	NatAgri_3000	-	-	365.70	9.54	10.40	0.12	3.56	1.00	-	-	10.39	24.68	-	-	0.05	0.00	-	-
Winter_1000	NatAgri_3000	-	-	365.70	9.54	10.40	0.13	3.06	1.00	-	-	15.41	11.07	-	-	0.00	0.00	-	-
Disp_5000	Winter_1000	ForWet_3000	-	365.70	9.54	11.30	0.13	1.70	2.51	1.02	-	3.33	5.39	4.53	-	0.22	0.17	0.03	-
Disp_5000	Winter_500	ForWet_3000	-	365.72	9.56	11.30	0.13	1.87	2.27	1.10	-	4.14	5.42	6.58	-	0.19	0.16	0.01	-
Disp_1000	Urban_3000	-	-	365.80	9.64	10.40	0.12	3.49	1.00	-	-	8.92	23.77	-	-	0.08	0.00	-	-
Disp_5000	Winter_1000	Surv_2500	ForWet_3000	365.82	9.66	12.00	0.13	1.51	2.58	1.93	1.00	1.55	6.10	1.89	4.13	0.24	0.14	0.44	0.04
Disp_2500	Winter_500	ForWet_3000	-	365.91	9.75	10.70	0.13	1.00	2.24	1.26	-	2.20	5.01	9.29	-	0.14	0.19	0.00	-
Winter_3000	Surv_2500	-	-	365.95	9.79	10.70	0.12	3.22	1.58	-	-	27.70	3.60	-	-	0.00	0.19	-	-

Disp_5000	Winter_500	Surv_1000	-	365.97	9.81	12.20	0.13	1.99	2.57	2.64	-	12.59	12.91	5.19	-	0.00	0.01	0.20	-
Disp_2500	Urban_3000	-	-	366.00	9.84	9.11	0.11	1.08	1.00	-	-	6.49	17.99	-	-	0.01	0.00	-	-
Disp_2500	Winter_3000	Surv_5000	NatAgri_3000	366.02	9.86	11.40	0.13	1.00	2.40	1.33	1.00	1.96	7.71	0.79	6.03	0.16	0.06	0.69	0.01
Disp_2500	Winter_1000	Surv_2500	ForWet_3000	366.06	9.90	11.60	0.13	1.00	2.59	1.90	1.17	0.89	6.01	1.75	5.53	0.34	0.15	0.47	0.02
Disp_2500	Winter_500	Surv_2500	ForWet_3000	366.07	9.91	11.60	0.13	1.00	2.37	2.01	1.25	1.08	5.91	1.95	8.67	0.30	0.13	0.45	0.01
Winter_500	ForWet_3000	-	-	366.10	9.94	10.50	0.13	2.39	1.55	-	-	5.93	13.83	-	-	0.14	0.00	-	-
Disp_2500	ForWet_3000	-	-	366.50	10.34	9.41	0.11	1.00	1.58	-	-	2.99	17.86	-	-	0.08	0.00	-	-
Winter_3000	Surv_2500	ForWet_3000	-	366.64	10.48	10.90	0.12	2.95	1.68	1.00	-	6.51	2.38	1.64	-	0.16	0.31	0.20	-
Winter_1000	Surv_5000	ForWet_3000	-	366.68	10.52	10.80	0.14	2.49	2.47	1.25	-	6.96	2.60	11.93	-	0.08	0.50	0.00	-
Disp_5000	ForWet_3000	-	-	366.90	10.74	9.95	0.12	1.93	1.47	-	-	4.68	12.52	-	-	0.16	0.00	-	-
Disp_5000	Winter_3000	Surv_2500	-	367.00	10.84	11.40	0.12	1.37	3.03	2.00	-	1.65	17.17	2.36	-	0.27	0.00	0.38	-
Disp_2500	NatAgri_3000	-	-	367.10	10.94	8.85	0.11	1.10	1.00	-	-	7.27	17.67	-	-	0.01	0.00	-	-
Disp_2500	Winter_3000	Surv_2500	-	367.11	10.95	11.20	0.12	1.00	3.22	1.95	-	1.16	22.03	2.17	-	0.28	0.00	0.40	-
Winter_1000	Surv_2500	-	-	367.13	10.97	9.86	0.11	3.23	1.00	-	-	24.78	4.11	-	-	0.00	0.04	-	-
Surv_2500	ForWet_3000	-	-	367.20	11.04	9.40	0.11	1.58	1.73	-	-	2.17	23.72	-	-	0.37	0.00	-	-
Winter_500	Surv_5000	ForWet_3000	-	367.20	11.04	10.60	0.12	2.41	1.00	1.37	-	6.24	0.75	9.91	-	0.11	0.39	0.00	-
Disp_5000	Winter_3000	Surv_5000	NatAgri_3000	367.26	11.10	11.50	0.13	1.55	2.27	1.35	1.00	1.60	7.29	0.97	4.90	0.37	0.06	0.64	0.03
Disp_2500	Winter_3000	ForWet_3000	-	367.29	11.13	10.50	0.12	1.00	2.70	1.00	-	2.44	4.34	2.54	-	0.12	0.32	0.11	-
Disp_2500	Winter_1000	Surv_5000	ForWet_3000	367.30	11.14	10.90	0.13	1.00	2.54	1.00	1.10	1.36	5.60	0.17	5.50	0.25	0.16	0.68	0.02
Disp_5000	Winter_1000	Surv_5000	ForWet_3000	367.47	11.31	11.30	0.13	1.67	2.54	1.00	1.00	2.50	5.60	0.16	4.21	0.32	0.16	0.68	0.04
Disp_2500	Winter_3000	-	-	367.48	11.32	10.20	0.12	1.00	3.14	-	-	3.10	20.82	-	-	0.08	0.00	-	-
ForWet_3000	-	-	-	367.50	11.34	8.86	0.11	1.87	-	-	-	30.17	-	-	-	0.00	-	-	-
Disp_5000	Winter_500	Surv_5000	ForWet_3000	367.50	11.34	11.30	0.13	1.85	2.30	1.00	1.05	3.38	5.60	0.13	6.31	0.26	0.15	0.72	0.01
Disp_5000	NatAgri_3000	-	-	367.60	11.44	9.44	0.12	2.16	1.00	-	-	9.59	11.86	-	-	0.02	0.00	-	-
Winter_3000	ForWet_3000	-	-	367.60	11.44	10.00	0.12	2.96	1.02	-	-	5.88	3.11	-	-	0.21	0.08	-	-
Disp_2500	Winter_3000	Surv_2500	ForWet_3000	367.64	11.48	11.40	0.12	1.00	2.91	2.00	1.00	1.26	5.48	1.91	1.74	0.26	0.24	0.46	0.19
Disp_2500	Winter_500	Surv_5000	ForWet_3000	367.67	11.51	10.70	0.12	1.00	2.27	1.00	1.20	1.53	5.21	0.13	8.55	0.22	0.18	0.72	0.01
Disp_5000	Winter_1000	Surv_2500	-	367.77	11.61	11.30	0.12	1.61	2.94	1.88	-	4.36	15.80	2.12	-	0.11	0.00	0.40	-
Disp_5000	Winter_3000	-	-	367.81	11.65	10.50	0.12	1.63	2.90	-	-	4.35	15.77	-	-	0.12	0.00	-	-
Disp_2500	Winter_500	Surv_1000	-	367.84	11.68	11.00	0.11	1.00	2.62	2.75	-	8.29	14.30	6.45	-	0.00	0.00	0.13	-
Disp_5000	Winter_3000	Surv_2500	ForWet_3000	368.02	11.86	11.60	0.12	1.48	2.75	1.99	1.00	1.43	4.70	2.03	1.30	0.36	0.28	0.44	0.27
Disp_5000	Winter_1000	-	-	368.03	11.87	10.50	0.12	1.80	2.93	-	-	7.82	15.16	-	-	0.03	0.00	-	-
Disp_5000	Winter_3000	ForWet_3000	-	368.08	11.92	10.70	0.13	1.71	2.48	1.00	-	3.34	3.38	2.00	-	0.22	0.39	0.16	-
Winter_3000	Surv_5000	-	-	368.20	12.04	10.00	0.11	3.21	1.00	-	-	27.97	2.14	-	-	0.00	0.14	-	-
Disp_1000	Winter_1000	Surv_1000	-	368.33	12.17	12.50	0.12	3.15	3.39	2.20	-	4.74	25.96	1.62	-	0.24	0.00	0.62	-
Disp_1000	Winter_1000	Surv_5000	-	368.39	12.23	12.10	0.13	3.30	3.31	1.00	-	7.35	25.50	2.43	-	0.13	0.00	0.12	-
Winter_3000	-	-	-	368.45	12.29	9.55	0.11	3.36	-	-	-	32.07	-	-	-	0.00	-	-	-
Winter_3000	Surv_5000	ForWet_3000	-	368.65	12.49	10.20	0.12	2.91	1.00	1.00	-	6.12	0.91	1.84	-	0.19	0.34	0.18	-
Surv_2500	NatAgri_3000	-	-	368.70	12.54	7.95	0.10	1.00	1.00	-	-	4.36	20.60	-	-	0.04	0.00	-	-
Disp_2500	Winter_3000	Surv_5000	-	368.74	12.58	10.30	0.11	1.00	3.10	1.00	-	1.56	20.74	0.71	-	0.21	0.00	0.40	-
Winter_1000	Surv_1000	-	-	368.75	12.59	10.60	0.11	3.36	2.38	-	-	26.40	2.16	-	-	0.00	0.55	-	-
Disp_1000	Winter_1000	-	-	368.77	12.61	11.60	0.12	3.40	3.41	-	-	7.85	25.98	-	-	0.11	0.00	-	-
Surv_1000	NatAgri_3000	-	-	368.80	12.64	8.62	0.10	2.08	1.00	-	-	2.75	23.14	-	-	0.38	0.00	-	-
Surv_5000	ForWet_3000	-	-	368.98	12.82	8.90	0.11	1.00	1.76	-	-	0.43	24.47	-	-	0.51	0.00	-	-
Disp_2500	Winter_3000	Surv_5000	ForWet_3000	369.11	12.95	10.50	0.12	1.00	2.70	1.00	1.00	1.64	4.53	0.15	1.95	0.20	0.30	0.70	0.16
Disp_5000	Winter_3000	Surv_5000	-	369.14	12.98	10.60	0.12	1.53	2.91	1.00	-	1.95	16.19	0.59	-	0.29	0.00	0.44	-
Surv_1000	Urban_3000	-	-	369.20	13.04	8.57	0.10	2.24	1.00	-	-	2.03	22.05	-	-	0.55	0.00	-	-
Disp_2500	Winter_1000	Surv_2500	-	369.30	13.14	10.30	0.11	1.00	3.11	1.63	-	1.21	19.47	2.11	-	0.27	0.00	0.35	-

Surv_2500	Urban_3000	-	-	369.40	13.24	7.86	0.10	1.16	1.00	-	-	3.00	19.49	-	-	0.15	0.00	-	-
Disp_5000	Winter_1000	Surv_5000	-	369.47	13.31	10.60	0.12	1.73	2.93	1.00	-	4.89	15.44	0.56	-	0.11	0.00	0.46	-
Disp_2500	Winter_1000	-	-	369.70	13.54	9.55	0.11	1.00	3.09	-	-	4.23	18.61	-	-	0.04	0.00	-	-
Disp_5000	Winter_3000	Surv_5000	ForWet_3000	369.80	13.64	10.80	0.12	1.64	2.54	1.00	1.00	2.39	3.73	0.17	1.57	0.33	0.36	0.68	0.21
Disp_5000	Winter_500	Surv_2500	-	369.82	13.66	10.80	0.11	1.95	2.64	2.03	-	8.18	13.10	2.32	-	0.03	0.00	0.39	-
Disp_1000	Winter_500	Surv_2500	-	370.05	13.89	11.00	0.11	3.28	3.02	1.00	-	7.47	21.78	3.93	-	0.12	0.00	0.05	-
Winter_1000	Surv_5000	-	-	370.40	14.24	9.46	0.11	3.24	1.00	-	-	25.25	3.02	-	-	0.00	0.08	-	-
Disp_5000	Winter_500	-	-	370.43	14.27	9.85	0.11	2.11	2.57	-	-	12.55	11.84	-	-	0.01	0.01	-	-
Disp_2500	Winter_1000	Surv_5000	-	370.65	14.49	9.80	0.11	1.00	3.06	1.00	-	1.99	18.74	1.02	-	0.16	0.00	0.31	-
Urban_3000	-	-	-	370.80	14.64	7.32	0.09	1.00	-	-	-	25.41	-	-	-	0.00	-	-	-
Winter_1000	-	-	-	371.55	15.39	8.77	0.10	3.41	-	-	-	28.81	-	-	-	0.00	-	-	-
Disp_5000	Winter_500	Surv_5000	-	371.87	15.71	9.99	0.11	2.07	2.59	1.00	-	8.47	12.18	0.56	-	0.03	0.01	0.46	-
Surv_5000	NatAgri_3000	-	-	372.00	15.84	7.52	0.09	1.00	1.00	-	-	2.59	21.05	-	-	0.11	0.00	-	-
Surv_5000	Urban_3000	-	-	372.10	15.94	7.51	0.09	1.00	1.00	-	-	0.74	20.20	-	-	0.39	0.00	-	-
Winter_500	Surv_2500	-	-	372.14	15.98	8.41	0.09	2.94	1.00	-	-	20.54	5.06	-	-	0.00	0.02	-	-
NatAgri_3000	-	-	-	372.90	16.74	6.81	0.09	1.00	-	-	-	24.91	-	-	-	0.00	-	-	-
Disp_2500	Winter_500	Surv_2500	-	373.30	17.14	9.20	0.09	1.00	2.78	1.83	-	2.37	15.53	2.18	-	0.12	0.00	0.36	-
Disp_1000	Winter_500	Surv_5000	-	373.42	17.26	10.60	0.11	3.37	2.96	1.00	-	7.66	20.96	2.89	-	0.11	0.00	0.09	-
Disp_1000	Winter_500	Surv_1000	-	373.60	17.44	11.00	0.11	3.22	2.99	2.21	-	5.33	21.31	1.76	-	0.22	0.00	0.58	-
Disp_2500	Winter_500	-	-	373.96	17.80	8.22	0.09	1.00	2.70	-	-	6.60	14.06	-	-	0.01	0.00	-	-
Winter_500	Surv_1000	-	-	374.34	18.18	8.90	0.09	3.00	2.35	-	-	21.69	2.34	-	-	0.00	0.51	-	-
Disp_1000	Winter_500	-	-	374.40	18.24	9.94	0.10	3.46	3.00	-	-	8.61	20.95	-	-	0.09	0.00	-	-
Disp_2500	Winter_500	Surv_5000	-	374.72	18.56	8.53	0.09	1.00	2.71	1.00	-	3.26	14.40	1.16	-	0.07	0.00	0.28	-
Disp_5000	Surv_1000	-	-	374.73	18.57	8.44	0.09	2.23	2.53	-	-	20.58	4.34	-	-	0.00	0.26	-	-
Winter_500	Surv_5000	-	-	375.73	19.57	7.90	0.09	2.92	1.00	-	-	20.64	4.07	-	-	0.00	0.04	-	-
Disp_5000	-	-	-	377.86	21.70	6.56	0.08	2.41	-	-	-	22.59	-	-	-	0.00	-	-	-
Winter_500	-	-	-	378.13	21.97	6.88	0.08	3.07	-	-	-	23.39	-	-	-	0.00	-	-	-
Disp_2500	Surv_1000	-	-	378.17	22.01	6.68	0.07	1.00	2.69	-	-	14.76	6.22	-	-	0.00	0.14	-	-
Disp_5000	Surv_2500	-	-	378.36	22.20	7.10	0.07	2.26	1.85	-	-	15.73	1.76	-	-	0.00	0.46	-	-
Disp_5000	Surv_5000	-	-	379.60	23.44	6.61	0.07	2.39	1.00	-	-	16.66	0.27	-	-	0.00	0.60	-	-
Disp_2500	-	-	-	383.70	27.54	4.07	0.05	1.00	-	-	-	15.21	-	-	-	0.00	-	-	-
Disp_2500	Surv_2500	-	-	384.23	28.07	4.49	0.05	1.00	1.57	-	-	7.53	1.75	-	-	0.01	0.46	-	-
Disp_2500	Surv_5000	-	-	384.85	28.69	4.28	0.05	1.00	1.00	-	-	9.43	0.81	-	-	0.00	0.37	-	-
Disp_1000	Surv_2500	-	-	387.77	31.61	6.50	0.06	3.39	3.62	-	-	7.55	7.09	-	-	0.13	0.20	-	-
Disp_1000	Surv_5000	-	-	388.11	31.95	6.88	0.07	3.44	3.63	-	-	8.17	8.57	-	-	0.10	0.08	-	-
Surv_2500	-	-	-	388.82	32.66	2.33	0.02	1.00	-	-	-	6.98	-	-	-	0.01	-	-	-
Disp_1000	-	-	-	391.00	34.84	3.49	0.03	3.47	-	-	-	9.93	-	-	-	0.05	-	-	-
Disp_1000	Surv_1000	-	-	391.15	34.99	4.51	0.04	3.27	1.92	-	-	5.99	1.71	-	-	0.21	0.53	-	-
Surv_1000	-	-	-	392.08	35.92	2.23	0.02	1.93	-	-	-	3.43	-	-	-	0.24	-	-	-
Surv_5000	-	-	-	392.37	36.21	3.01	0.03	2.58	-	-	-	8.67	-	-	-	0.04	-	-	-

Table 3: Generalized Additive Model Results for Leopard Frog

Variable 1	Variable 2	Variable 3	Variable 4	AIC	Delta	% Variance Explained	R^2	edf 1	edf 2	edf 3	edf 4	ANOVA F 1	ANOVA F 2	ANOVA F 3	ANOVA F 4	p-value 1	p-value 2	p-value 3	p-value 4
Disp_1000	Winter_3000	Surv_1000	Urban_3000	280.71	0.00	17.80	0.16	1.00	1.00	2.73	1.00	8.50	0.03	10.54	12.72	0.00	0.86	0.03	0.00
Disp_1000	Winter_1000	Surv_1000	Urban_3000	281.63	0.92	18.80	0.17	1.00	2.43	2.70	1.00	8.85	1.65	10.12	14.49	0.00	0.62	0.03	0.00
Disp_1000	Winter_500	Surv_1000	Urban_3000	281.79	1.08	18.20	0.17	1.00	1.71	2.71	1.00	8.69	0.55	10.24	14.43	0.00	0.77	0.03	0.00
Disp_1000	Winter_3000	Surv_2500	Urban_3000	284.14	3.43	17.20	0.16	1.00	1.00	2.53	1.00	10.67	0.00	3.44	14.79	0.00	0.97	0.29	0.00
Disp_1000	Winter_1000	Surv_2500	Urban_3000	284.67	3.96	18.40	0.17	1.00	2.50	2.53	1.00	10.60	1.52	3.43	16.41	0.00	0.64	0.29	0.00
Disp_1000	Winter_500	Surv_2500	Urban_3000	285.02	4.31	17.70	0.16	1.00	1.79	2.53	1.00	10.70	0.66	3.46	16.74	0.00	0.76	0.28	0.00
Disp_2500	Winter_3000	Surv_1000	Urban_3000	286.35	5.64	17.50	0.16	2.61	1.00	2.69	1.00	5.74	0.07	10.07	9.52	0.12	0.79	0.04	0.00
Surv_1000	Urban_3000	-	-	286.60	5.89	14.40	0.13	2.24	1.00	-	-	9.26	15.05	-	-	0.09	0.00	-	-
Disp_2500	Winter_500	Surv_1000	Urban_3000	287.36	6.65	17.60	0.16	2.52	1.55	2.67	1.00	5.75	0.41	9.72	10.17	0.12	0.80	0.04	0.00
Disp_2500	Winter_1000	Surv_1000	Urban_3000	287.40	6.69	18.30	0.16	2.44	2.50	2.68	1.00	6.03	1.61	9.54	10.47	0.10	0.63	0.05	0.00
Winter_1000	Surv_1000	Urban_3000	-	288.27	7.56	14.60	0.13	1.00	2.23	1.00	-	0.38	8.68	12.22	-	0.54	0.10	0.00	-
Winter_500	Surv_1000	Urban_3000	-	288.34	7.63	14.50	0.13	1.00	2.23	1.00	-	0.31	8.74	13.12	-	0.58	0.10	0.00	-
Winter_3000	Surv_1000	Urban_3000	-	288.47	7.76	14.50	0.13	1.00	2.25	1.00	-	0.17	8.90	10.98	-	0.68	0.09	0.00	-
Disp_1000	Urban_3000	-	-	289.60	8.89	13.90	0.14	1.70	1.00	-	-	15.12	17.73	-	-	0.00	0.00	-	-
Disp_5000	Winter_1000	Surv_1000	Urban_3000	290.17	9.46	15.00	0.13	1.60	1.00	1.98	1.00	1.50	0.74	8.66	12.67	0.43	0.39	0.12	0.00
Disp_5000	Winter_500	Surv_1000	Urban_3000	290.36	9.65	14.90	0.13	1.52	1.00	2.01	1.00	0.95	0.50	8.65	13.21	0.51	0.48	0.12	0.00
Disp_5000	Winter_3000	Surv_1000	Urban_3000	290.36	9.65	15.00	0.13	1.64	1.00	1.98	1.00	1.72	0.58	8.98	11.60	0.42	0.45	0.11	0.00
Disp_1000	Winter_3000	Surv_1000	NatAgri_3000	290.89	10.18	14.60	0.12	1.00	1.00	2.69	1.00	7.27	0.24	10.18	3.31	0.00	0.62	0.03	0.07
Disp_2500	Winter_3000	Surv_2500	Urban_3000	291.04	10.33	16.60	0.16	2.70	1.00	2.46	1.00	6.70	0.01	3.22	12.71	0.08	0.93	0.33	0.00
Disp_2500	Winter_1000	Surv_2500	Urban_3000	291.19	10.48	18.00	0.16	2.65	2.76	2.48	1.00	6.81	1.78	3.29	13.99	0.08	0.59	0.31	0.00
Disp_1000	Winter_3000	Urban_3000	-	291.59	10.88	13.90	0.14	1.60	1.00	1.00	-	14.61	0.02	14.12	-	0.00	0.89	0.00	-
Disp_1000	Winter_1000	Urban_3000	-	291.71	11.00	15.40	0.15	1.70	2.73	1.00	-	14.43	1.81	15.97	-	0.00	0.59	0.00	-
Disp_1000	Winter_3000	Surv_5000	Urban_3000	291.82	11.11	15.40	0.15	1.39	1.00	2.41	1.00	14.45	0.05	3.65	13.96	0.00	0.82	0.30	0.00
Disp_1000	Winter_500	Surv_1000	NatAgri_3000	291.90	11.19	15.00	0.13	1.00	1.63	2.67	1.00	7.79	0.73	9.99	5.02	0.01	0.70	0.03	0.03
Disp_2500	Winter_500	Surv_2500	Urban_3000	291.92	11.21	17.10	0.16	2.66	1.84	2.47	1.00	6.64	0.69	3.28	13.94	0.08	0.75	0.32	0.00
Disp_1000	Winter_1000	Surv_1000	NatAgri_3000	291.94	11.23	15.10	0.13	1.00	1.77	2.67	1.00	7.76	0.64	9.88	4.72	0.01	0.71	0.03	0.03
Disp_1000	Winter_3000	Surv_1000	-	292.37	11.66	13.50	0.11	1.00	1.00	2.64	-	6.50	2.26	9.22	-	0.01	0.13	0.05	-
Disp_1000	Winter_500	Urban_3000	-	292.42	11.71	14.60	0.14	1.68	2.04	1.00	-	14.56	0.71	16.11	-	0.00	0.78	0.00	-
Disp_1000	Winter_1000	Surv_5000	Urban_3000	292.49	11.78	16.50	0.15	1.42	2.48	2.36	1.00	14.14	1.43	3.48	15.34	0.00	0.66	0.33	0.00
Disp_1000	Winter_500	Surv_5000	Urban_3000	292.60	11.89	16.00	0.15	1.37	1.88	2.39	1.00	14.45	0.72	3.56	15.71	0.00	0.76	0.31	0.00
Disp_1000	Surv_1000	-	-	292.70	11.99	12.80	0.11	1.00	2.67	-	-	8.22	10.01	-	-	0.00	0.03	-	-
Surv_2500	Urban_3000	-	-	292.90	12.19	13.30	0.13	2.22	1.18	-	-	4.34	16.53	-	-	0.27	0.00	-	-
Disp_2500	Surv_1000	-	-	293.20	12.49	14.10	0.12	2.44	2.81	-	-	10.56	12.29	-	-	0.01	0.02	-	-
Disp_1000	Winter_1000	Surv_1000	-	293.26	12.55	13.20	0.11	1.00	1.00	2.61	-	6.77	1.43	8.76	-	0.01	0.23	0.05	-
Disp_1000	Winter_500	Surv_1000	-	293.65	12.94	13.10	0.11	1.00	1.00	2.62	-	7.62	1.04	9.03	-	0.01	0.31	0.05	-
Disp_2500	Winter_3000	Surv_1000	NatAgri_3000	294.16	13.45	15.10	0.13	2.60	1.00	2.73	1.00	6.90	0.09	11.10	2.07	0.08	0.76	0.03	0.15
Winter_500	Surv_2500	Urban_3000	-	294.19	13.48	13.80	0.13	1.00	2.24	1.37	-	0.87	3.94	15.00	-	0.35	0.31	0.00	-
Disp_1000	Winter_3000	Surv_1000	ForWet_3000	294.21	13.50	13.60	0.11	1.00	1.00	2.66	1.00	6.74	0.31	9.38	0.13	0.01	0.58	0.04	0.72
Disp_2500	Winter_3000	Surv_1000	-	294.43	13.72	14.20	0.12	2.32	1.00	2.74	-	7.60	0.98	10.96	-	0.06	0.32	0.03	-
Disp_2500	Winter_1000	Surv_1000	-	294.71	14.00	14.00	0.12	2.26	1.00	2.70	-	8.39	0.73	10.65	-	0.05	0.39	0.03	-
Winter_3000	Surv_2500	Urban_3000	-	294.75	14.04	13.60	0.12	1.00	2.22	1.42	-	0.42	4.17	13.32	-	0.51	0.29	0.00	-
Disp_2500	Winter_500	Surv_1000	-	294.89	14.18	14.00	0.12	2.23	1.00	2.70	-	9.01	0.51	11.07	-	0.03	0.48	0.03	-
Disp_2500	Winter_500	Surv_1000	NatAgri_3000	294.98	14.27	15.30	0.13	2.54	1.56	2.70	1.00	7.39	0.62	10.90	2.80	0.06	0.75	0.03	0.09
Disp_1000	Winter_500	Surv_1000	ForWet_3000	295.01	14.30	13.70	0.11	1.00	1.30	2.66	1.00	7.23	0.43	9.44	1.41	0.01	0.81	0.04	0.24
Winter_1000	Surv_2500	Urban_3000	-	295.07	14.36	14.90	0.13	2.56	2.22	1.40	-	1.62	4.04	14.66	-	0.60	0.30	0.00	-
Disp_1000	Winter_1000	Surv_1000	ForWet_3000	295.09	14.38	13.80	0.11	1.00	1.38	2.65	1.00	7.07	0.50	9.28	1.06	0.01	0.80	0.04	0.30

Disp_2500	Winter_1000	Surv_1000	NatAgri_3000	295.11	14.40	15.50	0.13	2.52	1.81	2.72	1.00	7.32	0.56	10.71	2.74	0.06	0.74	0.03	0.10
Disp_5000	Winter_500	Surv_2500	Urban_3000	296.16	15.45	14.20	0.13	1.42	1.00	2.14	1.46	0.57	1.04	4.47	15.36	0.58	0.31	0.27	0.00
Surv_1000	NatAgri_3000	-	-	296.30	15.59	11.50	0.09	2.27	1.01	-	-	11.00	5.80	-	-	0.05	0.02	-	-
Disp_2500	Winter_3000	Surv_1000	ForWet_3000	296.39	15.68	14.20	0.12	2.33	1.00	2.75	1.00	7.72	0.52	10.97	0.03	0.06	0.47	0.03	0.86
Disp_5000	Winter_3000	Surv_2500	Urban_3000	296.56	15.85	14.30	0.12	1.52	1.00	2.04	1.60	1.07	0.91	5.10	13.09	0.47	0.34	0.21	0.00
Disp_5000	Winter_1000	Surv_2500	Urban_3000	296.92	16.21	15.40	0.13	1.41	2.55	2.09	1.53	0.59	1.90	4.67	14.95	0.56	0.54	0.24	0.00
Winter_1000	Surv_1000	NatAgri_3000	-	297.20	16.49	11.80	0.09	1.00	2.25	1.00	-	1.10	9.77	3.70	-	0.29	0.08	0.06	-
Disp_2500	Winter_500	Surv_1000	ForWet_3000	297.22	16.51	14.20	0.11	2.28	1.24	2.75	1.03	7.94	0.40	11.00	0.27	0.06	0.80	0.03	0.64
Disp_2500	Winter_1000	Surv_1000	ForWet_3000	297.28	16.57	14.30	0.11	2.28	1.36	2.74	1.00	7.84	0.59	10.69	0.15	0.06	0.76	0.03	0.71
Disp_1000	Winter_3000	Surv_2500	NatAgri_3000	297.39	16.68	13.10	0.11	1.00	1.00	2.39	1.00	8.40	0.66	2.54	3.11	0.00	0.42	0.43	0.08
Winter_500	Surv_1000	NatAgri_3000	-	297.44	16.73	11.70	0.09	1.00	2.25	1.00	-	0.85	9.97	4.44	-	0.35	0.07	0.04	-
Winter_3000	Surv_1000	NatAgri_3000	-	297.57	16.86	12.00	0.09	1.00	2.28	1.22	-	1.07	9.92	3.23	-	0.30	0.06	0.16	-
Winter_3000	Surv_1000	-	-	297.90	17.19	11.00	0.09	1.00	2.23	-	-	3.84	9.95	-	-	0.05	0.07	-	-
Disp_1000	Winter_1000	Surv_2500	NatAgri_3000	298.08	17.37	13.60	0.11	1.00	1.73	2.39	1.00	8.39	1.05	2.53	4.47	0.00	0.59	0.43	0.03
Disp_1000	Winter_500	Surv_2500	NatAgri_3000	298.25	17.54	13.50	0.11	1.00	1.69	2.40	1.00	8.78	1.07	2.49	5.06	0.00	0.60	0.44	0.03
Disp_1000	Winter_3000	Surv_2500	-	298.62	17.91	12.00	0.09	1.00	1.00	2.29	-	6.91	3.15	2.45	-	0.01	0.08	0.46	-
Winter_1000	Surv_1000	-	-	298.99	18.28	10.60	0.08	1.00	2.18	-	-	2.83	9.77	-	-	0.09	0.08	-	-
Surv_1000	ForWet_3000	-	-	299.00	18.29	10.60	0.08	2.25	1.00	-	-	10.30	2.98	-	-	0.07	0.08	-	-
Disp_2500	Winter_1000	Surv_5000	Urban_3000	299.29	18.58	14.40	0.14	1.00	2.80	2.57	1.00	7.14	1.82	4.15	13.07	0.01	0.59	0.26	0.00
Disp_1000	Winter_1000	Surv_2500	-	299.32	18.61	11.80	0.09	1.00	1.00	2.27	-	6.47	2.45	2.45	-	0.01	0.12	0.47	-
Disp_2500	Urban_3000	-	-	299.50	18.79	11.40	0.13	2.45	1.00	-	-	9.89	14.62	-	-	0.02	0.00	-	-
Disp_2500	Winter_3000	Surv_5000	Urban_3000	299.54	18.83	12.80	0.13	1.00	1.00	2.58	1.00	6.78	0.03	4.26	11.85	0.01	0.85	0.25	0.00
Disp_5000	Winter_1000	Surv_1000	NatAgri_3000	299.60	18.89	12.20	0.09	1.55	1.00	2.13	1.02	0.73	1.30	9.07	3.68	0.63	0.26	0.10	0.06
Disp_5000	Winter_500	Surv_1000	NatAgri_3000	299.85	19.14	12.00	0.09	1.45	1.00	2.16	1.00	0.41	0.93	9.15	4.01	0.72	0.33	0.09	0.05
Winter_3000	Surv_1000	ForWet_3000	-	299.92	19.21	11.00	0.08	1.00	2.24	1.00	-	1.11	9.92	0.00	-	0.29	0.08	0.97	-
Disp_5000	Winter_3000	Surv_1000	NatAgri_3000	299.96	19.25	12.50	0.10	1.60	1.00	2.21	1.32	1.05	1.46	9.39	3.61	0.56	0.23	0.09	0.16
Winter_500	Surv_1000	-	-	299.97	19.26	10.30	0.08	1.00	2.18	-	-	1.97	10.10	-	-	0.16	0.08	-	-
Disp_2500	Winter_500	Surv_5000	Urban_3000	300.01	19.30	13.50	0.13	1.00	1.87	2.58	1.00	7.07	0.91	4.25	13.01	0.01	0.69	0.24	0.00
Disp_1000	Winter_500	Surv_2500	-	300.18	19.47	11.50	0.09	1.00	1.00	2.26	-	6.83	1.75	2.38	-	0.01	0.19	0.48	-
Surv_1000	-	-	-	300.20	19.49	9.62	0.07	2.70	-	-	-	11.76	-	-	-	0.05	-	-	-
Disp_1000	Surv_2500	-	-	300.20	19.49	10.90	0.08	1.00	2.25	-	-	7.92	2.57	-	-	0.00	0.47	-	-
Winter_1000	Surv_1000	ForWet_3000	-	300.20	19.49	10.90	0.08	1.00	2.22	1.00	-	0.84	9.54	0.74	-	0.35	0.08	0.39	-
Disp_5000	Winter_3000	Surv_1000	-	300.21	19.50	11.40	0.09	1.48	1.00	2.23	-	0.69	3.04	8.63	-	0.70	0.08	0.09	-
Winter_500	Surv_1000	ForWet_3000	-	300.46	19.75	10.80	0.08	1.00	2.23	1.00	-	0.57	9.66	1.41	-	0.45	0.08	0.23	-
Disp_5000	Surv_1000	-	-	300.50	19.79	10.30	0.08	1.00	2.39	-	-	1.40	9.24	-	-	0.24	0.04	-	-
Disp_1000	Winter_3000	Surv_2500	ForWet_3000	300.62	19.91	12.00	0.09	1.00	1.00	2.29	1.00	6.71	0.93	2.42	0.00	0.01	0.33	0.46	0.97
Disp_1000	Winter_1000	Surv_2500	ForWet_3000	300.68	19.97	12.00	0.09	1.00	1.00	2.31	1.00	6.92	0.84	2.30	0.59	0.01	0.36	0.48	0.44
Disp_5000	Winter_1000	Surv_1000	-	300.84	20.13	11.00	0.08	1.27	1.00	2.26	-	0.73	2.11	8.06	-	0.68	0.14	0.08	-
Disp_2500	Winter_1000	Urban_3000	-	301.02	20.31	13.20	0.13	2.30	2.96	1.00	-	9.33	2.36	13.69	-	0.02	0.53	0.00	-
Disp_5000	Winter_500	Surv_1000	-	301.19	20.48	10.70	0.08	1.05	1.00	2.31	-	0.74	1.41	8.19	-	0.45	0.23	0.07	-
Disp_1000	Winter_500	Surv_2500	ForWet_3000	301.30	20.59	12.00	0.09	1.00	1.15	2.32	1.00	7.39	0.75	2.22	1.17	0.01	0.56	0.49	0.28
Disp_2500	Winter_500	Urban_3000	-	301.53	20.82	11.10	0.12	1.00	2.04	1.00	-	7.73	0.82	13.27	-	0.01	0.75	0.00	-
Disp_2500	Winter_3000	Urban_3000	-	301.53	20.82	11.40	0.12	2.46	1.00	1.00	-	9.07	0.00	12.42	-	0.03	0.99	0.00	-
Disp_5000	Winter_3000	Surv_1000	ForWet_3000	302.21	21.50	11.40	0.08	1.48	1.00	2.24	1.00	0.72	1.27	8.50	0.00	0.69	0.26	0.08	0.95
Disp_1000	NatAgri_3000	-	-	302.30	21.59	9.99	0.09	1.63	1.00	-	-	17.79	5.96	-	-	0.00	0.02	-	-
Disp_5000	Winter_1000	Surv_1000	ForWet_3000	302.49	21.78	11.20	0.08	1.36	1.00	2.22	1.00	0.41	0.88	8.23	0.49	0.79	0.35	0.10	0.48
Surv_5000	Urban_3000	-	-	302.50	21.79	9.86	0.10	1.51	1.00	-	-	4.69	13.32	-	-	0.12	0.00	-	-
Disp_5000	Winter_500	Surv_1000	ForWet_3000	302.68	21.97	11.00	0.08	1.26	1.00	2.24	1.00	0.27	0.58	8.35	0.92	0.85	0.45	0.09	0.34
Disp_1000	Winter_3000	Surv_5000	-	302.91	22.20	10.30	0.08	1.53	1.00	1.00	-	9.62	2.55	2.76	-	0.01	0.22	0.10	-
Disp_2500	Winter_3000	Surv_2500	NatAgri_3000	302.94	22.23	12.60	0.10	2.47	1.00	2.30	1.00	5.71	0.56	3.06	2.02	0.12	0.46	0.34	0.16

Disp_2500	Winter_1000	Surv_2500	-	303.16	22.45	11.50	0.09	1.95	1.00	2.25	-	4.77	2.20	3.13	-	0.16	0.14	0.35	-
Disp_1000	Winter_1000	Surv_5000	-	303.19	22.48	10.20	0.08	1.49	1.00	1.00	-	9.31	2.13	2.96	-	0.01	0.14	0.09	-
Disp_2500	Winter_3000	Surv_2500	-	303.22	22.51	11.60	0.09	2.09	1.00	2.24	-	4.85	2.23	3.21	-	0.18	0.14	0.34	-
Disp_2500	Winter_1000	Surv_2500	NatAgri_3000	303.46	22.75	13.30	0.11	2.36	2.00	2.33	1.00	6.29	1.10	3.01	2.98	0.10	0.62	0.34	0.08
Disp_2500	Surv_2500	-	-	303.50	22.79	11.10	0.09	2.38	2.22	-	-	7.54	3.24	-	-	0.06	0.34	-	-
Winter_500	Surv_5000	Urban_3000	-	303.57	22.86	10.60	0.11	1.00	1.72	1.35	-	1.39	3.94	12.67	-	0.24	0.17	0.00	-
Disp_2500	Winter_500	Surv_2500	NatAgri_3000	303.59	22.88	13.00	0.11	2.37	1.66	2.30	1.00	6.45	1.14	2.97	3.28	0.10	0.57	0.34	0.07
Disp_1000	Surv_5000	-	-	303.70	22.99	9.40	0.08	1.48	1.00	-	-	11.13	3.36	-	-	0.01	0.07	-	-
Disp_1000	Winter_500	Surv_5000	-	303.73	23.02	9.99	0.08	1.48	1.00	1.00	-	9.63	1.67	2.99	-	0.01	0.20	0.08	-
Disp_1000	Winter_3000	NatAgri_3000	-	303.77	23.06	10.40	0.09	1.64	1.00	1.23	-	15.40	0.75	3.71	-	0.00	0.29	0.13	-
Disp_1000	Winter_3000	Surv_5000	NatAgri_3000	303.84	23.13	11.40	0.09	1.50	1.00	1.89	1.00	11.53	0.78	2.66	2.52	0.00	0.38	0.38	0.11
Disp_2500	Winter_500	Surv_2500	-	303.94	23.23	11.20	0.09	1.81	1.00	2.24	-	4.84	1.62	3.03	-	0.13	0.20	0.36	-
Winter_3000	Surv_2500	-	-	304.10	23.39	9.42	0.07	1.00	1.85	-	-	4.10	7.87	-	-	0.04	0.05	-	-
Disp_1000	Winter_3000	-	-	304.30	23.59	9.20	0.09	1.49	1.00	-	-	16.78	3.22	-	-	0.00	0.07	-	-
Winter_1000	Surv_2500	-	-	304.30	23.59	9.36	0.07	1.00	1.82	-	-	3.70	8.08	-	-	0.05	0.05	-	-
Disp_1000	Winter_500	NatAgri_3000	-	304.31	23.60	10.80	0.10	1.63	1.82	1.04	-	16.31	1.13	5.02	-	0.00	0.62	0.03	-
Winter_1000	Surv_2500	NatAgri_3000	-	304.32	23.61	10.40	0.08	1.00	2.04	1.21	-	2.24	6.16	2.96	-	0.13	0.14	0.18	-
Winter_1000	Surv_5000	Urban_3000	-	304.36	23.65	11.80	0.11	2.70	1.66	1.34	-	1.95	3.88	12.41	-	0.54	0.16	0.00	-
Disp_1000	Winter_1000	NatAgri_3000	-	304.40	23.69	11.00	0.10	1.66	1.98	1.07	-	15.92	0.93	4.67	-	0.00	0.66	0.04	-
Winter_3000	Surv_5000	Urban_3000	-	304.43	23.72	10.40	0.10	1.00	1.73	1.41	-	0.75	4.06	11.33	-	0.39	0.17	0.01	-
Disp_1000	Winter_1000	Surv_5000	NatAgri_3000	304.54	23.83	12.00	0.10	1.50	1.73	1.89	1.00	11.45	1.09	2.62	3.66	0.01	0.57	0.38	0.06
Disp_1000	Winter_500	Surv_5000	NatAgri_3000	304.65	23.94	11.90	0.10	1.49	1.73	1.89	1.00	11.83	1.17	2.58	4.14	0.00	0.59	0.39	0.04
Disp_1000	Winter_3000	Surv_5000	ForWet_3000	304.81	24.10	10.30	0.08	1.53	1.00	1.00	1.00	9.30	1.28	2.72	0.09	0.01	0.26	0.10	0.76
Winter_500	Surv_2500	NatAgri_3000	-	304.85	24.14	10.10	0.08	1.00	2.02	1.16	-	1.77	6.25	3.52	-	0.18	0.13	0.11	-
Disp_1000	Winter_1000	-	-	304.90	24.19	8.99	0.08	1.44	1.00	-	-	16.94	2.52	-	-	0.00	0.11	-	-
Disp_1000	ForWet_3000	-	-	304.90	24.19	9.04	0.08	1.49	1.00	-	-	17.12	2.97	-	-	0.00	0.09	-	-
Surv_2500	NatAgri_3000	-	-	304.90	24.19	9.44	0.08	1.93	1.15	-	-	7.31	4.73	-	-	0.08	0.06	-	-
Disp_2500	Winter_3000	Surv_2500	ForWet_3000	305.03	24.32	11.60	0.09	2.09	1.00	2.22	1.00	4.81	1.49	3.36	0.20	0.18	0.22	0.33	0.66
Winter_3000	Surv_2500	NatAgri_3000	-	305.10	24.39	10.30	0.08	1.00	2.01	1.38	-	1.87	6.23	2.43	-	0.17	0.13	0.33	-
Disp_2500	Winter_1000	Surv_2500	ForWet_3000	305.10	24.39	11.60	0.09	1.99	1.00	2.25	1.00	4.75	1.38	3.09	0.04	0.16	0.24	0.35	0.84
Surv_2500	-	-	-	305.30	24.59	7.63	0.06	1.00	-	-	-	11.92	-	-	-	0.00	-	-	-
Winter_500	Surv_2500	-	-	305.40	24.69	8.91	0.07	1.00	1.70	-	-	2.71	8.40	-	-	0.10	0.03	-	-
Disp_5000	Winter_500	Surv_5000	Urban_3000	305.46	24.75	10.80	0.10	1.33	1.00	1.42	1.40	0.26	1.49	4.84	12.50	0.72	0.22	0.13	0.00
Disp_1000	Winter_500	-	-	305.50	24.79	8.81	0.08	1.44	1.00	-	-	17.70	2.03	-	-	0.00	0.15	-	-
Disp_1000	Winter_1000	Surv_5000	ForWet_3000	305.55	24.84	10.40	0.08	1.48	1.00	1.00	1.35	9.58	0.98	2.51	0.57	0.01	0.32	0.11	0.76
Disp_5000	Winter_1000	Surv_5000	Urban_3000	305.68	24.97	12.00	0.11	1.28	2.77	1.17	1.45	0.33	2.25	4.72	12.35	0.65	0.49	0.07	0.00
Urban_3000	-	-	-	305.70	24.99	7.66	0.09	1.00	-	-	-	24.16	-	-	-	0.00	-	-	-
Disp_2500	Winter_500	Surv_2500	ForWet_3000	305.76	25.05	11.30	0.08	1.88	1.00	2.25	1.05	4.65	0.97	2.96	0.30	0.15	0.32	0.37	0.67
Winter_500	Urban_3000	-	-	305.80	25.09	8.25	0.10	1.00	1.00	-	-	1.58	19.14	-	-	0.21	0.00	-	-
Winter_3000	Surv_2500	ForWet_3000	-	305.82	25.11	9.47	0.07	1.00	1.78	1.00	-	2.44	8.12	0.28	-	0.12	0.04	0.59	-
Disp_1000	Winter_500	Surv_5000	ForWet_3000	305.86	25.15	10.40	0.08	1.48	1.00	1.00	1.41	9.91	0.79	2.42	1.06	0.01	0.37	0.12	0.63
Disp_1000	-	-	-	305.90	25.19	8.04	0.07	1.41	-	-	-	20.77	-	-	-	0.00	-	-	-
Disp_1000	Winter_1000	ForWet_3000	-	306.01	25.30	9.29	0.08	1.47	1.00	1.00	-	16.08	0.76	0.91	-	0.00	0.38	0.34	-
Disp_5000	Winter_3000	Surv_5000	Urban_3000	306.02	25.31	10.70	0.10	1.46	1.00	1.27	1.51	0.62	1.09	5.13	11.04	0.59	0.30	0.08	0.01
Winter_1000	Surv_2500	ForWet_3000	-	306.19	25.48	9.43	0.07	1.00	1.87	1.00	-	2.01	7.38	0.13	-	0.16	0.07	0.71	-
Disp_1000	Winter_3000	ForWet_3000	-	306.23	25.52	9.24	0.08	1.40	1.00	1.00	-	16.56	0.61	0.12	-	0.00	0.43	0.73	-
Disp_5000	Winter_3000	Surv_2500	-	306.23	25.52	9.89	0.07	1.60	1.00	1.71	-	1.00	4.24	6.72	-	0.58	0.04	0.07	-
Disp_5000	Winter_1000	Surv_2500	NatAgri_3000	306.44	25.73	10.90	0.08	1.56	1.00	1.91	1.27	0.90	2.50	6.11	3.40	0.57	0.11	0.14	0.16
Surv_2500	ForWet_3000	-	-	306.50	25.79	8.65	0.06	1.78	1.00	-	-	7.62	2.12	-	-	0.05	0.15	-	-
Winter_1000	Urban_3000	-	-	306.60	25.89	9.60	0.10	2.86	1.00	-	-	2.26	18.06	-	-	0.51	0.00	-	-

Disp_5000	Winter_1000	Surv_2500	-	306.63	25.92	9.76	0.07	1.45	1.00	1.86	-	0.50	3.59	6.25	-	0.74	0.06	0.12	-
Disp_5000	Winter_3000	Surv_2500	NatAgri_3000	306.94	26.23	10.90	0.08	1.61	1.00	1.77	1.59	1.46	2.43	6.44	2.94	0.48	0.12	0.09	0.28
Winter_500	Surv_2500	ForWet_3000	-	306.95	26.24	9.18	0.06	1.00	1.85	1.01	-	1.41	7.22	0.59	-	0.23	0.07	0.45	-
Winter_3000	Urban_3000	-	-	306.98	26.27	8.01	0.09	1.00	1.11	-	-	0.90	16.72	-	-	0.24	0.00	-	-
Disp_1000	Winter_500	ForWet_3000	-	307.05	26.34	9.53	0.08	1.48	1.53	1.00	-	16.41	1.04	1.56	-	0.00	0.64	0.21	-
Disp_5000	Winter_500	Surv_2500	NatAgri_3000	307.11	26.40	10.50	0.08	1.44	1.00	1.93	1.21	0.43	0.19	5.90	3.80	0.69	0.17	0.15	0.11
Disp_5000	Urban_3000	-	-	307.40	26.69	7.77	0.09	1.00	1.00	-	-	0.36	17.06	-	-	0.55	0.00	-	-
Disp_5000	Winter_500	Urban_3000	-	307.68	26.97	8.29	0.09	1.00	1.00	1.00	-	0.15	1.41	14.82	-	0.70	0.24	0.00	-
Disp_5000	Winter_500	Surv_2500	-	307.74	27.03	9.24	0.06	1.24	1.00	1.89	-	0.27	2.57	5.96	-	0.86	0.11	0.14	-
Disp_5000	Winter_3000	Surv_2500	ForWet_3000	307.97	27.26	10.00	0.07	1.63	1.00	1.70	1.00	1.10	2.71	6.84	0.26	0.58	0.10	0.06	0.61
Disp_2500	Surv_5000	-	-	308.30	27.59	7.49	0.06	1.00	1.00	-	-	6.06	4.28	-	-	0.01	0.04	-	-
Disp_5000	Winter_1000	Surv_2500	ForWet_3000	308.49	27.78	9.83	0.07	1.48	1.00	1.85	1.00	0.53	2.11	6.23	0.16	0.71	0.15	0.12	0.69
Disp_5000	Surv_2500	-	-	308.50	27.79	8.14	0.06	1.05	1.83	-	-	0.32	6.52	-	-	0.66	0.10	-	-
Disp_5000	Winter_1000	Urban_3000	-	308.54	27.83	9.62	0.10	1.00	2.83	1.00	-	0.12	2.05	13.87	-	0.73	0.55	0.00	-
Disp_2500	Winter_1000	Surv_5000	-	308.59	27.88	8.45	0.07	1.00	1.00	1.41	-	4.28	2.19	4.50	-	0.04	0.14	0.13	-
Disp_5000	Winter_3000	Urban_3000	-	308.71	28.00	8.00	0.09	1.00	1.00	1.00	-	0.12	0.66	13.55	-	0.73	0.42	0.00	-
Disp_2500	Winter_500	Surv_5000	-	308.82	28.11	8.27	0.07	1.00	1.00	1.30	-	4.60	1.82	4.56	-	0.03	0.18	0.11	-
Disp_2500	Winter_3000	Surv_5000	-	309.07	28.36	8.36	0.07	1.00	1.00	1.47	-	4.11	2.02	4.47	-	0.04	0.16	0.14	-
Disp_5000	Winter_500	Surv_2500	ForWet_3000	309.25	28.54	9.49	0.06	1.36	1.00	1.86	1.00	0.25	1.43	6.01	0.60	0.81	0.23	0.13	0.45
Disp_2500	Winter_3000	Surv_5000	ForWet_3000	309.66	28.95	8.29	0.07	1.00	1.00	1.00	1.00	3.78	1.89	4.35	0.56	0.05	0.17	0.04	0.46
Winter_1000	Surv_5000	-	-	309.80	29.09	7.01	0.06	1.00	1.00	-	-	3.85	8.58	-	-	0.05	0.00	-	-
Winter_3000	Surv_5000	-	-	310.00	29.29	6.96	0.06	1.00	1.00	-	-	3.99	8.24	-	-	0.05	0.00	-	-
Disp_2500	Winter_3000	Surv_5000	NatAgri_3000	310.23	29.52	9.03	0.08	1.00	1.00	1.93	1.02	4.78	0.81	3.94	1.37	0.03	0.36	0.24	0.25
Disp_2500	Winter_500	Surv_5000	NatAgri_3000	310.51	29.80	9.64	0.08	1.00	1.65	2.00	1.00	5.94	1.48	3.91	2.39	0.02	0.49	0.26	0.12
Disp_2500	Winter_1000	Surv_5000	NatAgri_3000	310.53	29.82	10.10	0.08	1.00	2.21	1.99	1.00	5.38	1.42	3.94	2.20	0.02	0.59	0.26	0.14
Winter_500	Surv_5000	-	-	310.70	29.99	6.74	0.06	1.00	1.00	-	-	3.14	8.99	-	-	0.08	0.00	-	-
Winter_1000	Surv_5000	NatAgri_3000	-	310.78	30.07	7.81	0.07	1.00	1.00	1.46	-	2.55	6.60	2.58	-	0.11	0.01	0.33	-
Winter_500	Surv_5000	NatAgri_3000	-	311.19	30.48	7.65	0.07	1.00	1.00	1.42	-	2.19	6.74	3.04	-	0.14	0.01	0.26	-
Disp_2500	Winter_500	Surv_5000	ForWet_3000	311.32	30.61	8.53	0.07	1.00	1.00	1.31	1.38	4.54	1.35	4.41	0.40	0.03	0.25	0.12	0.81
Disp_2500	Winter_1000	-	-	311.40	30.69	6.53	0.07	1.00	1.00	-	-	11.79	2.30	-	-	0.00	0.13	-	-
Winter_3000	Surv_5000	NatAgri_3000	-	311.45	30.74	7.72	0.06	1.00	1.00	1.59	-	2.22	6.49	2.10	-	0.14	0.01	0.40	-
Winter_3000	Surv_5000	ForWet_3000	-	311.52	30.81	7.11	0.06	1.00	1.00	1.00	-	2.82	8.24	0.51	-	0.09	0.00	0.47	-
Disp_2500	NatAgri_3000	-	-	311.60	30.89	8.12	0.08	2.60	1.25	-	-	13.80	4.11	-	-	0.00	0.11	-	-
Disp_2500	Winter_500	-	-	311.80	31.09	6.42	0.06	1.00	1.00	-	-	12.97	1.97	-	-	0.00	0.16	-	-
Disp_2500	Winter_3000	-	-	311.80	31.09	6.43	0.07	1.00	1.00	-	-	10.91	2.19	-	-	0.00	0.14	-	-
Surv_5000	NatAgri_3000	-	-	311.80	31.09	6.87	0.06	1.00	1.44	-	-	7.52	4.45	-	-	0.01	0.14	-	-
Winter_1000	Surv_5000	ForWet_3000	-	311.82	31.11	7.02	0.06	1.00	1.00	1.00	-	2.37	7.57	0.02	-	0.12	0.00	0.89	-
Disp_2500	Winter_1000	Surv_5000	ForWet_3000	312.09	31.38	9.54	0.07	1.00	2.50	1.20	1.40	4.52	1.90	4.31	0.36	0.03	0.56	0.09	0.80
Disp_5000	Winter_1000	Surv_5000	-	312.28	31.57	7.29	0.06	1.38	1.00	1.00	-	0.33	3.65	6.70	-	0.79	0.06	0.01	-
Disp_5000	Winter_3000	Surv_5000	-	312.41	31.70	7.37	0.06	1.52	1.00	1.00	-	0.61	3.96	6.94	-	0.67	0.05	0.01	-
Surv_5000	-	-	-	312.50	31.79	5.58	0.05	1.00	-	-	-	10.83	-	-	-	0.00	-	-	-
Disp_2500	Winter_3000	NatAgri_3000	-	312.62	31.91	7.23	0.07	1.00	1.00	1.44	-	8.70	0.86	2.64	-	0.00	0.35	0.23	-
Winter_500	Surv_5000	ForWet_3000	-	312.62	31.91	6.87	0.05	1.00	1.00	1.09	-	1.88	7.43	0.36	-	0.17	0.01	0.69	-
Disp_2500	ForWet_3000	-	-	312.70	31.99	6.15	0.06	1.00	1.00	-	-	11.02	1.47	-	-	0.00	0.23	-	-
Disp_2500	-	-	-	312.80	32.09	6.67	0.07	2.33	-	-	-	18.05	-	-	-	0.00	-	-	-
Surv_5000	ForWet_3000	-	-	312.80	32.09	6.20	0.05	1.00	1.08	-	-	7.53	2.01	-	-	0.01	0.21	-	-
Disp_2500	Winter_1000	NatAgri_3000	-	312.83	32.12	8.21	0.08	1.00	2.37	1.24	-	10.00	1.75	3.07	-	0.00	0.61	0.18	-
Disp_2500	Winter_500	NatAgri_3000	-	312.89	32.18	7.77	0.07	1.00	1.80	1.25	-	10.23	1.37	3.33	-	0.00	0.54	0.16	-
Disp_5000	Winter_500	Surv_5000	-	312.95	32.24	6.87	0.05	1.17	1.00	1.00	-	0.15	2.90	6.57	-	0.91	0.09	0.01	-
Disp_5000	Winter_1000	Surv_5000	NatAgri_3000	313.05	32.34	8.27	0.07	1.42	1.00	1.00	1.56	0.42	0.10	6.16	2.89	0.67	0.10	0.01	0.28

Disp_5000	Winter_500	Surv_5000	NatAgri_3000	313.48	32.77	7.95	0.06	1.28	1.00	1.00	1.51	0.16	2.29	6.08	3.25	0.78	0.13	0.01	0.24
Disp_5000	Winter_3000	Surv_5000	NatAgri_3000	313.53	32.82	8.29	0.06	1.48	1.00	1.00	1.71	0.68	2.70	6.25	2.44	0.58	0.10	0.01	0.33
Disp_2500	Winter_3000	ForWet_3000	-	313.76	33.05	6.53	0.06	1.00	1.00	1.00	-	10.54	0.84	0.00	-	0.00	0.36	0.99	-
Disp_5000	Winter_3000	Surv_5000	ForWet_3000	313.92	33.21	7.56	0.06	1.56	1.00	1.00	1.00	0.77	3.04	7.15	0.51	0.65	0.08	0.01	0.48
Disp_5000	Surv_5000	-	-	314.20	33.49	5.68	0.05	1.00	1.00	-	-	0.33	6.91	-	-	0.57	0.01	-	-
Disp_5000	Winter_1000	Surv_5000	ForWet_3000	314.34	33.63	7.33	0.05	1.41	1.00	1.00	1.04	0.35	2.43	6.52	0.04	0.78	0.12	0.01	0.93
Disp_2500	Winter_500	ForWet_3000	-	314.36	33.65	6.88	0.06	1.00	1.63	1.00	-	10.54	1.26	0.56	-	0.00	0.53	0.45	-
Disp_2500	Winter_1000	ForWet_3000	-	314.43	33.72	7.54	0.06	1.00	2.47	1.00	-	10.57	1.61	0.40	-	0.00	0.62	0.53	-
Disp_5000	Winter_500	Surv_5000	ForWet_3000	315.12	34.41	7.10	0.05	1.28	1.00	1.00	1.15	0.17	1.89	6.31	0.41	0.87	0.17	0.01	0.75
Winter_1000	NatAgri_3000	-	-	318.30	37.59	5.38	0.05	1.00	2.07	-	-	3.56	8.13	-	-	0.06	0.04	-	-
Winter_3000	NatAgri_3000	-	-	318.60	37.89	5.35	0.05	1.00	2.16	-	-	3.65	7.39	-	-	0.06	0.06	-	-
Winter_500	NatAgri_3000	-	-	319.00	38.29	5.14	0.05	1.00	2.05	-	-	3.00	9.11	-	-	0.08	0.02	-	-
Disp_5000	Winter_1000	NatAgri_3000	-	319.76	39.05	5.45	0.05	1.00	1.00	1.94	-	0.63	2.93	4.70	-	0.42	0.09	0.14	-
Disp_5000	Winter_3000	NatAgri_3000	-	320.29	39.58	5.37	0.05	1.00	1.00	2.05	-	0.41	2.77	4.85	-	0.52	0.10	0.16	-
Disp_5000	Winter_500	NatAgri_3000	-	320.30	39.59	5.25	0.05	1.00	1.00	1.89	-	0.84	2.52	4.87	-	0.36	0.11	0.13	-
Disp_5000	Winter_1000	-	-	320.40	39.69	3.79	0.04	1.00	1.00	-	-	3.51	3.77	-	-	0.06	0.05	-	-
NatAgri_3000	-	-	-	320.80	40.09	4.01	0.04	2.59	-	-	-	12.72	-	-	-	0.01	-	-	-
Disp_5000	Winter_3000	-	-	320.80	40.09	3.67	0.04	1.00	1.00	-	-	2.53	3.87	-	-	0.11	0.05	-	-
Disp_5000	Winter_500	-	-	321.20	40.49	3.54	0.03	1.00	1.00	-	-	4.45	3.16	-	-	0.03	0.08	-	-
Winter_3000	-	-	-	321.30	40.59	2.90	0.03	1.00	-	-	-	7.71	-	-	-	0.01	-	-	-
Disp_5000	NatAgri_3000	-	-	321.50	40.79	4.27	0.04	1.00	1.88	-	-	1.58	5.73	-	-	0.21	0.08	-	-
Winter_1000	-	-	-	321.80	41.09	2.73	0.02	1.00	-	-	-	6.55	-	-	-	0.01	-	-	-
Winter_1000	ForWet_3000	-	-	321.80	41.09	3.36	0.03	1.00	1.00	-	-	2.05	2.00	-	-	0.15	0.16	-	-
Disp_5000	Winter_1000	ForWet_3000	-	321.92	41.21	3.93	0.03	1.00	1.00	1.00	-	1.88	2.01	0.46	-	0.17	0.16	0.50	-
Winter_500	ForWet_3000	-	-	322.10	41.39	3.27	0.03	1.00	1.00	-	-	1.80	3.32	-	-	0.18	0.07	-	-
ForWet_3000	-	-	-	322.20	41.49	2.60	0.02	1.00	-	-	-	7.76	-	-	-	0.01	-	-	-
Disp_5000	Winter_500	ForWet_3000	-	322.22	41.51	3.84	0.03	1.00	1.00	1.00	-	1.88	1.77	0.94	-	0.17	0.18	0.33	-
Disp_5000	ForWet_3000	-	-	322.30	41.59	3.19	0.03	1.00	1.00	-	-	1.93	2.78	-	-	0.17	0.10	-	-
Disp_5000	Winter_3000	ForWet_3000	-	322.76	42.05	3.67	0.03	1.00	1.00	1.00	-	2.09	1.44	0.01	-	0.15	0.23	0.93	-
Winter_3000	ForWet_3000	-	-	322.80	42.09	3.04	0.03	1.00	1.00	-	-	1.29	0.43	-	-	0.26	0.51	-	-
Disp_5000	-	-	-	323.30	42.59	2.29	0.02	1.00	-	-	-	7.54	-	-	-	0.01	-	-	-
Winter_500	-	-	-	323.60	42.89	2.19	0.02	1.00	-	-	-	5.21	-	-	-	0.02	-	-	-

Table 4: Generalized Additive Model Results for American Toad

Variable 1	Variable 2	Variable 3	Variable 4	AIC	Delta	% Variance Explained	R^2	edf 1	edf 2	edf 3	edf 4	ANOVA F 1	ANOVA F 2	ANOVA F 3	ANOVA F 4	p-value 1	p-value 2	p-value 3	p-value 4
NatAgri_3000	-	-	-	209.10	0.00	4.75	0.03	2.70	-	-	-	7.96	-	-	-	0.07	-	-	-
Surv_2500	NatAgri_3000	-	-	209.12	0.02	7.58	0.04	2.38	2.79	-	-	3.79	9.16	-	-	0.29	0.05	-	-
Winter_500	Surv_2500	NatAgri_3000	-	209.35	0.25	8.50	0.04	1.00	2.45	2.78	-	1.48	4.56	8.83	-	0.22	0.22	0.05	-
Urban_3000	-	-	-	209.50	0.40	5.64	0.03	4.51	-	-	-	8.98	-	-	-	0.09	-	-	-
Winter_500	NatAgri_3000	-	-	209.90	0.80	5.21	0.03	1.00	2.62	-	-	1.03	7.03	-	-	0.31	0.10	-	-
Surv_2500	Urban_3000	-	-	210.00	0.90	7.94	0.04	2.27	3.55	-	-	2.89	9.35	-	-	0.41	0.07	-	-
Winter_1000	Urban_3000	-	-	210.10	1.00	8.88	0.04	3.03	3.57	-	-	2.46	8.64	-	-	0.51	0.10	-	-
Winter_1000	Surv_1000	Urban_3000	-	210.10	1.00	11.30	0.06	3.09	2.01	3.63	-	2.91	1.08	9.34	-	0.46	0.72	0.08	-
Winter_500	Surv_2500	Urban_3000	-	210.11	1.01	8.89	0.04	1.00	2.34	3.52	-	1.57	3.32	9.07	-	0.21	0.35	0.08	-
Surv_1000	Urban_3000	-	-	210.13	1.03	7.60	0.04	1.95	3.65	-	-	0.87	8.72	-	-	0.74	0.09	-	-
Disp_5000	NatAgri_3000	-	-	210.40	1.30	6.38	0.03	1.72	2.91	-	-	1.58	7.73	-	-	0.44	0.06	-	-
Winter_1000	Surv_2500	Urban_3000	-	210.40	1.30	11.40	0.06	3.04	2.29	3.53	-	2.49	3.14	9.24	-	0.52	0.37	0.08	-
Winter_1000	NatAgri_3000	-	-	210.52	1.42	7.37	0.04	2.86	2.63	-	-	1.85	6.98	-	-	0.60	0.10	-	-
Winter_1000	Surv_2500	NatAgri_3000	-	210.54	1.44	10.30	0.05	2.83	2.40	2.74	-	1.72	3.90	8.41	-	0.63	0.28	0.06	-
Disp_2500	NatAgri_3000	-	-	210.61	1.51	5.09	0.03	1.00	2.80	-	-	0.32	8.42	-	-	0.57	0.07	-	-
Disp_5000	Winter_500	NatAgri_3000	-	210.74	1.64	7.22	0.03	1.79	1.00	2.87	-	2.15	1.36	7.47	-	0.34	0.24	0.07	-
Disp_1000	NatAgri_3000	-	-	210.78	1.68	4.78	0.02	1.00	2.62	-	-	0.35	6.47	-	-	0.55	0.12	-	-
Disp_2500	Winter_3000	Surv_1000	Urban_3000	210.81	1.71	8.05	0.03	1.00	1.00	1.00	3.89	1.75	0.13	2.20	10.73	0.19	0.72	0.14	0.06
Disp_2500	Winter_1000	Surv_1000	Urban_3000	210.92	1.82	11.70	0.05	1.00	3.04	1.77	3.75	0.87	2.62	1.32	10.31	0.35	0.48	0.61	0.06
Surv_5000	NatAgri_3000	-	-	210.97	1.87	4.82	0.02	1.00	2.72	-	-	0.03	7.63	-	-	0.86	0.08	-	-
Disp_5000	Winter_500	Surv_2500	NatAgri_3000	210.97	1.87	9.90	0.05	1.81	1.00	2.38	2.86	1.63	1.59	3.33	7.64	0.46	0.21	0.34	0.07
Disp_1000	Urban_3000	-	-	210.98	1.88	5.75	0.03	1.00	3.52	-	-	0.67	7.32	-	-	0.41	0.13	-	-
Disp_2500	Winter_500	NatAgri_3000	-	210.99	1.89	5.82	0.03	1.00	1.00	2.78	-	0.73	1.39	8.21	-	0.39	0.25	0.07	-
Disp_5000	Winter_1000	Surv_1000	Urban_3000	211.06	1.96	13.00	0.07	1.81	3.06	1.88	3.81	2.19	2.69	1.20	9.82	0.36	0.48	0.68	0.07
Surv_1000	NatAgri_3000	-	-	211.07	1.97	6.09	0.03	2.01	2.66	-	-	0.79	6.89	-	-	0.83	0.11	-	-
Disp_5000	Winter_500	Surv_2500	Urban_3000	211.11	2.01	10.80	0.06	1.92	1.00	2.28	3.60	2.29	1.74	2.69	8.97	0.37	0.19	0.42	0.09
Winter_500	Urban_3000	-	-	211.13	2.03	7.81	0.04	2.49	3.59	-	-	1.10	8.78	-	-	0.74	0.09	-	-
Disp_1000	Winter_1000	Surv_2500	NatAgri_3000	211.16	2.06	11.10	0.06	1.00	2.80	2.53	2.70	1.54	1.71	5.67	8.21	0.22	0.64	0.15	0.07
Winter_500	Surv_1000	Urban_3000	-	211.22	2.12	10.40	0.05	2.68	2.02	3.67	-	1.30	1.03	9.60	-	0.69	0.74	0.07	-
Disp_5000	Urban_3000	-	-	211.30	2.20	6.91	0.04	1.69	3.74	-	-	1.30	8.89	-	-	0.51	0.10	-	-
Disp_2500	Urban_3000	-	-	211.35	2.25	5.75	0.03	1.00	3.67	-	-	0.09	8.54	-	-	0.77	0.09	-	-
Surv_5000	Urban_3000	-	-	211.37	2.27	5.70	0.03	1.00	3.64	-	-	0.13	8.73	-	-	0.72	0.10	-	-
Disp_1000	Winter_500	Surv_2500	NatAgri_3000	211.45	2.35	9.78	0.05	1.00	1.76	2.56	2.77	1.41	1.00	6.05	8.49	0.23	0.64	0.13	0.06
Disp_2500	Winter_500	Surv_1000	Urban_3000	211.47	2.37	11.00	0.05	1.00	2.69	1.73	3.80	1.29	1.57	1.40	10.86	0.26	0.63	0.56	0.05
Disp_2500	Winter_500	Surv_2500	NatAgri_3000	211.60	2.50	8.86	0.04	1.30	1.00	2.40	2.88	0.23	1.46	3.54	8.66	0.87	0.22	0.32	0.05
Disp_5000	Winter_1000	Urban_3000	-	211.61	2.51	10.30	0.05	1.67	3.02	3.72	-	1.51	2.45	8.99	-	0.47	0.51	0.09	-
Disp_5000	Winter_500	Surv_1000	Urban_3000	211.71	2.61	12.40	0.06	1.88	2.69	1.89	3.86	2.60	1.51	1.17	10.14	0.31	0.65	0.69	0.07
Winter_500	Surv_5000	NatAgri_3000	-	211.77	2.67	5.31	0.02	1.00	1.00	2.66	-	1.05	0.07	7.01	-	0.31	0.80	0.10	-
Disp_5000	Winter_1000	Surv_2500	Urban_3000	211.77	2.67	12.90	0.07	1.85	2.98	2.24	3.67	1.88	2.25	2.62	8.95	0.45	0.55	0.43	0.09
Disp_1000	Winter_1000	Surv_2500	Urban_3000	211.79	2.69	11.60	0.06	1.00	3.02	2.41	3.36	1.03	2.36	4.05	8.52	0.31	0.54	0.27	0.10
Disp_5000	Winter_1000	NatAgri_3000	-	211.81	2.71	9.00	0.04	1.72	2.81	2.84	-	1.67	1.76	7.04	-	0.43	0.62	0.08	-
Winter_500	Surv_1000	NatAgri_3000	-	211.81	2.71	6.80	0.03	1.00	2.11	2.66	-	1.10	1.09	6.75	-	0.30	0.79	0.12	-
Disp_1000	Winter_1000	Urban_3000	-	211.83	2.73	8.91	0.04	1.00	3.02	3.49	-	0.49	2.45	7.73	-	0.50	0.51	0.13	-
Disp_2500	Winter_1000	Urban_3000	-	211.85	2.75	9.05	0.04	1.00	3.03	3.62	-	0.15	2.44	8.85	-	0.70	0.51	0.09	-
Disp_1000	Winter_1000	Surv_1000	Urban_3000	211.90	2.80	11.40	0.06	1.00	3.10	2.11	3.50	0.28	2.97	0.95	8.56	0.60	0.46	0.66	0.10

Winter_3000	NatAgri_3000	-	-	211.95	2.85	5.59	0.03	1.80	2.73	-	-	0.92	8.49	-	-	0.66	0.06	-	-
Winter_1000	Surv_5000	Urban_3000	-	211.96	2.86	8.96	0.04	3.03	1.00	3.59	-	2.47	0.12	8.54	-	0.51	0.73	0.10	-
Disp_2500	Winter_500	Surv_2500	Urban_3000	211.98	2.88	9.17	0.04	1.13	1.00	2.26	3.59	0.24	1.62	2.61	8.90	0.82	0.20	0.43	0.08
Winter_1000	Surv_1000	NatAgri_3000	-	212.05	2.95	9.09	0.04	2.92	2.04	2.64	-	2.07	1.01	6.50	-	0.57	0.79	0.13	-
Disp_2500	Winter_1000	NatAgri_3000	-	212.07	2.97	7.69	0.04	1.00	2.83	1.74	-	0.33	1.73	7.60	-	0.56	0.62	0.09	-
Winter_3000	Surv_2500	NatAgri_3000	-	212.09	2.99	8.22	0.04	1.69	2.37	2.80	-	0.67	3.58	9.58	-	0.72	0.31	0.04	-
Disp_5000	Winter_500	Surv_1000	NatAgri_3000	212.13	3.03	9.04	0.03	1.93	1.00	1.90	2.95	2.75	1.29	0.71	7.08	0.28	0.26	0.80	0.09
Disp_1000	Winter_3000	Surv_2500	NatAgri_3000	212.22	3.12	9.59	0.05	1.00	1.89	2.53	2.80	2.09	1.08	5.66	9.48	0.15	0.63	0.15	0.04
Disp_2500	Winter_1000	Surv_2500	Urban_3000	212.22	3.12	11.40	0.05	1.00	3.04	2.24	3.50	0.03	2.48	2.70	8.84	0.87	0.53	0.42	0.08
Disp_5000	Winter_500	Urban_3000	-	212.32	3.22	9.53	0.05	1.76	2.52	3.74	-	1.80	1.34	9.17	-	0.42	0.69	0.09	-
Disp_1000	Winter_1000	NatAgri_3000	-	212.33	3.23	7.38	0.03	1.00	2.80	2.56	-	0.29	1.93	5.89	-	0.59	0.56	0.15	-
Disp_2500	Winter_500	Surv_1000	NatAgri_3000	212.33	3.23	7.55	0.03	1.12	1.00	1.78	2.84	1.10	1.30	0.80	7.19	0.31	0.25	0.75	0.08
Disp_5000	Winter_1000	Surv_2500	NatAgri_3000	212.41	3.31	11.40	0.05	1.75	2.75	2.33	2.78	1.34	1.62	3.13	7.99	0.52	0.65	0.37	0.08
Winter_1000	Surv_5000	NatAgri_3000	-	212.44	3.34	7.46	0.03	2.87	1.00	2.65	-	1.85	0.03	6.80	-	0.61	0.86	0.11	-
Winter_500	-	-	-	212.50	3.40	0.90	0.00	1.00	-	-	-	1.47	-	-	-	0.23	-	-	-
Winter_3000	Urban_3000	-	-	212.50	3.40	6.37	0.03	1.74	3.69	-	-	0.65	9.40	-	-	0.75	0.08	-	-
Winter_1000	-	-	-	212.60	3.50	3.42	0.01	3.02	-	-	-	2.50	-	-	-	0.50	-	-	-
Disp_5000	Winter_3000	Surv_1000	Urban_3000	212.67	3.57	9.74	0.04	1.91	1.00	1.81	3.90	2.49	0.17	1.35	9.75	0.32	0.68	0.62	0.08
Disp_2500	Winter_500	Urban_3000	-	212.69	3.59	8.11	0.03	1.00	2.50	3.66	-	0.29	1.23	9.22	-	0.59	0.71	0.08	-
Disp_5000	Winter_500	Surv_5000	NatAgri_3000	212.69	3.59	7.30	0.03	1.83	1.00	1.00	2.87	2.18	1.36	0.04	7.15	0.34	0.24	0.84	0.08
Disp_1000	-	-	-	212.70	3.60	0.80	0.00	1.00	-	-	-	1.55	-	-	-	0.21	-	-	-
Disp_1000	Winter_500	Surv_2500	Urban_3000	212.80	3.70	10.40	0.05	1.00	2.33	2.44	3.40	1.06	1.07	4.23	8.12	0.30	0.78	0.25	0.10
Disp_2500	Winter_1000	Surv_2500	NatAgri_3000	212.80	3.70	10.50	0.05	1.22	2.82	2.38	2.73	0.05	1.69	3.52	8.11	0.93	0.64	0.32	0.07
Disp_1000	Winter_500	Urban_3000	-	212.88	3.78	7.85	0.03	1.00	2.49	3.52	-	0.38	0.98	7.95	-	0.54	0.78	0.12	-
Winter_3000	Surv_2500	Urban_3000	-	212.93	3.83	8.48	0.04	1.58	2.27	3.60	-	0.51	2.78	9.60	-	0.76	0.42	0.07	-
Disp_5000	Winter_1000	Surv_5000	Urban_3000	212.95	3.85	10.80	0.05	1.77	3.02	1.00	3.78	2.01	2.54	0.48	9.24	0.37	0.49	0.49	0.09
Disp_2500	Winter_500	Surv_5000	NatAgri_3000	212.98	3.88	5.82	0.02	1.00	1.00	1.00	2.78	0.67	1.30	0.01	7.97	0.41	0.25	0.94	0.07
Disp_5000	Winter_1000	Surv_1000	NatAgri_3000	212.98	3.88	10.90	0.05	1.86	2.82	1.88	1.90	2.18	1.80	0.76	6.55	0.36	0.61	0.79	0.10
Winter_500	Surv_5000	Urban_3000	-	213.03	3.93	7.86	0.03	2.49	1.00	3.60	-	1.09	0.08	8.70	-	0.74	0.77	0.10	-
Surv_1000	-	-	-	213.05	3.95	1.72	0.00	1.78	-	-	-	1.06	-	-	-	0.64	-	-	-
Disp_1000	Winter_500	Surv_1000	Urban_3000	213.07	3.97	10.50	0.05	1.00	2.67	2.10	3.60	0.20	1.24	0.88	8.89	0.65	0.71	0.70	0.09
Winter_500	ForWet_3000	-	-	213.10	4.00	1.55	0.00	1.00	1.00	-	-	2.28	1.41	-	-	0.13	0.24	-	-
Winter_3000	Surv_1000	Urban_3000	-	213.11	4.01	8.41	0.04	1.75	1.96	3.72	-	0.69	0.87	9.59	-	0.72	0.64	0.08	-
Disp_2500	Winter_1000	Surv_1000	NatAgri_3000	213.13	4.03	9.38	0.04	1.00	2.83	1.83	2.80	0.66	1.78	0.75	7.56	0.41	0.61	0.76	0.97
Disp_1000	Surv_2500	-	-	213.17	4.07	3.29	0.01	1.00	2.35	-	-	2.15	3.56	-	-	0.14	0.32	-	-
Disp_5000	Winter_3000	Surv_2500	Urban_3000	213.22	4.12	9.77	0.05	1.90	1.00	2.24	3.72	1.97	0.07	2.52	8.95	0.42	0.79	0.45	0.09
Disp_1000	Winter_500	NatAgri_3000	-	213.29	4.19	6.09	0.02	1.00	2.12	2.56	-	0.18	0.78	6.09	-	0.68	0.77	0.13	-
Surv_2500	-	-	-	213.30	4.20	2.02	0.00	2.74	-	-	-	2.09	-	-	-	0.50	-	-	-
Winter_500	Surv_2500	-	-	213.32	4.22	3.09	0.01	1.00	2.25	-	-	1.66	2.54	-	-	0.20	0.45	-	-
Disp_5000	Winter_3000	NatAgri_3000	-	213.38	4.28	6.83	0.03	1.72	1.54	2.92	-	1.32	0.47	7.81	-	0.50	0.77	0.06	-
Disp_2500	Winter_1000	Surv_5000	Urban_3000	213.45	4.35	9.27	0.04	1.00	3.00	1.00	3.66	0.35	2.44	0.30	9.04	0.55	0.51	0.59	0.09
Disp_1000	Winter_1000	-	-	213.50	4.40	3.93	0.01	1.00	2.99	-	-	1.20	2.44	-	-	0.27	0.51	-	-
Disp_1000	Winter_3000	NatAgri_3000	-	213.56	4.46	5.78	0.02	1.00	1.89	2.62	-	0.58	1.22	7.00	-	0.44	0.60	0.10	-
Disp_1000	Winter_1000	Surv_1000	NatAgri_3000	213.57	4.47	9.45	0.04	1.00	2.93	2.17	2.61	0.52	2.18	1.04	6.09	0.47	0.56	0.66	0.14
Disp_1000	Winter_500	Surv_2500	-	213.59	4.49	4.10	0.01	1.00	1.00	2.40	-	1.72	1.31	3.98	-	0.19	0.25	0.27	-
Winter_1000	Surv_1000	-	-	213.60	4.50	5.18	0.01	3.04	1.88	-	-	2.63	0.91	-	-	0.48	0.71	-	-
Disp_2500	Winter_3000	NatAgri_3000	-	213.62	4.52	5.75	0.03	1.00	1.72	2.81	-	0.17	0.72	8.62	-	0.68	0.72	0.06	-
Disp_1000	Winter_500	ForWet_3000	-	213.66	4.56	2.23	0.00	1.00	1.00	1.00	-	1.38	1.88	1.92	-	0.24	0.17	0.17	-

Winter_1000	Surv_2500	-	-	213.70	4.60	5.47	0.02	3.03	2.20	-	-	2.53	2.31	-	-	0.50	0.47	-	-
Winter_1000	ForWet_3000	-	-	213.70	4.60	3.85	0.01	3.00	1.00	-	-	2.97	1.00	-	-	0.42	0.32	-	-
Disp_5000	Winter_500	Surv_5000	Urban_3000	213.74	4.64	9.93	0.04	1.85	2.49	1.00	3.80	2.29	1.40	0.43	9.37	0.34	0.67	0.51	0.08
Winter_500	Surv_1000	-	-	213.76	4.66	2.49	0.00	1.00	1.91	-	-	1.16	0.86	-	-	0.28	0.75	-	-
Disp_5000	Winter_1000	Surv_5000	NatAgri_3000	213.76	4.66	9.07	0.04	1.76	2.81	1.00	2.84	1.72	1.75	0.04	6.70	0.42	0.62	0.85	0.09
Winter_500	Surv_2500	ForWet_3000	-	213.82	4.72	3.74	0.01	1.00	2.20	1.00	-	2.52	2.16	1.50	-	0.11	0.50	0.22	-
Winter_3000	Surv_1000	NatAgri_3000	-	213.82	4.72	7.02	0.03	1.82	1.94	2.70	-	1.03	0.76	7.56	-	0.62	0.82	0.09	-
Disp_1000	Winter_1000	Surv_5000	Urban_3000	213.84	4.74	8.98	0.04	1.00	3.00	1.00	3.52	0.39	2.47	0.00	7.81	0.58	0.51	1.00	0.13
Disp_5000	Winter_3000	Urban_3000	-	213.89	4.79	7.46	0.04	1.74	1.41	3.81	-	1.32	0.41	9.14	-	0.51	0.82	0.09	-
Winter_3000	Surv_5000	NatAgri_3000	-	213.93	4.83	5.64	0.02	1.82	1.00	2.74	-	0.90	0.02	8.11	-	0.67	0.89	0.07	-
Disp_5000	Winter_3000	Surv_2500	NatAgri_3000	213.95	4.85	9.25	0.04	1.72	1.58	2.34	2.85	1.19	0.54	3.05	8.69	0.55	0.76	0.38	0.06
Surv_5000	-	-	-	213.97	4.87	0.18	0.00	1.00	-	-	-	0.35	-	-	-	0.55	-	-	-
Winter_500	Surv_1000	ForWet_3000	-	213.97	4.87	3.26	0.00	1.00	1.85	1.00	-	2.08	0.96	1.75	-	0.15	0.60	0.19	-
Disp_1000	Winter_3000	Surv_2500	Urban_3000	214.04	4.94	9.05	0.04	1.00	1.76	2.42	3.35	1.54	0.72	4.03	8.31	0.21	0.72	0.27	0.09
Disp_1000	Winter_3000	Urban_3000	-	214.05	4.95	6.59	0.03	1.00	1.84	3.55	-	0.81	0.85	8.11	-	0.37	0.70	0.12	-
Disp_2500	Winter_1000	Surv_5000	NatAgri_3000	214.05	4.95	7.70	0.03	1.00	2.83	1.00	2.74	0.30	1.73	0.00	7.42	0.58	0.62	0.97	0.09
Disp_1000	Winter_1000	Surv_5000	NatAgri_3000	214.11	5.01	7.63	0.03	1.03	2.87	1.00	2.61	0.50	1.95	0.24	6.29	0.51	0.59	0.63	0.13
Disp_1000	Winter_1000	Surv_2500	-	214.12	5.02	6.40	0.02	1.00	3.00	2.35	-	1.80	2.29	3.63	-	0.18	0.54	0.31	-
Disp_1000	ForWet_3000	-	-	214.13	5.03	1.06	0.00	1.00	1.00	-	-	1.95	0.60	-	-	0.16	0.44	-	-
Disp_2500	-	-	-	214.20	5.10	0.07	0.00	1.00	-	-	-	0.14	-	-	-	0.71	-	-	-
Disp_5000	-	-	-	214.20	5.10	1.14	0.00	2.14	-	-	-	1.42	-	-	-	0.48	-	-	-
ForWet_3000	-	-	-	214.20	5.10	0.08	0.00	1.00	-	-	-	0.17	-	-	-	0.68	-	-	-
Disp_1000	Winter_500	Surv_2500	ForWet_3000	214.23	5.13	4.69	0.02	1.00	1.00	2.35	1.00	1.62	2.06	3.23	1.38	0.20	0.15	0.36	0.24
Disp_5000	Winter_500	-	-	214.25	5.15	2.18	0.00	1.80	1.00	-	-	1.60	1.51	-	-	0.46	0.22	-	-
Winter_500	Surv_5000	-	-	214.27	5.17	0.99	0.00	1.00	1.00	-	-	1.35	0.18	-	-	0.25	0.67	-	-
Winter_500	Surv_5000	ForWet_3000	-	214.28	5.18	1.94	0.00	1.00	1.00	1.00	-	2.41	0.73	2.05	-	0.12	0.29	0.15	-
Disp_2500	Winter_500	Surv_5000	Urban_3000	214.31	5.21	8.27	0.03	1.00	2.46	1.00	3.68	0.53	1.30	0.30	9.30	0.46	0.68	0.58	0.08
Disp_1000	Winter_1000	ForWet_3000	-	214.34	5.24	4.48	0.01	1.00	2.97	1.00	-	1.45	2.59	1.27	-	0.23	0.48	0.26	-
Disp_2500	Winter_3000	Urban_3000	-	214.36	5.26	6.43	0.03	1.00	1.68	3.73	-	0.06	0.59	9.30	-	0.81	0.76	0.09	-
Winter_3000	-	-	-	214.40	5.30	0.00	0.00	1.00	-	-	-	0.00	-	-	-	1.00	-	-	-
Disp_5000	Surv_2500	-	-	214.40	5.30	3.77	0.01	1.84	2.84	-	-	2.34	2.63	-	-	0.33	0.42	-	-
Winter_1000	Surv_5000	-	-	214.40	5.30	3.53	0.01	3.01	1.00	-	-	2.48	0.24	-	-	0.50	0.63	-	-
Winter_1000	Surv_1000	ForWet_3000	-	214.40	5.30	5.66	0.01	3.00	1.85	1.00	-	2.92	0.98	1.21	-	0.43	0.67	0.27	-
Disp_5000	Winter_500	Surv_2500	-	214.43	5.33	4.86	0.02	1.91	1.00	2.27	-	2.45	1.60	2.74	-	0.34	0.21	0.41	-
Disp_1000	Surv_1000	-	-	214.44	5.34	2.39	0.00	1.00	2.09	-	-	0.79	0.74	-	-	0.38	0.75	-	-
Winter_3000	Surv_5000	Urban_3000	-	214.44	5.34	6.44	0.03	1.75	1.00	3.69	-	0.65	0.11	9.11	-	0.74	0.74	0.09	-
Disp_5000	Winter_3000	Surv_1000	NatAgri_3000	214.45	5.35	8.64	0.03	1.90	1.52	1.79	2.97	2.01	0.44	0.85	7.34	0.38	0.77	0.72	0.08
Disp_2500	Winter_500	-	-	214.46	5.36	0.90	0.00	1.00	1.00	-	-	0.00	1.37	-	-	0.99	0.24	-	-
Disp_5000	Winter_500	Surv_2500	ForWet_3000	214.48	5.38	5.75	0.02	1.85	1.00	2.31	1.00	2.94	2.58	3.03	2.03	0.26	0.11	0.38	0.15
Disp_5000	Winter_3000	Surv_5000	Urban_3000	214.49	5.39	7.64	0.03	1.85	1.00	1.00	3.86	1.94	0.14	0.45	9.29	0.39	0.71	0.50	0.09
Disp_5000	Surv_1000	-	-	214.50	5.40	3.21	0.01	1.89	1.75	-	-	1.85	1.22	-	-	0.42	0.61	-	-
Surv_1000	ForWet_3000	-	-	214.50	5.40	1.88	0.00	1.71	1.00	-	-	1.26	0.45	-	-	0.56	0.50	-	-
Disp_2500	Winter_3000	Surv_2500	NatAgri_3000	214.51	5.41	8.80	0.04	1.47	1.73	2.37	2.77	0.28	0.72	3.44	8.94	0.81	0.71	0.33	0.05
Winter_1000	Surv_2500	ForWet_3000	-	214.55	5.45	5.99	0.20	3.01	2.17	1.00	-	3.18	2.14	1.21	-	0.40	0.49	0.27	-
Disp_1000	Winter_3000	-	-	214.60	5.50	0.83	0.00	1.00	1.00	-	-	1.66	0.12	-	-	0.19	0.73	-	-
Disp_2500	Winter_1000	-	-	214.63	5.53	3.45	0.01	1.00	3.03	-	-	0.06	2.53	-	-	0.81	0.50	-	-
Disp_1000	Surv_5000	-	-	214.72	5.62	0.78	0.00	1.00	1.00	-	-	1.21	0.00	-	-	0.27	0.98	-	-
Disp_2500	Winter_3000	Surv_1000	NatAgri_3000	214.75	5.65	7.45	0.03	1.17	1.68	1.69	2.86	0.56	0.73	0.92	8.59	0.51	0.70	0.65	0.07

Disp_5000	Winter_1000	-	-	214.76	5.66	4.39	0.01	1.71	2.96	-	-	1.33	2.22	-	-	0.52	0.54	-	-
Disp_1000	Winter_1000	Surv_1000	-	214.78	5.68	5.83	0.02	1.00	3.05	2.10	-	0.83	2.73	0.89	-	0.36	0.47	0.69	-
Disp_5000	Winter_500	ForWet_3000	-	214.79	5.69	2.76	0.01	1.71	1.00	1.00	-	1.63	2.25	1.55	-	0.43	0.13	0.21	-
Disp_1000	Winter_500	Surv_1000	NatAgri_3000	214.84	5.74	7.92	0.03	1.00	2.06	2.20	2.62	0.43	0.89	1.05	5.35	0.51	0.73	0.68	0.13
Disp_1000	Winter_500	Surv_5000	Urban_3000	214.85	5.75	7.90	0.03	1.00	2.50	1.00	3.50	0.29	0.98	0.00	8.01	0.59	0.77	1.00	0.12
Disp_2500	Winter_500	ForWet_3000	-	214.94	5.84	1.62	0.00	1.00	1.00	1.00	-	0.15	2.13	1.57	-	0.70	0.14	0.21	-
Disp_5000	Winter_500	Surv_1000	-	214.97	5.87	4.09	0.01	1.93	1.00	1.81	-	2.21	1.30	1.05	-	0.37	0.25	0.68	-
Disp_1000	Winter_500	-	-	214.98	5.88	2.24	0.00	1.00	2.09	-	-	1.05	0.87	-	-	0.31	0.76	-	-
Winter_3000	Surv_1000	-	-	214.98	5.88	1.72	0.00	1.00	1.76	-	-	0.04	1.09	-	-	0.85	0.63	-	-
Winter_1000	Surv_5000	ForWet_3000	-	214.98	5.88	4.18	0.01	2.97	1.00	1.00	-	3.01	0.70	1.54	-	0.41	0.40	0.22	-
Disp_1000	Winter_500	Surv_5000	NatAgri_3000	214.99	5.89	6.44	0.02	1.00	2.24	1.00	2.61	0.35	0.84	0.25	6.47	0.56	0.79	0.62	0.12
Disp_1000	Winter_3000	Surv_1000	Urban_3000	215.01	5.91	8.60	0.04	1.00	1.82	2.09	3.62	0.33	0.77	0.77	8.72	0.57	0.71	0.74	0.10
Disp_2500	Surv_1000	-	-	215.08	5.98	2.49	0.00	1.59	1.68	-	-	0.70	1.25	-	-	0.68	0.56	-	-
Disp_2500	Surv_2500	-	-	215.09	5.99	3.43	0.01	1.80	2.25	-	-	1.82	2.78	-	-	0.54	0.40	-	-
Surv_2500	ForWet_3000	-	-	215.10	6.00	2.10	0.00	2.13	1.00	-	-	0.94	0.21	-	-	0.52	0.65	-	-
Disp_1000	Winter_3000	Surv_2500	-	215.12	6.02	3.31	0.01	1.00	1.00	2.35	-	2.19	0.04	3.50	-	0.14	0.84	0.32	-
Disp_5000	Winter_1000	Surv_2500	-	215.12	6.02	6.96	0.02	1.83	2.94	2.25	-	2.21	2.11	2.70	-	0.37	0.57	0.41	-
Disp_1000	Winter_1000	Surv_2500	ForWet_3000	215.14	6.04	6.82	0.02	1.00	3.00	2.31	1.00	1.58	2.63	3.11	0.96	0.21	0.48	0.37	0.33
Disp_2500	Winter_3000	Surv_2500	Urban_3000	215.16	6.06	8.92	0.04	1.35	1.55	2.25	3.62	0.21	0.46	2.60	9.10	0.88	0.78	0.43	0.08
Disp_1000	Winter_500	Surv_1000	-	215.19	6.09	3.02	0.00	1.00	1.00	2.12	-	0.63	1.05	0.82	-	0.43	0.31	0.73	-
Disp_5000	Winter_1000	Surv_1000	-	215.27	6.17	6.42	0.02	1.85	2.96	1.84	-	1.78	2.25	1.09	-	0.44	0.54	0.68	-
Winter_3000	Surv_2500	-	-	215.30	6.20	2.02	0.00	1.00	2.17	-	-	0.00	2.09	-	-	1.00	0.50	-	-
Disp_1000	Winter_500	Surv_1000	ForWet_3000	215.33	6.23	3.89	0.01	1.00	1.00	2.10	1.00	0.77	1.96	0.81	1.88	0.38	0.16	0.73	0.17
Disp_5000	Winter_3000	Surv_5000	NatAgri_3000	215.33	6.23	6.89	0.03	1.76	1.53	1.00	2.92	1.37	0.44	0.03	7.52	0.49	0.78	0.86	0.07
Disp_2500	Winter_500	Surv_2500	-	215.34	6.24	4.20	0.01	1.71	1.00	2.28	-	1.31	1.45	2.80	-	0.61	0.23	0.40	-
Disp_1000	Winter_3000	Surv_1000	NatAgri_3000	215.34	6.24	7.54	0.03	1.00	1.91	2.19	2.67	0.62	1.23	0.90	7.15	0.43	0.58	0.72	0.09
Disp_5000	Winter_500	Surv_1000	ForWet_3000	215.44	6.34	4.81	0.01	1.85	1.00	1.89	1.00	1.99	2.12	1.04	1.60	0.39	0.15	0.71	0.21
Surv_5000	ForWet_3000	-	-	215.50	6.40	0.40	0.00	1.00	1.00	-	-	0.60	0.46	-	-	0.44	0.50	-	-
Disp_1000	Winter_500	Surv_5000	ForWet_3000	215.53	6.43	2.29	0.00	1.00	1.00	1.00	1.00	0.73	1.93	0.12	2.03	0.39	0.16	0.73	0.15
Disp_1000	Winter_1000	Surv_5000	-	215.54	6.44	3.94	0.01	1.00	3.00	1.00	-	0.96	2.46	0.00	-	0.33	0.50	0.97	-
Disp_2500	Winter_1000	ForWet_3000	-	215.54	6.44	3.96	0.01	1.00	3.00	1.00	-	0.23	2.87	1.18	-	0.63	0.44	0.28	-
Disp_5000	Winter_1000	Surv_2500	ForWet_3000	215.56	6.46	7.69	0.03	1.82	2.92	2.28	1.00	2.73	2.69	2.96	1.70	0.29	0.47	0.38	0.19
Disp_2500	Winter_500	Surv_1000	-	215.58	6.48	3.18	0.00	1.53	1.00	1.71	-	0.66	1.25	1.14	-	0.63	0.26	0.60	-
Disp_2500	Winter_3000	Surv_5000	NatAgri_3000	215.63	6.53	5.76	0.02	1.00	1.73	1.00	2.81	0.15	0.72	0.00	8.38	0.71	0.71	0.99	0.07
Disp_1000	Winter_1000	Surv_1000	ForWet_3000	215.66	6.56	6.33	0.02	1.00	3.02	2.09	1.00	0.83	2.80	0.84	1.20	0.36	0.45	0.70	0.27
Disp_2500	Winter_500	Surv_2500	ForWet_3000	215.69	6.59	5.00	0.02	1.74	1.00	2.27	1.00	1.59	2.31	2.77	1.69	0.55	0.13	0.41	0.19
Disp_5000	Winter_1000	ForWet_3000	-	215.70	6.60	4.79	0.01	1.66	2.92	1.00	-	1.52	2.57	1.20	-	0.47	0.48	0.27	-
Disp_2500	Winter_1000	Surv_1000	-	215.78	6.68	5.51	0.01	1.34	2.99	1.81	-	0.15	2.40	1.03	-	0.84	0.51	0.68	-
Disp_5000	Surv_5000	-	-	215.81	6.71	1.46	0.00	1.81	1.00	-	-	1.49	0.38	-	-	0.48	0.54	-	-
Disp_2500	ForWet_3000	-	-	215.83	6.73	0.25	-0.01	1.00	1.00	-	-	0.36	0.39	-	-	0.55	0.53	-	-
Winter_3000	ForWet_3000	-	-	215.84	6.74	0.24	0.03	1.80	2.73	-	-	0.92	8.49	-	-	0.66	0.06	-	-
Disp_2500	Winter_1000	Surv_2500	-	215.85	6.75	6.39	0.02	1.60	3.00	2.26	-	0.86	2.30	2.84	-	0.62	0.54	0.40	-
Disp_5000	Winter_500	Surv_5000	-	215.85	6.75	2.47	0.00	1.88	1.00	1.00	-	1.87	1.51	0.36	-	0.42	0.22	0.55	-
Disp_5000	ForWet_3000	-	-	215.87	6.77	1.26	0.00	1.68	1.00	-	-	1.62	0.38	-	-	0.44	0.54	-	-
Disp_1000	Winter_3000	ForWet_3000	-	215.91	6.81	1.16	0.00	1.00	1.00	1.00	-	1.83	0.21	0.69	-	0.18	0.65	0.41	-
Disp_2500	Surv_5000	-	-	215.96	6.86	0.19	-0.01	1.00	1.00	-	-	0.01	0.24	-	-	0.92	0.63	-	-
Winter_3000	Surv_5000	-	-	215.96	6.86	0.19	-0.01	1.00	1.00	-	-	0.02	0.36	-	-	0.90	0.55	-	-
Disp_2500	Winter_3000	Surv_5000	Urban_3000	215.97	6.87	6.54	0.02	1.00	1.61	1.00	3.76	0.18	0.53	0.22	9.34	0.66	0.76	0.63	0.09

Disp_5000	Winter_500	Surv_5000	ForWet_3000	216.04	6.94	3.25	0.01	1.81	1.00	1.00	1.00	1.67	2.41	0.67	1.90	0.44	0.12	0.41	0.17
Disp_1000	Winter_3000	Surv_5000	Urban_3000	216.07	6.97	6.64	0.03	1.00	1.87	1.00	3.57	0.71	0.87	0.01	8.18	0.40	0.70	0.91	0.12
Disp_5000	Winter_1000	Surv_1000	ForWet_3000	216.11	7.01	6.94	0.02	1.81	2.91	1.89	1.00	1.83	2.60	1.11	1.26	0.43	0.48	0.69	0.26
Disp_2500	Winter_500	Surv_1000	ForWet_3000	216.17	7.07	3.97	0.00	1.55	1.00	1.80	1.00	0.55	2.04	1.09	1.49	0.73	0.15	0.66	0.22
Disp_2500	Winter_3000	-	-	216.20	7.10	0.08	-0.01	1.00	1.00	-	-	0.16	0.02	-	-	0.69	0.89	-	-
Winter_3000	Surv_1000	ForWet_3000	-	216.20	7.10	2.09	0.00	1.00	1.76	1.00	-	0.35	1.21	0.76	-	0.56	0.59	0.38	-
Disp_2500	Winter_500	Surv_5000	-	216.21	7.11	1.02	-0.01	1.00	1.00	1.00	-	0.06	1.37	0.23	-	0.81	0.24	0.63	-
Disp_1000	Winter_1000	Surv_5000	ForWet_3000	216.23	7.13	4.53	0.01	1.00	2.96	1.00	1.00	0.80	2.62	0.09	1.36	0.37	0.47	0.76	0.24
Disp_5000	Winter_3000	-	-	216.24	7.14	1.17	0.00	1.73	1.00	-	-	1.45	0.00	-	-	0.48	1.00	-	-
Disp_2500	Winter_500	Surv_5000	ForWet_3000	216.27	7.17	1.94	0.00	1.00	1.00	1.00	1.00	0.00	2.32	0.60	2.00	0.97	0.13	0.44	0.16
Disp_1000	Winter_3000	Surv_1000	-	216.34	7.24	2.43	0.00	1.00	1.00	2.08	-	0.84	0.09	0.73	-	0.36	0.77	0.75	-
Disp_5000	Winter_1000	Surv_5000	-	216.38	7.28	4.65	0.01	1.79	2.94	1.00	-	1.50	2.20	0.33	-	0.49	0.54	0.56	-
Disp_2500	Winter_1000	Surv_5000	-	216.43	7.33	3.54	0.00	1.00	3.02	1.00	-	0.00	2.50	0.19	-	0.98	0.50	0.67	-
Disp_5000	Winter_3000	Surv_2500	-	216.44	7.34	3.79	0.01	1.85	1.00	2.24	-	2.37	0.01	2.63	-	0.33	0.95	0.42	-
Disp_5000	Winter_3000	Surv_1000	-	216.51	7.41	3.22	0.00	1.90	1.00	1.74	-	1.83	0.00	1.22	-	0.42	0.98	0.61	-
Disp_2500	Winter_1000	Surv_2500	ForWet_3000	216.57	7.47	7.04	0.02	1.64	2.90	2.25	1.00	1.24	2.79	2.77	1.36	0.57	0.46	0.40	0.25
Disp_1000	Winter_3000	Surv_5000	-	216.61	7.51	0.83	-0.01	1.00	1.00	1.00	-	1.30	0.12	0.00	-	0.25	0.74	1.00	-
Winter_3000	Surv_2500	ForWet_3000	-	216.70	7.60	2.27	-0.01	1.00	2.12	1.00	-	0.39	1.91	0.63	-	0.53	0.52	0.43	-
Disp_2500	Winter_1000	Surv_1000	ForWet_3000	216.70	7.60	6.10	0.01	1.38	2.96	1.83	1.00	0.24	2.75	1.05	1.17	0.85	0.45	0.68	0.28
Disp_1000	Winter_3000	Surv_2500	ForWet_3000	216.78	7.68	3.42	0.01	1.00	1.00	2.31	1.00	1.95	0.12	2.96	0.35	0.16	0.73	0.39	0.56
Disp_5000	Winter_1000	Surv_5000	ForWet_3000	216.95	7.85	5.25	0.01	1.77	2.89	1.00	1.00	1.54	2.72	0.65	1.56	0.48	0.45	0.42	0.21
Disp_2500	Winter_1000	Surv_5000	ForWet_3000	216.96	7.86	4.20	0.01	1.00	2.98	1.00	1.00	0.02	2.94	0.52	1.56	0.89	0.42	0.47	0.21
Disp_1000	Winter_500	Surv_5000	-	216.98	7.88	2.29	0.00	1.00	2.13	1.00	-	0.86	0.89	0.00	-	0.35	0.77	0.95	-
Winter_3000	Surv_5000	ForWet_3000	-	216.99	7.89	0.65	-0.01	1.00	1.00	1.00	-	0.49	0.76	0.95	-	0.48	0.39	0.33	-
Disp_2500	Winter_3000	Surv_1000	-	217.07	7.97	2.52	0.00	1.61	1.00	1.68	-	0.76	0.01	1.25	-	0.68	0.94	0.56	-
Disp_2500	Winter_3000	Surv_2500	-	217.07	7.97	3.47	0.01	1.82	1.00	2.26	-	1.90	0.02	2.79	-	0.53	0.89	0.40	-
Disp_5000	Winter_3000	Surv_2500	ForWet_3000	217.35	8.25	4.35	0.01	1.89	1.00	2.24	1.00	2.98	0.56	2.68	1.11	0.25	0.46	0.42	0.29
Disp_5000	Winter_3000	ForWet_3000	-	217.39	8.29	1.58	0.00	1.75	1.00	1.00	-	1.85	0.45	0.85	-	0.40	0.50	0.36	-
Disp_2500	Winter_3000	ForWet_3000	-	217.54	8.44	0.39	-0.01	1.00	1.00	1.00	-	0.30	0.28	0.65	-	0.58	0.60	0.42	-
Disp_5000	Winter_3000	Surv_1000	ForWet_3000	217.60	8.50	3.80	0.00	1.92	1.00	1.84	1.00	2.14	0.53	1.24	0.97	0.37	0.47	0.65	0.33
Disp_1000	Winter_3000	Surv_1000	ForWet_3000	217.61	8.51	2.77	0.00	1.00	1.00	2.08	1.00	0.81	0.26	0.74	0.73	0.37	0.61	0.75	0.39
Disp_5000	Winter_3000	Surv_5000	-	217.81	8.71	1.48	0.00	1.82	1.00	1.00	-	1.50	0.00	0.38	-	0.47	0.99	0.54	-
Disp_1000	Winter_3000	Surv_5000	ForWet_3000	217.83	8.73	1.20	-0.01	1.00	1.00	1.00	1.00	1.12	0.25	0.08	0.39	0.29	0.62	0.78	0.39
Disp_1000	Winter_3000	Surv_5000	NatAgri_3000	217.83	8.73	1.20	-0.01	1.00	1.00	1.00	1.00	1.12	0.25	0.08	0.76	0.29	0.62	0.78	0.28
Disp_2500	Winter_3000	Surv_5000	-	217.94	8.84	0.20	-0.01	1.00	1.00	1.00	-	0.02	0.03	0.24	-	0.89	0.87	0.62	-
Disp_2500	Winter_3000	Surv_1000	ForWet_3000	218.35	9.25	3.06	0.00	1.70	1.00	1.74	1.00	0.70	0.40	1.29	0.78	0.67	0.53	0.58	0.38
Disp_2500	Winter_3000	Surv_2500	ForWet_3000	218.39	9.29	3.79	0.01	1.85	1.00	2.22	1.00	2.07	0.30	2.58	0.69	0.51	0.58	0.43	0.41
Disp_5000	Winter_3000	Surv_5000	ForWet_3000	218.61	9.51	2.10	0.00	1.87	1.00	1.00	1.00	1.83	0.65	0.69	1.19	0.41	0.42	0.41	0.27
Disp_2500	Winter_3000	Surv_5000	ForWet_3000	218.95	9.85	0.67	-0.01	1.00	1.00	1.00	1.00	0.04	0.44	0.53	0.97	0.85	0.51	0.47	0.32

Table 5: Generalized Additive Model Results for Spring Peeper

Variable 1	Variable 2	Variable 3	Variable 4	AIC	Delta	% Variance Explained	R^2	edf 1	edf 2	edf 3	edf 4	ANOVA F 1	ANOVA F 2	ANOVA F 3	ANOVA F 4	p-value 1	p-value 2	p-value 3	p-value 4
Winter_3000	Surv_5000	NatAgri_3000	-	175.50	0.00	41.30	0.41	1.00	1.00	1.37	-	8.70	2.93	25.39	-	0.003	0.087	0.000	-
Disp_1000	Winter_3000	Surv_5000	NatAgri_3000	175.71	0.21	43.20	0.43	2.21	1.00	1.00	1.41	3.42	8.74	2.88	24.67	0.220	0.003	0.089	0.000
Disp_2500	Winter_3000	Surv_5000	NatAgri_3000	176.12	0.62	43.00	0.43	2.29	1.00	1.00	1.26	4.26	8.97	2.82	25.20	0.290	0.003	0.093	0.000
Disp_1000	Winter_3000	Surv_1000	NatAgri_3000	177.25	1.75	41.90	0.42	2.26	1.00	1.00	1.36	4.05	8.71	1.66	31.13	0.176	0.003	0.202	0.000
Winter_500	Surv_5000	NatAgri_3000	-	177.54	2.04	41.10	0.42	1.68	1.00	1.21	-	7.09	3.24	41.07	-	0.05	0.07	0.00	-
Disp_5000	Winter_3000	Surv_5000	NatAgri_3000	177.55	2.05	41.40	0.41	1.00	1.00	1.00	1.49	0.02	8.02	2.50	24.60	0.90	0.00	0.11	0.00
Winter_3000	Surv_1000	NatAgri_3000	-	177.67	2.17	39.80	0.40	1.00	1.00	1.36	-	8.41	1.54	32.07	-	0.00	0.21	0.00	-
Disp_1000	Winter_3000	Surv_5000	Urban_3000	177.71	2.21	42.00	0.41	2.28	1.00	1.00	1.00	3.77	13.43	1.78	19.52	0.19	0.00	0.18	0.00
Winter_3000	Surv_2500	NatAgri_3000	-	177.79	2.29	40.00	0.40	1.00	1.00	1.60	-	9.28	0.89	27.74	-	0.00	0.35	0.00	-
Disp_1000	Winter_500	Surv_5000	NatAgri_3000	177.83	2.33	43.10	0.44	2.23	1.72	1.00	1.31	3.67	7.03	3.48	40.34	0.22	0.06	0.06	0.00
Winter_1000	Surv_5000	NatAgri_3000	-	177.85	2.35	40.10	0.41	1.00	1.00	1.07	-	7.46	3.21	34.01	-	0.01	0.07	0.00	-
Disp_1000	Winter_1000	Surv_5000	NatAgri_3000	177.85	2.35	42.20	0.43	2.27	1.00	1.00	1.16	3.95	7.56	3.36	33.70	0.19	0.01	0.07	0.00
Winter_3000	Surv_5000	Urban_3000	-	177.90	2.40	40.00	0.39	1.00	1.00	1.00	-	13.94	1.75	20.48	-	0.00	0.19	0.00	-
Disp_1000	Winter_3000	Surv_2500	NatAgri_3000	178.00	2.50	41.80	0.42	2.21	1.00	1.00	1.53	3.47	9.18	1.15	27.56	0.23	0.00	0.28	0.00
Disp_2500	Winter_3000	Surv_1000	NatAgri_3000	178.29	2.79	41.40	0.41	2.20	1.00	1.00	1.25	4.16	8.53	1.23	30.61	0.30	0.00	0.27	0.00
Winter_3000	NatAgri_3000	-	-	178.30	2.80	40.00	0.41	1.00	1.84	-	-	9.61	30.44	-	-	0.00	0.00	-	-
Disp_2500	Winter_500	Surv_5000	NatAgri_3000	178.43	2.93	42.50	0.43	2.09	1.78	1.00	1.00	3.49	6.81	2.85	37.45	0.39	0.08	0.09	0.00
Disp_1000	Winter_3000	Urban_3000	-	178.48	2.98	40.80	0.41	2.05	1.00	1.00	-	3.35	13.60	29.07	-	0.21	0.00	0.00	-
Winter_3000	Urban_3000	-	-	178.50	3.00	39.00	0.38	1.00	1.00	-	-	14.91	29.92	-	-	0.00	0.00	-	-
Disp_1000	Winter_3000	NatAgri_3000	-	178.64	3.14	41.40	0.42	1.92	1.00	1.62	-	3.07	8.74	29.72	-	0.24	0.00	0.00	-
Disp_2500	Winter_3000	Surv_2500	NatAgri_3000	178.79	3.29	41.50	0.41	2.24	1.00	1.00	1.47	3.94	9.01	0.89	28.95	0.34	0.00	0.35	0.00
Disp_1000	Winter_3000	Surv_2500	Urban_3000	178.82	3.32	40.90	0.40	2.27	1.00	1.00	1.00	3.82	13.75	0.73	23.33	0.20	0.00	0.39	0.00
Disp_2500	Winter_3000	NatAgri_3000	-	178.94	3.44	41.30	0.42	1.99	1.00	1.61	-	3.78	8.43	30.13	-	0.31	0.00	0.00	-
Disp_2500	Winter_3000	Surv_5000	Urban_3000	178.96	3.46	41.70	0.40	2.39	1.00	1.00	1.00	3.45	13.35	1.42	20.45	0.34	0.00	0.23	0.00
Winter_3000	Surv_2500	Urban_3000	-	179.01	3.51	38.80	0.38	1.00	1.00	1.00	-	14.59	0.50	24.64	-	0.00	0.48	0.00	-
Disp_1000	Winter_3000	Surv_1000	Urban_3000	179.08	3.58	40.80	0.40	2.29	1.00	1.00	1.00	4.08	13.30	0.78	25.71	0.18	0.00	0.38	0.00
Disp_2500	Winter_3000	Urban_3000	-	179.10	3.60	40.80	0.40	2.20	1.00	1.00	-	4.15	12.98	27.94	-	0.32	0.00	0.00	-
Disp_5000	Winter_500	Surv_5000	NatAgri_3000	179.18	3.68	41.10	0.41	1.00	1.69	1.00	1.11	0.22	6.54	2.42	35.12	0.63	0.06	0.12	0.00
Disp_5000	Winter_3000	Urban_3000	-	179.41	3.91	39.40	0.39	1.00	1.00	1.00	-	1.14	11.22	26.22	-	0.29	0.00	0.00	-
Winter_3000	Surv_1000	Urban_3000	-	179.49	3.99	38.70	0.38	1.00	1.00	1.00	-	14.04	0.65	26.91	-	0.00	0.42	0.00	-
Disp_2500	Winter_1000	Surv_5000	NatAgri_3000	179.56	4.06	42.10	0.42	2.27	1.63	1.00	1.00	4.30	6.21	2.76	33.17	0.30	0.06	0.10	0.00
Disp_1000	Winter_500	Surv_1000	NatAgri_3000	179.58	4.08	41.60	0.42	2.23	1.83	1.00	1.06	4.00	6.91	1.76	47.17	0.18	0.09	0.19	0.00
Disp_5000	Winter_3000	Surv_1000	NatAgri_3000	179.61	4.11	39.80	0.40	1.00	1.00	1.00	1.35	0.06	7.50	1.13	28.54	0.80	0.01	0.29	0.00
Disp_5000	Winter_1000	Surv_5000	NatAgri_3000	179.65	4.15	40.10	0.40	1.00	1.00	1.00	1.00	0.12	6.73	2.45	30.64	0.72	0.01	0.11	0.00
Disp_5000	Winter_3000	Surv_5000	Urban_3000	179.70	4.20	40.00	0.39	1.00	1.00	1.00	1.00	0.19	11.61	1.18	20.38	0.66	0.00	0.27	0.00
Disp_5000	Winter_3000	Surv_2500	NatAgri_3000	179.71	4.21	40.00	0.40	1.00	1.00	1.00	1.57	0.10	8.01	0.63	26.15	0.75	0.00	0.43	0.00
Disp_5000	Winter_3000	NatAgri_3000	-	179.76	4.26	40.10	0.40	1.00	1.00	1.70	-	0.56	7.84	25.93	-	0.46	0.01	0.00	-
Winter_500	Surv_1000	NatAgri_3000	-	179.91	4.41	39.60	0.41	1.78	1.00	1.15	-	6.73	1.74	50.41	-	0.08	0.19	0.00	-
Disp_2500	Winter_3000	Surv_2500	Urban_3000	180.01	4.51	40.60	0.40	2.39	1.00	1.00	1.00	3.44	13.30	0.30	24.36	0.33	0.00	0.59	0.00
Disp_5000	Winter_3000	Surv_2500	Urban_3000	180.42	4.92	39.10	0.38	1.00	1.00	1.00	1.00	0.59	11.44	0.18	23.45	0.44	0.00	0.67	0.00
Disp_2500	Winter_3000	Surv_1000	Urban_3000	180.44	4.94	0.39	0.39	2.28	1.00	1.00	1.00	3.84	12.94	0.30	26.35	0.36	0.00	0.58	0.00
Winter_500	Surv_2500	NatAgri_3000	-	180.57	5.07	39.60	0.40	1.61	1.00	1.47	-	7.07	1.11	49.55	-	0.03	0.29	0.00	-
Disp_2500	Winter_500	Surv_1000	NatAgri_3000	180.74	5.24	41.00	0.41	2.01	1.87	1.00	1.00	3.41	6.27	1.09	43.05	0.36	0.12	0.30	0.00
Disp_1000	Winter_1000	Surv_1000	NatAgri_3000	180.82	5.32	41.30	0.42	2.30	1.72	1.00	1.17	4.39	6.21	1.66	43.43	0.16	0.08	0.20	0.00
Disp_5000	Winter_3000	Surv_1000	Urban_3000	180.88	5.38	38.90	0.38	1.00	1.00	1.00	1.00	0.61	11.16	0.27	24.97	0.43	0.00	0.60	0.00
Disp_5000	Winter_500	Surv_1000	NatAgri_3000	181.05	5.55	39.70	0.40	1.18	1.00	1.00	1.00	0.65	6.05	1.03	36.69	0.42	0.11	0.31	0.00

Disp_1000	Winter_500	Surv_2500	NatAgri_3000	181.10	5.60	41.30	0.42	2.17	1.68	1.00	1.39	3.31	7.02	1.33	47.61	0.26	0.05	0.25	0.00
Winter_500	NatAgri_3000	-	-	181.20	5.70	39.70	0.41	1.70	1.78	-	-	7.59	51.18	-	-	0.04	0.00	-	-
Winter_1000	Surv_1000	NatAgri_3000	-	181.43	5.93	39.00	0.40	1.65	1.00	1.20	-	5.72	1.66	45.48	-	0.08	0.20	0.00	-
Disp_2500	Winter_500	NatAgri_3000	-	181.50	6.00	40.80	0.42	1.68	1.78	1.36	-	3.29	6.10	48.99	-	0.23	0.10	0.00	-
Disp_5000	Winter_500	NatAgri_3000	-	181.52	6.02	40.00	0.41	1.00	1.73	1.45	-	1.77	6.23	41.66	-	0.18	0.09	0.00	-
Disp_2500	Winter_500	Surv_2500	NatAgri_3000	181.66	6.16	40.80	0.41	1.99	1.73	1.00	1.18	3.23	6.69	0.78	44.64	0.40	0.07	0.38	0.00
Disp_5000	Winter_500	Surv_2500	NatAgri_3000	181.66	6.16	39.70	0.40	1.00	1.64	1.00	1.24	0.82	6.37	0.59	38.90	0.36	0.06	0.44	0.00
Winter_1000	Surv_2500	NatAgri_3000	-	181.76	6.26	38.90	0.40	1.41	1.00	1.45	-	8.17	1.00	43.62	-	0.06	0.31	0.00	-
Disp_2500	Winter_1000	Surv_1000	NatAgri_3000	181.78	6.28	40.80	0.41	2.21	1.86	1.00	1.01	4.40	5.88	1.11	39.13	0.28	0.13	0.29	0.00
Disp_1000	Winter_500	NatAgri_3000	-	181.80	6.30	40.90	0.42	1.80	1.78	1.48	-	2.98	6.33	55.48	-	0.25	0.10	0.00	-
ForWet_3000	-	-	-	181.86	6.36	37.10	0.38	1.00	-	-	-	48.63	-	-	-	0.00	-	-	-
Surv_2500	ForWet_3000	-	-	182.00	6.50	37.00	0.38	1.00	1.00	-	-	0.02	41.89	-	-	0.89	0.00	-	-
Disp_1000	Winter_1000	Surv_2500	NatAgri_3000	182.02	6.52	41.00	0.41	2.25	1.60	1.00	1.40	3.79	6.00	1.19	41.51	0.21	0.05	0.27	0.00
Surv_5000	ForWet_3000	-	-	182.20	6.70	37.70	0.38	1.00	1.00	-	-	1.27	35.54	-	-	0.26	0.00	-	-
Disp_1000	ForWet_3000	-	-	182.30	6.80	38.80	0.40	2.03	1.00	-	-	3.10	44.20	-	-	0.25	0.00	-	-
Disp_1000	Winter_500	Surv_5000	ForWet_3000	182.38	6.88	41.10	0.40	2.26	1.64	1.00	1.00	4.12	2.00	1.70	25.89	0.18	0.40	0.19	0.00
Winter_1000	NatAgri_3000	-	-	182.40	6.90	39.30	0.40	1.65	1.78	-	-	6.73	44.98	-	-	0.05	0.00	-	-
Disp_1000	Winter_500	Surv_1000	ForWet_3000	182.44	6.94	40.60	0.40	2.33	1.83	1.00	1.00	4.89	1.95	1.10	33.16	0.13	0.50	0.29	0.00
Disp_1000	Winter_1000	NatAgri_3000	-	182.50	7.00	40.90	0.42	1.96	1.81	1.55	-	3.44	6.01	48.41	-	0.21	0.12	0.00	-
Winter_500	Surv_2500	ForWet_3000	-	182.51	7.01	38.20	0.38	1.50	1.00	1.00	-	1.31	0.04	32.56	-	0.41	0.84	0.00	-
Winter_500	ForWet_3000	-	-	182.60	7.10	38.40	0.38	1.68	1.00	-	-	1.65	37.78	-	-	0.50	0.00	-	-
Surv_1000	ForWet_3000	-	-	182.60	7.10	36.90	0.37	1.00	1.00	-	-	0.49	43.52	-	-	0.48	0.00	-	-
Disp_2500	Winter_1000	NatAgri_3000	-	182.60	7.10	40.80	0.42	2.00	1.82	1.47	-	4.40	5.79	44.83	-	0.24	0.12	0.00	-
Winter_500	Surv_5000	ForWet_3000	-	182.64	7.14	38.90	0.38	1.56	1.00	1.00	-	1.44	1.37	27.30	-	0.42	0.24	0.00	-
Disp_2500	Winter_1000	Surv_2500	NatAgri_3000	182.73	7.23	40.70	0.41	2.23	1.73	1.00	1.27	4.26	6.31	0.79	41.05	0.31	0.08	0.37	0.00
Disp_5000	Winter_1000	Surv_1000	NatAgri_3000	182.73	7.23	39.10	0.39	1.00	1.69	1.00	1.04	0.52	5.09	1.00	33.98	0.47	0.12	0.32	0.00
Disp_1000	Winter_500	Surv_2500	ForWet_3000	182.78	7.28	40.20	0.40	2.21	1.60	1.00	1.00	3.65	1.74	0.37	30.88	0.22	0.41	0.54	0.00
Disp_1000	Winter_500	ForWet_3000	-	182.89	7.39	40.20	0.40	2.08	1.80	1.00	-	3.32	1.71	35.62	-	0.23	0.54	0.00	-
Disp_2500	ForWet_3000	-	-	182.90	7.40	38.70	0.40	2.19	1.00	-	-	3.75	39.79	-	-	0.38	0.00	-	-
Disp_5000	Winter_1000	NatAgri_3000	-	183.02	7.52	39.60	0.40	1.00	1.72	1.51	-	1.47	5.40	37.96	-	0.23	0.12	0.00	-
Disp_2500	Winter_500	Surv_5000	ForWet_3000	183.16	7.66	41.30	0.40	2.67	1.74	1.00	1.00	4.64	2.01	1.46	27.25	0.25	0.45	0.23	0.00
Disp_5000	Winter_1000	Surv_2500	NatAgri_3000	183.20	7.70	39.10	0.39	1.00	1.53	1.00	1.29	0.65	4.09	0.52	35.90	0.42	0.08	0.47	0.00
Disp_2500	Winter_500	Surv_2500	ForWet_3000	183.27	7.77	40.50	0.40	2.72	1.68	1.00	1.00	4.38	1.91	0.17	31.06	0.28	0.45	0.68	0.00
Disp_2500	Winter_500	ForWet_3000	-	183.31	7.81	40.40	0.40	2.46	1.83	1.00	-	3.92	1.70	32.88	-	0.29	0.55	0.00	-
Winter_500	Surv_1000	ForWet_3000	-	183.44	7.94	38.10	0.37	1.73	1.00	1.00	-	1.58	0.39	34.77	-	0.54	0.53	0.00	-
Disp_5000	ForWet_3000	-	-	183.70	8.20	37.20	0.38	1.00	1.00	-	-	0.18	34.55	-	-	0.67	0.00	-	-
Winter_3000	ForWet_3000	-	-	183.70	8.20	37.20	0.37	1.00	1.00	-	-	0.19	23.10	-	-	0.67	0.00	-	-
Disp_1000	Winter_3000	Surv_5000	ForWet_3000	183.71	8.21	39.80	0.39	2.22	1.00	1.00	1.00	3.70	0.53	1.65	13.80	0.20	0.47	0.20	0.00
Winter_3000	Surv_5000	ForWet_3000	-	183.75	8.25	37.90	0.37	1.00	1.00	1.00	-	0.41	1.45	14.97	-	0.52	0.23	0.00	-
Winter_3000	Surv_2500	ForWet_3000	-	183.81	8.31	37.20	0.37	1.00	1.00	1.07	-	0.29	0.05	15.48	-	0.59	0.83	0.00	-
Disp_2500	Winter_500	Surv_1000	ForWet_3000	183.83	8.33	40.30	0.39	2.55	1.86	1.00	1.00	4.43	1.70	0.47	32.18	0.25	0.56	0.50	0.00
Disp_1000	Winter_3000	Surv_1000	ForWet_3000	183.91	8.41	39.10	0.39	2.26	1.00	1.00	1.00	4.21	0.29	0.97	19.96	0.17	0.59	0.32	0.00
Disp_1000	Winter_3000	ForWet_3000	-	184.06	8.56	38.90	0.39	2.05	1.00	1.00	-	3.12	0.19	22.31	-	0.24	0.67	0.00	-
Disp_1000	Winter_1000	Surv_5000	ForWet_3000	184.06	8.56	40.40	0.40	2.26	1.50	1.00	1.00	4.01	1.04	1.56	22.43	0.18	0.58	0.21	0.00
Disp_1000	Winter_1000	Surv_5000	Urban_3000	184.12	8.62	39.90	0.40	2.42	1.00	1.00	1.00	5.44	11.07	2.29	26.55	0.12	0.00	0.13	0.00
Disp_1000	Winter_3000	Surv_2500	ForWet_3000	184.21	8.71	38.90	0.39	2.15	1.00	1.00	1.00	3.28	0.37	0.25	17.61	0.24	0.54	0.62	0.00
Disp_2500	Winter_3000	Surv_5000	ForWet_3000	184.38	8.88	39.90	0.39	2.52	1.00	1.00	1.00	4.08	0.65	1.52	14.77	0.28	0.42	0.22	0.00
Disp_5000	Winter_500	ForWet_3000	-	184.39	8.89	38.50	0.38	1.00	1.69	1.00	-	0.17	1.62	27.94	-	0.68	0.51	0.00	-
Winter_3000	Surv_1000	ForWet_3000	-	184.39	8.89	36.90	0.37	1.00	1.00	1.00	-	0.17	0.49	21.61	-	0.68	0.49	0.00	-
Winter_1000	Surv_5000	ForWet_3000	-	184.42	8.92	38.30	0.37	1.49	1.00	1.00	-	0.77	1.35	23.95	-	0.66	0.25	0.00	-

Disp_1000	Winter_1000	Surv_1000	ForWet_3000	184.42	8.92	40.00	0.40	2.31	1.79	1.00	1.09	4.65	0.92	1.00	21.31	0.14	0.70	0.32	0.00
Disp_5000	Winter_500	Surv_2500	ForWet_3000	184.46	8.96	38.20	0.37	1.00	1.51	1.00	1.00	0.06	1.30	0.02	26.73	0.81	0.42	0.90	0.00
Disp_2500	Winter_3000	ForWet_3000	-	184.58	9.08	38.90	0.39	2.27	1.00	1.00	-	4.00	0.24	21.31	-	0.35	0.62	0.00	-
Winter_1000	Surv_2500	ForWet_3000	-	184.58	9.08	37.70	0.37	1.56	1.00	1.10	-	0.69	0.04	20.94	-	0.71	0.85	0.00	-
Winter_1000	ForWet_3000	-	-	184.60	9.10	37.80	0.38	1.68	1.11	-	-	0.66	22.35	-	-	0.75	0.00	-	-
Disp_1000	Winter_1000	ForWet_3000	-	184.60	9.10	39.70	0.40	2.10	1.81	1.02	-	3.49	0.80	29.29	-	0.21	0.75	0.00	-
Disp_5000	Winter_500	Surv_5000	ForWet_3000	184.61	9.11	38.90	0.38	1.00	1.54	1.00	1.00	0.01	1.39	1.24	24.30	0.94	0.41	0.27	0.00
Disp_1000	Winter_1000	Surv_2500	ForWet_3000	184.64	9.14	39.60	0.39	2.20	1.62	1.00	1.04	3.59	0.87	0.25	0.00	0.22	0.66	0.62	0.00
Disp_2500	Winter_3000	Surv_2500	ForWet_3000	184.68	9.18	39.10	0.39	2.51	1.00	1.00	1.00	3.69	0.42	0.12	18.78	0.32	0.52	0.73	0.00
Disp_2500	Winter_1000	Surv_5000	ForWet_3000	184.97	9.47	40.60	0.40	2.63	1.68	1.00	1.00	4.52	0.96	1.25	23.89	0.26	0.65	0.25	0.00
Disp_5000	Winter_1000	Urban_3000	-	185.02	9.52	37.40	0.38	1.00	1.00	1.00	-	3.24	9.05	33.73	-	0.07	0.00	0.00	-
Disp_2500	Winter_1000	ForWet_3000	-	185.03	9.53	39.80	0.40	2.45	1.83	1.00	-	4.04	0.78	29.54	-	0.27	0.75	0.00	-
Disp_5000	Winter_500	Urban_3000	-	185.04	9.54	37.40	0.38	1.00	1.00	1.00	-	4.47	9.18	36.58	-	0.03	0.00	0.00	-
Disp_2500	Winter_3000	Surv_1000	ForWet_3000	185.07	9.57	38.80	0.38	2.38	1.00	1.00	1.00	3.97	0.29	0.50	20.49	0.29	0.59	0.48	0.00
Winter_1000	Surv_5000	Urban_3000	-	185.18	9.68	37.40	0.37	1.00	1.00	1.00	-	11.33	2.02	28.46	-	0.00	0.16	0.00	-
Disp_2500	Winter_1000	Surv_2500	ForWet_3000	185.19	9.69	39.80	0.39	2.65	1.71	1.00	1.00	4.24	0.84	0.11	27.75	0.29	0.70	0.74	0.00
Disp_5000	Winter_1000	Surv_5000	ForWet_3000	185.22	9.72	38.10	0.37	1.00	1.00	1.00	1.00	0.00	0.77	1.27	22.02	0.95	0.38	0.26	0.00
Winter_1000	Surv_1000	ForWet_3000	-	185.25	9.75	37.50	0.37	1.72	1.00	1.03	-	0.61	0.44	28.26	-	0.78	0.51	0.00	-
Disp_5000	Winter_500	Surv_1000	ForWet_3000	185.41	9.91	38.10	0.37	1.00	1.73	1.00	1.00	0.03	1.56	0.28	27.39	0.86	0.54	0.59	0.00
Disp_5000	Winter_3000	ForWet_3000	-	185.48	9.98	37.30	0.37	1.00	1.00	1.00	-	0.19	0.19	19.00	-	0.67	0.67	0.00	-
Disp_1000	Winter_500	Surv_5000	Urban_3000	185.49	9.99	39.30	0.39	2.36	1.00	1.00	1.00	4.57	10.47	2.52	29.78	0.16	0.00	0.11	0.00
Disp_2500	Winter_1000	Surv_1000	ForWet_3000	185.55	10.05	39.80	0.39	2.52	1.89	1.00	1.00	4.45	0.82	0.47	29.05	0.25	0.75	0.50	0.00
Disp_1000	Winter_1000	Urban_3000	-	185.60	10.10	38.40	0.39	2.12	1.00	1.00	-	3.90	10.99	40.61	-	0.17	0.00	0.00	-
Disp_5000	Winter_3000	Surv_5000	ForWet_3000	185.74	10.24	37.90	0.37	1.00	1.00	1.00	1.00	0.01	0.41	1.30	14.30	0.94	0.52	0.23	0.00
Disp_5000	Winter_3000	Surv_2500	ForWet_3000	185.75	10.25	37.20	0.37	1.00	1.00	1.00	1.00	0.06	0.28	0.02	14.27	0.80	0.59	0.90	0.00
Disp_5000	Winter_1000	Surv_5000	Urban_3000	185.77	10.27	37.90	0.38	1.00	1.00	1.00	1.00	1.41	9.25	0.91	27.62	0.23	0.00	0.34	0.00
Disp_5000	Winter_500	Surv_5000	Urban_3000	185.91	10.41	37.80	0.38	1.00	1.00	1.00	1.00	2.23	9.33	0.83	30.38	0.13	0.00	0.36	0.00
Disp_1000	Winter_1000	Surv_2500	Urban_3000	185.96	10.46	38.40	0.38	2.36	1.00	1.00	1.00	4.84	11.34	0.89	33.22	0.15	0.00	0.34	0.00
Disp_1000	Winter_1000	Surv_1000	Urban_3000	186.18	10.68	38.40	0.38	2.36	1.00	1.00	1.00	4.92	11.10	0.80	36.74	0.14	0.00	0.37	0.00
Winter_1000	Urban_3000	-	-	186.20	10.70	36.30	0.36	1.00	1.00	-	-	12.22	42.19	-	-	0.00	0.00	-	-
Disp_2500	Winter_1000	Urban_3000	-	186.26	10.76	38.10	0.38	1.99	1.00	1.04	-	4.20	10.07	37.88	-	0.26	0.00	0.00	-
Disp_5000	Winter_1000	ForWet_3000	-	186.28	10.78	37.90	0.38	1.00	1.71	1.04	-	0.23	0.64	22.62	-	0.63	0.77	0.00	-
Disp_2500	Winter_1000	Surv_5000	Urban_3000	186.30	10.80	39.00	0.38	2.28	1.00	1.00	1.00	3.53	10.42	1.25	28.71	0.40	0.00	0.26	0.00
Disp_5000	Winter_3000	Surv_1000	ForWet_3000	186.36	10.86	36.90	0.37	1.00	1.00	1.00	1.00	0.02	0.17	0.37	18.44	0.88	0.68	0.55	0.00
Disp_5000	Winter_1000	Surv_2500	Urban_3000	186.41	10.91	36.90	0.37	1.00	1.00	1.00	1.00	2.40	9.19	0.06	31.38	0.12	0.00	0.81	0.00
Disp_5000	Winter_1000	Surv_2500	ForWet_3000	186.52	11.02	37.70	0.37	1.00	1.60	1.00	1.08	0.09	0.66	0.01	19.17	0.76	0.73	0.93	0.00
Winter_500	Surv_5000	Urban_3000	-	186.57	11.07	38.70	0.38	1.00	2.84	1.00	-	10.70	4.75	26.36	-	0.00	0.22	0.00	-
Disp_5000	Winter_500	Surv_2500	Urban_3000	186.60	11.10	37.00	0.37	1.00	1.00	1.00	1.08	3.49	9.26	0.05	34.02	0.06	0.00	0.82	0.00
Disp_5000	Winter_1000	Surv_1000	Urban_3000	186.73	11.23	36.80	0.37	1.00	1.00	1.00	1.00	2.44	8.95	0.10	32.75	0.12	0.00	0.76	0.00
Winter_1000	Surv_2500	Urban_3000	-	186.81	11.31	36.10	0.36	1.00	1.00	1.00	-	11.85	0.61	35.45	-	0.00	0.43	0.00	-
Disp_5000	Winter_500	Surv_1000	Urban_3000	186.93	11.43	36.80	0.37	1.00	1.00	1.00	1.00	3.56	9.03	0.08	35.31	0.06	0.00	0.77	0.00
Disp_2500	Winter_500	Urban_3000	-	186.96	11.46	37.20	0.38	1.20	1.00	1.11	-	2.56	9.36	41.52	-	0.13	0.00	0.00	-
Winter_1000	Surv_1000	Urban_3000	-	187.15	11.65	35.90	0.36	1.00	1.00	1.00	-	11.33	0.69	38.55	-	0.00	0.41	0.00	-
Disp_5000	Winter_1000	Surv_1000	ForWet_3000	187.20	11.70	37.50	0.37	1.00	1.74	1.00	1.00	0.05	0.62	0.31	23.44	0.82	0.78	0.58	0.00
Disp_1000	Winter_500	Urban_3000	-	187.40	11.90	37.70	0.38	2.01	1.00	1.00	-	3.48	10.09	45.37	-	0.20	0.00	0.00	-
Disp_2500	Winter_500	Surv_5000	Urban_3000	187.47	11.97	37.90	0.38	1.49	1.00	1.00	1.00	1.05	9.64	1.12	32.08	0.46	0.00	0.29	0.00
Winter_500	Urban_3000	-	-	187.50	12.00	35.90	0.36	1.00	1.00	-	-	11.74	47.49	-	-	0.00	0.00	-	-
Disp_2500	Winter_1000	Surv_2500	Urban_3000	187.51	12.01	37.80	0.37	2.24	1.00	1.00	1.00	4.01	10.40	0.13	34.56	0.33	0.00	0.71	0.00
Disp_1000	Winter_500	Surv_2500	Urban_3000	187.60	12.10	37.80	0.38	2.27	1.00	1.00	1.00	4.08	10.56	0.94	37.75	0.18	0.00	0.33	0.00
Winter_500	Surv_2500	Urban_3000	-	187.89	12.39	35.70	0.36	1.00	1.00	1.00	-	11.50	0.69	39.76	-	0.00	0.41	0.00	-

Disp_1000	Winter_500	Surv_1000	Urban_3000	187.90	12.40	37.70	0.38	2.27	1.00	1.00	1.00	4.17	10.31	0.79	41.53	0.17	0.00	0.37	0.00
Disp_2500	Winter_1000	Surv_1000	Urban_3000	188.07	12.57	37.60	0.37	2.00	1.00	1.00	1.14	3.59	9.92	0.08	36.64	0.34	0.00	0.77	0.00
Winter_500	Surv_1000	Urban_3000	-	188.28	12.78	35.50	0.36	1.00	1.00	1.00	-	11.00	0.74	43.03	-	0.00	0.39	0.00	-
Surv_5000	NatAgri_3000	-	-	188.40	12.90	36.10	0.39	1.00	1.50	-	-	3.92	51.30	-	-	0.05	0.00	-	-
Disp_2500	Winter_500	Surv_2500	Urban_3000	188.65	13.15	36.70	0.37	1.29	1.00	1.00	1.18	1.51	9.46	0.04	38.73	0.27	0.00	0.84	0.00
Disp_2500	Winter_500	Surv_1000	Urban_3000	189.01	13.51	36.70	0.37	1.33	1.00	1.00	1.24	1.63	9.18	0.03	40.33	0.25	0.00	0.87	0.00
Surv_1000	NatAgri_3000	-	-	189.80	14.30	34.50	0.38	1.05	1.14	-	-	3.17	61.50	-	-	0.10	0.00	-	-
Disp_2500	NatAgri_3000	-	-	190.30	14.80	35.60	0.39	1.27	1.28	-	-	4.43	55.94	-	-	0.04	0.00	-	-
Disp_1000	NatAgri_3000	-	-	191.13	15.63	35.80	0.39	1.69	1.35	-	-	5.52	67.02	-	-	0.07	0.00	-	-
Disp_5000	NatAgri_3000	-	-	191.40	15.90	35.00	0.38	1.00	1.46	-	-	4.08	47.56	-	-	0.04	0.00	-	-
Surv_2500	NatAgri_3000	-	-	192.10	16.60	34.30	0.37	1.00	1.73	-	-	1.53	54.43	-	-	0.22	0.00	-	-
NatAgri_3000	-	-	-	193.13	17.63	34.20	0.38	1.95	-	-	-	65.07	-	-	-	0.00	-	-	-
Disp_5000	Urban_3000	-	-	197.20	21.70	33.20	0.35	1.00	1.68	-	-	9.03	42.79	-	-	0.00	0.00	-	-
Winter_3000	Surv_5000	-	-	197.50	22.00	34.40	0.32	1.00	3.17	-	-	19.89	14.85	-	-	0.00	0.00	-	-
Disp_1000	Winter_3000	Surv_5000	-	197.50	22.00	36.10	0.34	2.22	1.00	2.96	-	3.59	20.14	13.19	-	0.22	0.00	0.01	-
Disp_2500	Urban_3000	-	-	198.50	23.00	33.00	0.35	1.00	1.90	-	-	7.39	49.48	-	-	0.01	0.00	-	-
Disp_5000	Winter_3000	Surv_5000	-	198.79	23.29	34.80	0.32	1.00	1.00	3.40	-	0.43	19.05	11.53	-	0.51	0.00	0.02	-
Disp_2500	Winter_3000	Surv_5000	-	199.76	24.26	35.10	0.32	1.74	1.00	3.16	-	0.75	20.05	11.92	-	0.66	0.00	0.02	-
Surv_5000	Urban_3000	-	-	201.00	25.50	33.80	0.34	3.00	1.73	-	-	7.28	32.77	-	-	0.09	0.00	-	-
Disp_1000	Urban_3000	-	-	201.40	25.90	32.60	0.34	1.96	1.51	-	-	6.10	57.43	-	-	0.06	0.00	-	-
Surv_1000	Urban_3000	-	-	203.20	27.70	30.00	0.31	1.03	1.37	-	-	1.73	54.27	-	-	0.21	0.00	-	-
Surv_2500	Urban_3000	-	-	203.60	28.10	29.60	0.31	1.00	1.21	-	-	1.26	50.33	-	-	0.26	0.00	-	-
Urban_3000	-	-	-	203.74	28.24	29.60	0.31	1.16	-	-	-	61.57	-	-	-	0.00	-	-	-
Disp_1000	Winter_3000	Surv_2500	-	204.60	29.10	31.10	0.28	2.42	1.00	1.00	-	5.98	25.46	4.17	-	0.10	0.00	0.04	-
Disp_5000	Winter_3000	Surv_2500	-	205.95	30.45	29.20	0.26	1.00	1.00	1.00	-	2.34	19.71	1.30	-	0.13	0.00	0.25	-
Winter_3000	Surv_2500	-	-	206.30	30.80	28.40	0.25	1.00	1.00	-	-	26.44	3.09	-	-	0.00	0.08	-	-
Disp_2500	Winter_3000	Surv_2500	-	207.31	31.81	30.10	0.27	2.39	1.00	1.00	-	3.53	24.05	2.06	-	0.34	0.00	0.15	-
Disp_5000	Winter_3000	Surv_1000	-	208.15	32.65	28.40	0.26	1.00	1.00	1.00	-	3.45	19.17	0.87	-	0.06	0.00	0.35	-
Disp_1000	Winter_3000	Surv_1000	-	208.20	32.70	29.70	0.27	2.33	1.00	1.00	-	5.39	25.49	2.73	-	0.11	0.00	0.10	-
Disp_5000	Winter_3000	-	-	208.30	32.80	28.50	0.26	1.00	1.00	-	-	6.24	19.58	-	-	0.01	0.00	-	-
Disp_1000	Winter_1000	Surv_5000	-	208.90	33.40	32.50	0.29	2.37	1.00	3.31	-	5.36	16.93	24.11	-	0.12	0.00	0.00	-
Winter_3000	Surv_1000	-	-	209.60	34.10	27.20	0.24	1.00	1.00	-	-	26.68	2.51	-	-	0.00	0.11	-	-
Disp_2500	Winter_3000	Surv_1000	-	210.17	34.67	28.80	0.26	2.06	1.00	1.00	-	3.98	23.41	1.00	-	0.31	0.00	0.32	-
Winter_1000	Surv_5000	-	-	210.70	35.20	30.00	0.28	1.00	3.55	-	-	16.07	25.74	-	-	0.00	0.00	-	-
Disp_2500	Winter_3000	-	-	210.90	35.40	28.30	0.26	1.65	1.00	-	-	4.58	24.03	-	-	0.10	0.00	-	-
Disp_1000	Winter_3000	-	-	211.90	36.40	28.20	0.26	1.97	1.00	-	-	4.23	27.36	-	-	0.15	0.00	-	-
Disp_2500	Winter_1000	Surv_5000	-	212.26	36.76	30.20	0.27	1.00	1.00	3.62	-	0.24	16.05	19.20	-	0.63	0.00	0.00	-
Winter_3000	-	-	-	212.67	37.17	26.30	0.23	1.00	-	-	-	30.00	-	-	-	0.00	-	-	-
Disp_1000	Winter_500	Surv_5000	-	212.78	37.28	31.20	0.28	2.24	1.00	3.49	-	4.54	15.28	27.61	-	0.15	0.00	0.00	-
Disp_5000	Winter_1000	Surv_5000	-	212.94	37.44	30.30	0.28	1.26	1.00	3.60	-	0.18	15.10	13.76	-	0.87	0.00	0.01	-
Winter_500	Surv_5000	-	-	213.90	38.40	29.00	0.27	1.00	3.67	-	-	14.32	30.05	-	-	0.00	0.00	-	-
Disp_2500	Winter_500	Surv_5000	-	215.48	39.98	29.10	0.26	1.00	1.00	3.72	-	0.18	14.34	21.27	-	0.67	0.00	0.00	-
Disp_5000	Winter_500	Surv_5000	-	216.07	40.57	29.80	0.27	1.71	1.00	3.74	-	1.39	13.59	14.08	-	0.57	0.00	0.01	-
Disp_5000	Winter_1000	Surv_2500	-	223.77	48.27	23.80	0.20	1.30	1.44	1.00	-	8.42	14.67	0.85	-	0.01	0.01	0.36	-
Disp_5000	Winter_1000	-	-	225.10	49.60	23.90	0.21	1.52	1.65	-	-	15.58	11.66	-	-	0.00	0.01	-	-
Disp_5000	Winter_1000	Surv_1000	-	225.48	49.98	23.50	0.20	1.37	1.72	1.00	-	11.21	11.52	0.33	-	0.00	0.01	0.57	-
Disp_1000	Winter_1000	Surv_2500	-	225.90	50.40	24.00	0.20	2.62	1.00	1.28	-	8.10	21.20	5.90	-	0.05	0.00	0.02	-
Disp_5000	Winter_500	Surv_2500	-	226.84	51.34	22.50	0.19	1.68	1.00	1.00	-	12.66	12.20	0.76	-	0.00	0.00	0.38	-
Winter_1000	Surv_2500	-	-	228.30	52.80	22.60	0.19	1.00	3.15	-	-	19.55	10.87	-	-	0.00	0.03	-	-
Disp_5000	Winter_500	-	-	228.40	52.90	22.60	0.20	1.84	1.20	-	-	20.64	12.82	-	-	0.00	0.01	-	-

Disp_5000	Winter_500	Surv_1000	-	229.22	53.72	22.30	0.19	1.75	1.45	1.00	-	15.65	6.13	0.32	-	0.00	0.02	0.57	-
Disp_2500	Winter_1000	Surv_2500	-	229.25	53.75	22.10	0.18	2.22	1.00	1.00	-	4.68	18.23	1.85	-	0.26	0.00	0.17	-
Disp_2500	Winter_1000	-	-	231.90	56.40	20.60	0.18	1.00	1.35	-	-	8.46	18.49	-	-	0.00	0.01	-	-
Disp_1000	Winter_1000	Surv_1000	-	232.10	56.60	21.90	0.17	2.45	1.50	1.00	-	7.38	21.29	3.12	-	0.06	0.00	0.08	-
Disp_2500	Winter_1000	Surv_1000	-	232.62	57.12	21.10	0.17	1.64	1.57	1.00	-	5.46	15.67	0.39	-	0.07	0.00	0.53	-
Disp_1000	Winter_500	Surv_2500	-	234.14	58.64	22.30	0.18	2.34	1.00	2.86	-	4.74	17.26	9.93	-	0.17	0.00	0.03	-
Winter_500	Surv_2500	-	-	234.60	59.10	20.60	0.17	1.00	3.41	-	-	16.37	12.85	-	-	0.00	0.01	-	-
Winter_1000	Surv_1000	-	-	234.60	59.10	18.70	0.15	1.35	1.03	-	-	22.35	3.18	-	-	0.00	0.09	-	-
Disp_2500	Winter_500	Surv_2500	-	235.27	59.77	18.70	0.15	1.00	1.00	1.00	-	3.55	14.53	1.39	-	0.06	0.00	0.24	-
Surv_5000	-	-	-	235.67	60.17	20.50	0.21	3.76	-	-	-	42.62	-	-	-	0.00	-	-	-
Disp_1000	Winter_1000	-	-	236.90	61.40	20.20	0.16	2.10	1.61	-	-	5.95	18.67	-	-	0.07	0.00	-	-
Disp_5000	Surv_5000	-	-	236.97	61.47	21.70	0.21	1.88	3.46	-	-	3.48	13.31	-	-	0.26	0.01	-	-
Disp_2500	Winter_500	Surv_1000	-	237.30	61.80	18.00	0.15	1.00	1.00	1.00	-	6.44	13.55	0.29	-	0.01	0.00	0.59	-
Disp_2500	Winter_500	-	-	237.40	61.90	18.20	0.16	1.00	1.00	-	-	11.19	13.99	-	-	0.00	0.00	-	-
Disp_2500	Surv_5000	-	-	237.70	62.20	20.50	0.20	1.00	3.60	-	-	0.37	22.48	-	-	0.54	0.00	-	-
Disp_1000	Surv_5000	-	-	238.10	62.60	21.20	0.21	1.73	3.60	-	-	1.34	33.19	-	-	0.51	0.00	-	-
Winter_1000	-	-	-	238.27	62.77	17.20	0.13	1.00	-	-	-	24.58	-	-	-	0.00	-	-	-
Disp_1000	Winter_500	Surv_1000	-	240.20	64.70	18.30	0.14	2.35	1.00	1.00	-	5.92	2.79	2.79	-	0.10	0.00	0.10	-
Winter_500	Surv_1000	-	-	241.90	66.40	15.60	0.12	1.00	1.00	-	-	17.90	3.40	-	-	0.00	0.07	-	-
Disp_1000	Winter_500	-	-	244.90	69.40	16.60	0.13	1.94	1.00	-	-	6.29	17.39	-	-	0.06	0.00	-	-
Disp_5000	-	-	-	245.61	70.11	15.40	0.14	1.93	-	-	-	34.73	-	-	-	0.00	-	-	-
Disp_5000	Surv_2500	-	-	246.20	70.70	15.20	0.13	1.95	1.00	-	-	21.90	0.63	-	-	0.00	0.43	-	-
Disp_5000	Surv_1000	-	-	246.30	70.80	15.10	0.13	1.98	1.00	-	-	25.00	0.46	-	-	0.00	0.50	-	-
Winter_500	-	-	-	247.62	72.12	13.90	0.11	1.00	-	-	-	20.90	-	-	-	0.00	-	-	-
Surv_2500	-	-	-	257.48	81.98	12.10	0.10	4.82	-	-	-	25.72	-	-	-	0.00	-	-	-
Disp_2500	Surv_2500	-	-	258.10	82.60	9.84	0.09	1.00	1.00	-	-	10.40	1.35	-	-	0.00	0.25	-	-
Disp_2500	Surv_1000	-	-	258.30	82.80	9.76	0.09	1.00	1.00	-	-	14.22	0.26	-	-	0.00	0.61	-	-
Disp_2500	-	-	-	259.47	83.97	9.72	0.10	1.00	-	-	-	23.46	-	-	-	0.00	-	-	-
Disp_1000	Surv_2500	-	-	261.60	86.10	11.90	0.10	1.86	3.55	-	-	1.56	13.90	-	-	0.49	0.01	-	-
Disp_1000	Surv_1000	-	-	269.60	94.10	6.99	0.05	2.22	1.00	-	-	5.71	2.38	-	-	0.09	0.12	-	-
Surv_1000	-	-	-	270.30	94.80	6.15	0.05	2.94	-	-	-	11.37	-	-	-	0.02	-	-	-
Disp_1000	-	-	-	273.33	97.83	5.39	0.05	1.80	-	-	-	13.54	-	-	-	0.00	-	-	-

Table 6: Generalized Additive Model Results for Gray Treefrog

Variable 1	Variable 2	Variable 3	Variable 4	AIC	Delta	% Variance Explained	R^2	edf 1	edf 2	edf 3	edf 4	ANOVA F 1	ANOVA F 2	ANOVA F 3	ANOVA F 4	p-value 1	p-value 2	p-value 3	p-value 4
Disp_1000	Winter_3000	Surv_5000	NatAgri_3000	185.89	0.00	47.30	0.51	3.89	1.26	1.00	1.00	11.68	13.54	3.85	24.71	0.047	0.010	0.050	0.000
Disp_1000	Winter_1000	Surv_5000	NatAgri_3000	186.52	0.63	48.20	0.51	3.82	1.00	2.65	1.00	10.15	10.13	5.74	28.77	0.066	0.001	0.126	0.000
Winter_3000	Surv_5000	NatAgri_3000	-	187.40	1.51	48.00	0.49	4.29	3.22	1.00	-	15.29	8.55	19.66	-	0.008	0.069	0.000	-
Disp_1000	Winter_3000	Surv_1000	NatAgri_3000	189.07	3.18	45.30	0.49	3.62	1.00	1.00	1.00	11.30	10.66	1.75	31.89	0.03	0.00	0.19	0.00
Disp_1000	Winter_500	Surv_5000	NatAgri_3000	189.09	3.20	47.40	0.50	3.73	1.00	2.77	1.00	9.15	8.95	5.98	33.53	0.09	0.00	0.12	0.00
Disp_1000	Winter_3000	Surv_2500	NatAgri_3000	189.23	3.34	45.70	0.50	3.87	1.19	1.10	1.00	11.51	13.21	1.55	27.43	0.04	0.01	0.22	0.00
Disp_2500	Winter_3000	Surv_2500	NatAgri_3000	189.26	3.37	47.20	0.48	1.00	4.36	2.78	1.00	2.73	12.13	3.43	26.07	0.10	0.03	0.45	0.00
Disp_5000	Winter_1000	NatAgri_3000	-	189.80	3.91	43.70	0.46	2.03	1.00	1.00	-	11.79	7.04	32.90	-	0.01	0.01	0.00	-
Disp_1000	Winter_1000	Surv_2500	NatAgri_3000	190.09	4.20	45.50	0.49	3.91	1.00	1.31	1.00	10.78	9.98	1.79	38.91	0.05	0.00	0.22	0.00
Disp_5000	Winter_1000	Surv_5000	NatAgri_3000	190.12	4.23	45.90	0.46	2.14	1.00	2.77	1.00	5.53	7.67	3.29	27.58	0.12	0.01	0.42	0.00
Disp_5000	Winter_500	Surv_5000	NatAgri_3000	190.13	4.24	46.10	0.48	2.36	1.00	2.84	1.00	6.99	7.84	3.29	30.98	0.07	0.01	0.43	0.00
Disp_1000	Winter_1000	Surv_1000	NatAgri_3000	190.23	4.34	44.80	0.48	3.54	1.00	1.00	1.00	11.06	9.89	1.92	45.55	0.03	0.00	0.17	0.00
Disp_2500	Winter_1000	Surv_5000	NatAgri_3000	190.89	5.00	44.60	0.48	1.00	1.00	2.75	1.00	2.65	8.39	4.11	31.60	0.10	0.00	0.30	0.00
Disp_1000	Winter_3000	NatAgri_3000	-	190.98	5.09	44.90	0.49	3.50	1.19	1.20	-	11.37	12.66	36.37	-	0.04	0.01	0.00	-
Disp_5000	Winter_1000	Surv_1000	NatAgri_3000	191.08	5.19	43.40	0.46	1.96	1.00	1.00	1.00	8.30	6.96	0.42	33.00	0.03	0.01	0.51	0.00
Disp_5000	Winter_500	Surv_1000	NatAgri_3000	191.21	5.32	43.50	0.46	2.16	1.00	1.00	1.00	9.96	7.17	0.43	36.17	0.02	0.01	0.51	0.00
Disp_5000	Winter_1000	Surv_2500	NatAgri_3000	191.23	5.34	45.10	0.47	2.24	1.00	2.79	1.00	6.58	7.30	3.59	31.47	0.08	0.01	0.44	0.00
Disp_5000	Winter_500	Surv_2500	NatAgri_3000	191.29	5.40	45.40	0.47	2.48	1.00	2.89	1.00	8.19	7.38	3.86	34.81	0.05	0.01	0.42	0.00
Disp_5000	Winter_3000	NatAgri_3000	-	191.30	5.41	43.10	0.46	1.87	1.00	1.00	-	9.76	7.39	25.38	-	0.01	0.01	0.00	-
Disp_2500	Winter_3000	Surv_5000	NatAgri_3000	191.32	5.43	44.70	0.48	1.00	1.29	2.66	1.00	2.43	11.51	3.73	22.52	0.12	0.02	0.34	0.00
Winter_1000	Surv_5000	NatAgri_3000	-	191.36	5.47	44.00	0.48	1.00	3.10	1.00	-	10.66	9.07	29.56	-	0.00	0.05	0.00	-
Disp_2500	Winter_3000	NatAgri_3000	-	191.55	5.66	42.30	0.46	1.00	1.11	1.00	-	7.85	9.55	30.51	-	0.01	0.01	0.00	-
Disp_2500	Winter_1000	NatAgri_3000	-	191.60	5.71	42.20	0.46	1.00	1.00	1.00	-	8.48	7.56	42.72	-	0.00	0.01	0.00	-
Disp_5000	Winter_3000	Surv_5000	NatAgri_3000	191.73	5.84	45.40	0.48	1.97	1.12	2.77	1.00	3.94	8.70	3.23	20.51	0.21	0.01	0.43	0.00
Disp_1000	Winter_1000	NatAgri_3000	-	192.00	6.11	44.00	0.48	3.42	1.00	1.00	-	10.81	9.33	46.94	-	0.04	0.00	0.00	-
Disp_2500	Winter_500	Surv_5000	NatAgri_3000	192.02	6.13	44.20	0.48	1.00	1.00	2.78	1.00	3.16	7.95	4.06	36.60	0.08	0.00	0.31	0.00
Disp_5000	Winter_3000	Surv_1000	NatAgri_3000	192.21	6.32	42.80	0.46	1.74	1.00	1.00	1.00	6.17	7.32	0.63	25.51	0.06	0.01	0.43	0.00
Disp_5000	Winter_3000	Surv_2500	NatAgri_3000	192.55	6.66	44.50	0.47	2.08	1.00	2.78	1.00	4.89	7.32	3.57	23.67	0.15	0.01	0.44	0.00
Disp_2500	Winter_500	NatAgri_3000	-	192.70	6.81	41.80	0.46	1.00	1.00	1.00	-	9.75	7.15	48.14	-	0.00	0.01	0.00	-
Disp_2500	Winter_3000	Surv_1000	NatAgri_3000	192.87	6.98	42.00	0.46	1.00	1.12	1.00	1.00	4.15	9.62	0.29	30.09	0.04	0.01	0.59	0.00
Winter_500	Surv_5000	NatAgri_3000	-	192.94	7.05	43.60	0.47	1.00	3.17	1.00	-	10.06	9.79	34.42	-	0.00	0.04	0.00	-
Disp_2500	Winter_1000	Surv_1000	NatAgri_3000	193.05	7.16	41.80	0.45	1.00	1.00	1.00	1.00	4.81	7.50	0.21	42.33	0.03	0.01	0.64	0.00
Disp_1000	Winter_500	Surv_2500	NatAgri_3000	193.21	7.32	44.50	0.48	3.84	1.00	1.34	1.00	9.88	8.49	1.70	45.68	0.07	0.00	0.25	0.00
Disp_1000	Winter_500	Surv_1000	NatAgri_3000	193.29	7.40	43.80	0.47	3.44	1.00	1.00	1.00	9.83	8.39	1.85	52.23	0.05	0.00	0.17	0.00
Winter_3000	Surv_2500	NatAgri_3000	-	193.32	7.43	43.50	0.47	1.37	3.30	1.00	-	7.43	8.57	25.71	-	0.01	0.08	0.00	-
Disp_2500	Winter_1000	Surv_2500	NatAgri_3000	193.53	7.64	43.00	0.46	1.00	1.00	2.56	1.00	2.84	8.02	2.78	39.12	0.09	0.00	0.49	0.00
Winter_3000	Surv_1000	NatAgri_3000	-	193.60	7.71	43.30	0.47	1.25	3.32	1.00	-	12.48	8.68	31.36	-	0.01	0.08	0.00	-
Winter_1000	Surv_2500	NatAgri_3000	-	193.80	7.91	43.00	0.47	1.00	3.34	1.00	-	10.70	9.21	38.22	-	0.00	0.06	0.00	-
Winter_1000	Surv_1000	NatAgri_3000	-	193.90	8.01	43.00	0.47	1.00	3.49	1.00	-	9.46	9.39	45.27	-	0.00	0.07	0.00	-
Disp_2500	Winter_500	Surv_1000	NatAgri_3000	194.13	8.24	41.50	0.45	1.00	1.00	1.00	1.00	5.60	7.11	0.24	47.65	0.02	0.01	0.62	0.00
Disp_1000	Winter_3000	Surv_5000	Urban_3000	194.73	8.84	46.40	0.48	3.80	1.71	2.81	1.00	10.01	20.09	5.64	14.88	0.07	0.00	0.14	0.00
Disp_1000	Winter_500	NatAgri_3000	-	194.87	8.98	43.10	0.47	3.28	1.00	1.00	-	10.23	7.98	53.67	-	0.04	0.00	0.00	-
Disp_2500	Winter_500	Surv_2500	NatAgri_3000	194.88	8.99	42.50	0.46	1.00	1.00	2.42	1.00	3.79	7.41	2.24	45.06	0.05	0.01	0.54	0.00
Winter_500	Surv_1000	NatAgri_3000	-	195.40	9.51	42.60	0.46	1.00	3.57	1.00	-	8.86	9.93	51.90	-	0.00	0.06	0.00	-
Winter_500	Surv_2500	NatAgri_3000	-	195.70	9.81	42.40	0.46	1.00	3.41	1.00	-	9.77	9.71	44.53	-	0.00	0.06	0.00	-
Winter_3000	Surv_5000	Urban_3000	-	195.70	9.81	45.30	0.45	4.06	3.39	1.00	-	23.23	9.62	13.03	-	0.00	0.05	0.00	-

Disp_2500	Winter_3000	Surv_5000	Urban_3000	195.74	9.85	45.90	0.46	1.00	4.14	3.19	1.00	1.97	20.95	5.09	14.20	0.16	0.00	0.25	0.00
Disp_1000	Winter_3000	Surv_2500	Urban_3000	196.72	10.83	43.90	0.45	3.84	1.80	1.00	1.00	11.68	22.71	1.23	21.96	0.03	0.00	0.27	0.00
Disp_5000	Winter_3000	Urban_3000	-	196.98	11.09	42.00	0.43	1.97	1.56	1.00	-	10.17	10.80	20.72	-	0.01	0.00	0.00	-
Disp_1000	Winter_3000	Urban_3000	-	197.40	11.51	43.30	0.45	3.53	1.79	1.00	-	11.00	22.36	28.33	-	0.04	0.00	0.00	-
Disp_1000	Winter_1000	Surv_5000	Urban_3000	197.48	11.59	45.20	0.47	3.91	1.00	3.16	1.00	11.10	14.99	8.99	20.10	0.05	0.00	0.04	0.00
Disp_1000	Winter_3000	Surv_1000	Urban_3000	197.68	11.79	43.40	0.45	3.66	1.83	1.00	1.00	11.28	22.96	0.77	25.88	0.03	0.00	0.38	0.00
Disp_5000	Winter_3000	Surv_5000	Urban_3000	197.82	11.93	44.50	0.45	2.24	1.69	3.11	1.00	5.12	14.33	3.61	14.04	0.16	0.00	0.42	0.00
Winter_3000	NatAgri_3000	-	-	198.20	12.31	40.40	0.44	1.38	1.45	-	-	8.56	37.36	-	-	0.01	0.00	-	-
Disp_1000	Winter_1000	Surv_5000	ForWet_3000	198.24	12.35	43.50	0.45	3.83	1.00	1.00	1.43	11.37	2.53	2.89	14.68	0.04	0.11	0.09	0.00
Disp_2500	Winter_3000	Urban_3000	-	198.50	12.61	40.90	0.43	1.00	1.90	1.00	-	6.72	18.62	24.69	-	0.01	0.00	0.00	-
Disp_5000	Winter_1000	Urban_3000	-	198.50	12.61	42.90	0.44	2.42	1.00	2.81	-	15.93	9.73	27.70	-	0.00	0.00	0.00	-
Disp_1000	Winter_500	Surv_5000	ForWet_3000	198.50	12.61	43.40	0.45	3.78	1.00	1.00	1.43	10.90	2.44	2.71	19.51	0.05	0.12	0.10	0.00
Disp_5000	Winter_3000	Surv_1000	Urban_3000	198.80	12.91	41.50	0.42	1.96	1.58	1.00	1.00	8.56	11.34	0.03	20.07	0.02	0.00	0.87	0.00
Winter_3000	Surv_2500	Urban_3000	-	198.90	13.01	43.80	0.43	3.83	3.53	1.00	-	23.59	7.77	18.63	-	0.00	0.12	0.00	-
Winter_1000	NatAgri_3000	-	-	198.96	13.07	39.50	0.44	1.00	1.27	-	-	12.23	53.28	-	-	0.00	0.00	-	-
Disp_5000	Winter_3000	Surv_2500	Urban_3000	199.01	13.12	43.10	0.43	2.20	1.62	2.57	1.00	6.43	13.34	2.50	19.13	0.08	0.00	0.55	0.00
Disp_5000	Winter_1000	Surv_5000	Urban_3000	199.01	13.12	45.40	0.46	2.65	1.00	3.26	2.82	8.99	10.30	4.51	21.32	0.04	0.00	0.34	0.00
Disp_5000	Winter_500	Urban_3000	-	199.50	13.61	42.90	0.43	2.67	1.00	3.02	-	19.16	9.30	30.38	-	0.00	0.00	0.00	-
Disp_5000	Winter_500	ForWet_3000	-	199.90	14.01	41.10	0.42	2.22	1.00	1.37	-	8.29	2.35	16.14	-	0.03	0.13	0.00	-
Disp_5000	Winter_500	Surv_5000	Urban_3000	199.96	14.07	45.60	0.46	2.90	1.00	3.32	3.06	11.65	9.78	4.56	24.24	0.02	0.00	0.34	0.00
Disp_1000	Winter_3000	Surv_5000	ForWet_3000	199.98	14.09	43.10	0.44	3.82	1.00	1.00	1.57	11.16	1.38	2.75	12.58	0.04	0.24	0.10	0.00
Disp_2500	Winter_3000	Surv_2500	Urban_3000	200.19	14.30	40.50	0.42	1.00	1.95	1.00	1.00	4.77	18.82	0.01	22.42	0.03	0.00	0.94	0.00
Disp_1000	Winter_1000	Surv_2500	ForWet_3000	200.23	14.34	42.80	0.44	3.74	1.00	1.39	1.53	9.66	2.24	0.95	22.76	0.07	0.13	0.43	0.00
Disp_1000	Winter_500	Surv_2500	ForWet_3000	200.30	14.41	42.70	0.44	3.69	1.00	1.35	1.53	9.37	2.26	0.77	27.82	0.08	0.13	0.48	0.00
Disp_2500	Winter_3000	Surv_1000	Urban_3000	200.33	14.44	40.40	0.42	1.00	1.88	1.00	1.00	5.16	18.40	0.01	23.83	0.02	0.00	0.93	0.00
Disp_5000	Winter_500	Surv_2500	ForWet_3000	200.34	14.45	43.10	0.44	2.46	1.00	3.16	1.36	5.83	2.50	4.93	15.55	0.12	0.11	0.32	0.00
Disp_5000	Winter_1000	Surv_1000	Urban_3000	200.36	14.47	42.40	0.43	2.43	1.00	1.00	2.80	14.50	9.66	0.02	27.35	0.00	0.00	0.88	0.00
Disp_5000	NatAgri_3000	-	-	200.40	14.51	40.30	0.43	2.68	1.00	-	-	18.48	40.96	-	-	0.00	0.00	-	-
Disp_5000	Winter_1000	Surv_2500	Urban_3000	200.41	14.52	44.20	0.44	2.70	1.00	2.91	2.79	10.85	9.60	3.67	25.68	0.02	0.00	0.45	0.00
Disp_1000	Winter_1000	Surv_1000	ForWet_3000	200.44	14.55	42.10	0.43	3.53	1.00	1.00	1.00	10.52	1.94	1.08	25.79	0.04	0.16	0.30	0.00
Disp_1000	Winter_500	Surv_1000	ForWet_3000	200.50	14.61	42.10	0.43	3.50	1.00	1.00	1.51	10.17	2.01	1.04	29.75	0.05	0.16	0.31	0.00
Disp_5000	Winter_1000	ForWet_3000	-	200.54	14.65	40.90	0.42	2.17	1.00	1.39	-	8.09	1.78	14.37	-	0.04	0.18	0.00	-
Disp_5000	Winter_500	Surv_5000	ForWet_3000	200.74	14.85	43.20	0.45	2.41	1.00	3.15	1.15	5.57	2.94	3.41	14.28	0.14	0.09	0.44	0.00
Disp_1000	Winter_500	ForWet_3000	-	200.78	14.89	41.90	0.44	3.41	1.00	1.57	-	9.07	1.87	37.54	-	0.07	0.17	0.00	-
Disp_1000	Winter_1000	ForWet_3000	-	200.80	14.91	41.90	0.44	3.44	1.00	1.57	-	9.45	1.73	32.99	-	0.06	0.19	0.00	-
Disp_5000	ForWet_3000	-	-	201.10	15.21	40.10	0.42	2.19	1.36	-	-	8.12	20.99	-	-	0.04	0.00	-	-
Disp_5000	Winter_1000	Surv_2500	ForWet_3000	201.10	15.21	42.70	0.44	2.38	1.00	3.07	1.38	5.54	1.87	4.72	13.67	0.14	0.17	0.34	0.00
Disp_1000	ForWet_3000	-	-	201.11	15.22	41.20	0.43	3.47	1.53	-	-	9.55	41.06	-	-	0.06	0.00	-	-
Disp_5000	Winter_500	Surv_2500	Urban_3000	201.31	15.42	44.40	0.44	2.98	1.00	3.05	3.00	13.62	9.07	4.00	28.47	0.01	0.00	0.42	0.00
Disp_5000	Winter_500	Surv_1000	Urban_3000	201.40	15.51	42.40	0.43	2.69	1.00	1.00	3.01	17.63	9.24	0.04	30.01	0.00	0.00	0.85	0.00
Disp_5000	Winter_500	Surv_1000	ForWet_3000	201.53	15.64	40.70	0.42	2.22	1.00	1.00	1.36	7.34	2.30	0.01	15.79	0.05	0.13	0.93	0.00
Disp_5000	Winter_1000	Surv_5000	ForWet_3000	201.53	15.64	42.90	0.44	2.34	1.00	3.10	1.18	5.21	2.36	3.31	11.25	0.16	0.12	0.45	0.00
Disp_5000	Winter_500	NatAgri_3000	-	201.56	15.67	38.80	0.46	2.21	1.00	1.00	-	13.74	7.27	36.17	-	0.00	0.01	0.00	-
Winter_500	NatAgri_3000	-	-	201.60	15.71	38.80	0.43	1.00	1.36	-	-	11.18	62.90	-	-	0.00	0.00	-	-
Disp_1000	Winter_3000	Surv_2500	ForWet_3000	201.84	15.95	42.40	0.44	3.73	1.00	1.30	1.67	9.72	1.10	0.69	18.78	0.07	0.29	0.48	0.00
Winter_3000	Surv_1000	Urban_3000	-	201.90	16.01	41.50	0.43	2.12	2.51	1.00	-	23.11	7.15	25.07	-	0.00	0.15	0.00	-
Winter_500	Surv_2500	ForWet_3000	-	202.11	16.22	40.80	0.43	1.00	3.31	1.43	-	2.47	6.85	21.86	-	0.12	0.15	0.00	-
Disp_1000	Winter_3000	Surv_1000	ForWet_3000	202.13	16.24	41.70	0.43	3.54	1.00	1.00	1.64	10.30	0.72	0.98	22.98	0.05	0.40	0.32	0.00
Winter_3000	Urban_3000	-	-	202.13	16.24	40.40	0.41	3.68	1.00	-	-	27.73	26.64	-	-	0.00	0.00	-	-
Disp_5000	Winter_1000	Surv_1000	ForWet_3000	202.14	16.25	40.40	0.42	2.17	1.00	1.00	1.38	7.09	1.74	0.01	14.03	0.06	0.19	0.93	0.00

Disp_2500	Winter_500	ForWet_3000	-	202.20	16.31	39.30	0.42	1.00	1.00	1.45	-	4.42	1.78	23.62	-	0.04	0.18	0.00	-
Disp_1000	Winter_3000	ForWet_3000	-	202.30	16.41	41.50	0.43	3.44	1.00	1.66	-	9.43	0.65	24.77	-	0.06	0.42	0.00	-
Disp_2500	ForWet_3000	-	-	202.40	16.51	38.60	0.42	1.00	1.43	-	-	5.05	28.26	-	-	0.02	0.00	-	-
Disp_5000	Winter_3000	ForWet_3000	-	202.40	16.51	40.40	0.42	2.12	1.00	1.53	-	7.81	0.62	12.99	-	0.04	0.43	0.00	-
Disp_2500	Winter_1000	ForWet_3000	-	202.50	16.61	39.20	0.42	1.00	1.00	1.46	-	4.49	1.42	21.05	-	0.03	0.23	0.00	-
Winter_1000	Surv_2500	ForWet_3000	-	202.55	16.66	40.60	0.43	1.00	3.29	1.45	-	2.12	6.83	18.74	-	0.15	0.15	0.00	-
Winter_500	Surv_5000	ForWet_3000	-	202.69	16.80	40.70	0.43	1.00	3.08	1.22	-	2.93	6.36	15.61	-	0.09	0.14	0.00	-
Disp_2500	NatAgri_3000	-	-	202.80	16.91	38.00	0.43	1.00	1.00	-	-	15.33	56.10	-	-	0.00	0.00	-	-
Winter_1000	Surv_5000	ForWet_3000	-	202.88	16.99	40.70	0.43	1.00	3.09	1.24	-	2.70	6.60	12.02	-	0.10	0.13	0.00	-
Disp_5000	Winter_3000	Surv_2500	ForWet_3000	203.07	17.18	42.20	0.43	2.35	1.00	3.01	1.52	5.33	0.61	4.47	11.57	0.15	0.44	0.36	0.00
Disp_1000	Winter_1000	Surv_2500	Urban_3000	203.11	17.22	41.80	0.43	4.00	1.00	1.69	1.00	11.39	15.43	3.22	30.48	0.04	0.00	0.25	0.00
Surv_2500	ForWet_3000	-	-	203.20	17.31	39.70	0.42	3.25	1.42	-	-	6.67	27.81	-	-	0.16	0.00	-	-
Disp_1000	Winter_500	Surv_5000	Urban_3000	203.22	17.33	43.40	0.44	3.85	1.00	3.29	1.00	10.22	12.08	10.91	22.94	0.06	0.00	0.03	0.00
Disp_2500	Winter_1000	Surv_5000	Urban_3000	203.45	17.56	43.70	0.45	2.52	1.00	3.37	2.47	5.52	12.54	6.37	22.96	0.20	0.00	0.19	0.00
Winter_1000	Surv_5000	Urban_3000	-	203.50	17.61	40.50	0.42	1.00	3.50	1.00	-	14.60	12.33	19.64	-	0.00	0.02	0.00	-
Disp_2500	Winter_500	Surv_5000	ForWet_3000	203.59	17.70	40.80	0.43	1.00	1.00	2.71	1.21	1.46	2.32	2.99	16.37	0.23	0.13	0.43	0.00
Disp_2500	Winter_1000	Surv_2500	ForWet_3000	203.62	17.73	40.50	0.43	1.00	1.00	2.84	1.41	1.31	1.61	3.86	17.56	0.25	0.21	0.39	0.00
Disp_2500	Winter_500	Surv_1000	ForWet_3000	203.68	17.79	38.90	0.41	1.00	1.00	1.00	1.43	3.49	1.73	0.01	22.50	0.06	0.19	0.94	0.00
Disp_2500	Winter_500	Surv_2500	ForWet_3000	203.68	17.79	41.00	0.43	1.38	1.00	2.98	1.39	1.13	2.05	4.27	10.04	0.43	0.15	0.36	0.00
Disp_2500	Winter_3000	ForWet_3000	-	203.80	17.91	38.90	0.42	1.00	1.00	1.58	-	4.69	0.51	20.10	-	0.03	0.47	0.00	-
Disp_2500	Winter_1000	Surv_5000	ForWet_3000	203.83	17.94	40.70	0.43	1.00	1.00	2.73	1.22	1.41	2.04	3.12	13.05	0.24	0.15	0.41	0.00
Disp_5000	Winter_3000	Surv_1000	ForWet_3000	203.98	18.09	40.00	0.41	2.12	1.00	1.00	1.51	6.67	0.60	0.86	12.14	0.07	0.44	0.86	0.00
Disp_5000	Winter_3000	Surv_5000	ForWet_3000	204.00	18.11	32.30	0.43	2.27	1.00	3.04	1.45	4.75	1.01	2.98	6.72	0.19	0.31	0.50	0.02
Disp_2500	Winter_1000	Surv_1000	ForWet_3000	204.03	18.14	38.80	0.41	1.00	1.00	1.00	1.43	3.53	1.39	0.01	20.04	0.06	0.24	0.93	0.00
Winter_3000	Surv_2500	ForWet_3000	-	204.17	18.28	40.20	0.42	1.00	3.27	1.60	-	1.00	6.68	17.96	-	0.32	0.16	0.00	-
Disp_1000	Winter_1000	Urban_3000	-	204.20	18.31	40.40	0.42	3.60	1.00	1.00	-	11.89	15.16	40.60	-	0.03	0.00	0.00	-
Disp_2500	Winter_1000	Urban_3000	-	204.20	18.31	41.30	0.43	2.85	1.00	2.66	-	13.64	11.91	36.19	-	0.01	0.00	0.00	-
Disp_1000	Winter_1000	Surv_1000	Urban_3000	204.31	18.42	40.40	0.42	3.69	1.00	1.00	1.00	12.46	15.42	0.83	37.84	0.02	0.00	0.36	0.00
Disp_1000	NatAgri_3000	-	-	204.40	18.51	40.10	0.46	4.19	1.00	-	-	16.47	65.10	-	-	0.01	0.00	-	-
Winter_500	ForWet_3000	-	-	204.60	18.71	38.10	0.40	1.00	1.65	-	-	2.35	45.64	-	-	0.13	0.00	-	-
Winter_3000	Surv_5000	ForWet_3000	-	204.66	18.77	40.40	0.42	1.01	3.09	1.50	-	1.66	6.44	7.34	-	0.20	0.14	0.01	-
Surv_5000	ForWet_3000	-	-	204.70	18.81	39.30	0.42	2.89	1.21	-	-	5.39	22.79	-	-	0.18	0.00	-	-
Surv_1000	ForWet_3000	-	-	204.90	19.01	39.20	0.41	3.16	1.50	-	-	5.33	36.09	-	-	0.21	0.00	-	-
Winter_1000	ForWet_3000	-	-	204.99	19.10	38.00	0.40	1.00	1.67	-	-	1.94	38.72	-	-	0.16	0.00	-	-
Disp_2500	Winter_3000	Surv_2500	ForWet_3000	205.09	19.20	2.29	0.42	1.00	1.00	2.74	1.54	1.55	0.63	3.47	14.70	0.21	0.43	0.42	0.00
Winter_500	Surv_1000	ForWet_3000	-	205.14	19.25	38.00	0.40	1.00	1.00	1.58	-	2.14	0.86	37.48	-	0.14	0.36	0.00	-
Disp_2500	Winter_3000	Surv_1000	ForWet_3000	205.34	19.45	38.50	0.41	1.00	1.00	1.00	1.56	3.58	0.50	0.00	18.07	0.06	0.48	0.97	0.00
ForWet_3000	-	-	-	205.55	19.66	37.20	0.40	1.63	-	-	-	59.29	-	-	-	0.00	-	-	-
Winter_1000	Surv_1000	ForWet_3000	-	205.55	19.66	37.90	0.40	1.00	1.06	1.60	-	1.76	1.00	36.01	-	0.18	0.37	0.00	-
Disp_2500	Winter_3000	Surv_5000	ForWet_3000	205.57	19.68	40.40	0.43	1.00	1.00	2.67	1.46	1.50	1.04	2.87	7.90	0.22	0.31	0.45	0.01
Disp_2500	Winter_1000	Surv_1000	Urban_3000	206.01	20.12	40.60	0.42	2.67	1.00	1.00	2.63	11.60	11.71	0.27	35.69	0.02	0.00	0.60	0.00
Disp_2500	Winter_500	Surv_5000	Urban_3000	206.32	20.43	43.30	0.45	2.68	1.00	3.44	2.85	7.43	10.98	6.58	26.66	0.12	0.00	0.18	0.00
Winter_3000	ForWet_3000	-	-	206.50	20.61	37.70	0.40	1.00	1.79	-	-	0.85	25.65	-	-	0.36	0.00	-	-
Winter_3000	Surv_1000	ForWet_3000	-	206.86	20.97	37.60	0.40	1.00	1.06	1.72	-	0.78	1.13	22.79	-	0.38	0.35	0.00	-
Winter_3000	Surv_5000	-	-	206.88	20.99	41.50	0.40	4.19	3.76	-	-	31.76	22.41	-	-	0.00	0.00	-	-
Surv_5000	NatAgri_3000	-	-	206.90	21.01	38.60	0.43	3.21	1.00	-	-	13.28	42.52	-	-	0.01	0.00	-	-
Winter_1000	Surv_2500	Urban_3000	-	206.90	21.01	39.10	0.41	1.00	3.73	1.00	-	14.57	9.91	29.18	-	0.00	0.06	0.00	-
Disp_2500	Winter_1000	Surv_2500	Urban_3000	207.08	21.19	41.70	0.43	2.32	1.00	3.09	2.48	4.91	11.75	3.77	30.96	0.16	0.00	0.44	0.00
Disp_2500	Winter_500	Urban_3000	-	207.40	21.51	40.50	0.42	2.86	1.00	2.89	-	15.97	10.20	40.52	-	0.00	0.00	0.00	-
Winter_1000	Surv_1000	Urban_3000	-	208.20	22.31	38.60	0.40	1.00	3.77	1.00	-	14.56	8.95	37.01	-	0.00	0.09	0.00	-

Winter_500	Surv_5000	Urban_3000	-	208.30	22.41	39.10	0.41	1.00	3.59	1.00	-	12.09	13.58	22.54	-	0.00	0.01	0.00	-
Disp_1000	Winter_3000	Surv_5000	-	208.40	22.51	41.90	0.42	3.64	1.86	3.35	-	8.46	30.56	20.83	-	0.11	0.00	0.00	-
Disp_2500	Winter_3000	Surv_5000	-	208.40	22.51	41.70	0.40	1.00	4.24	3.70	-	0.47	30.58	14.79	-	0.49	0.00	0.01	-
Disp_5000	Winter_3000	Surv_5000	-	208.97	23.08	41.40	0.41	2.56	2.00	3.94	-	5.08	25.17	11.40	-	0.19	0.00	0.04	-
Surv_1000	NatAgri_3000	-	-	209.40	23.51	37.50	0.43	3.60	1.00	-	-	13.80	62.98	-	-	0.01	0.00	-	-
Surv_2500	NatAgri_3000	-	-	209.40	23.51	37.50	0.42	3.53	1.00	-	-	12.88	53.76	-	-	0.02	0.00	-	-
Disp_1000	Winter_500	Surv_2500	Urban_3000	210.13	24.24	40.30	0.41	3.84	1.00	2.73	1.00	8.36	11.58	5.22	34.23	0.13	0.00	0.22	0.00
Disp_2500	Winter_500	Surv_1000	Urban_3000	210.14	24.25	40.40	0.41	2.86	1.00	1.75	2.86	13.25	10.09	0.59	40.19	0.01	0.00	0.75	0.00
Disp_2500	Winter_500	Surv_2500	Urban_3000	210.19	24.30	41.20	0.42	2.43	1.00	3.26	2.80	7.14	9.98	3.94	35.49	0.08	0.00	0.43	0.00
Disp_1000	Winter_500	Urban_3000	-	211.20	25.31	38.00	0.39	3.45	1.00	1.00	-	10.82	11.43	45.96	-	0.03	0.00	0.00	-
Disp_1000	Winter_500	Surv_1000	Urban_3000	211.48	25.59	38.10	0.39	3.58	1.00	1.00	1.00	11.21	11.74	0.81	43.21	0.03	0.00	0.37	0.00
Winter_1000	Urban_3000	-	-	211.60	25.71	35.30	0.38	1.00	1.00	-	-	16.77	40.84	-	-	0.00	0.00	-	-
Disp_5000	Urban_3000	-	-	211.70	25.81	38.10	0.39	2.93	2.30	-	-	24.09	34.78	-	-	0.00	0.00	-	-
Winter_500	Surv_2500	Urban_3000	-	211.80	25.91	37.60	0.39	1.00	3.84	1.00	-	11.83	10.93	34.12	-	0.00	0.05	0.00	-
Winter_500	Surv_1000	Urban_3000	-	213.50	27.61	37.00	0.38	1.00	3.75	1.00	-	12.01	9.60	42.51	-	0.00	0.07	0.00	-
Disp_5000	Winter_1000	Surv_5000	-	217.10	31.21	38.40	0.38	2.93	1.00	4.17	-	8.42	15.85	13.62	-	0.06	0.00	0.02	-
Disp_1000	Winter_1000	Surv_5000	-	217.20	31.31	38.40	0.38	3.80	1.00	3.68	-	10.12	21.11	32.05	-	0.06	0.00	0.00	-
Disp_5000	Winter_3000	Surv_2500	-	217.22	31.33	37.60	0.37	2.52	1.88	3.21	-	7.34	24.89	5.66	-	0.07	0.00	0.25	-
Winter_500	Urban_3000	-	-	217.70	31.81	33.30	0.35	1.00	1.00	-	-	13.90	47.35	-	-	0.00	0.00	-	-
Winter_3000	Surv_2500	-	-	218.10	32.21	37.20	0.35	3.96	3.67	-	-	36.68	14.73	-	-	0.00	0.01	-	-
NatAgri_3000	-	-	-	218.30	32.41	32.90	0.38	1.35	-	-	-	80.23	-	-	-	0.00	-	-	-
Disp_1000	Winter_3000	Surv_2500	-	218.60	32.71	38.00	0.37	3.59	2.13	3.00	-	7.58	38.29	11.76	-	0.15	0.00	0.02	-
Disp_5000	Winter_3000	-	-	218.80	32.91	34.80	0.34	2.24	1.65	-	-	17.62	22.89	-	-	0.00	0.00	-	-
Disp_2500	Winter_3000	Surv_2500	-	219.20	33.31	37.40	0.35	1.00	4.05	3.40	-	0.86	33.21	7.39	-	0.36	0.00	0.13	-
Disp_5000	Winter_3000	Surv_1000	-	219.80	33.91	34.50	0.34	2.22	1.69	1.00	-	13.52	22.95	0.30	-	0.00	0.00	0.58	-
Disp_2500	Urban_3000	-	-	220.30	34.41	33.40	0.37	1.00	1.97	-	-	17.92	47.77	-	-	0.00	0.00	-	-
Disp_5000	Winter_500	Surv_5000	-	221.40	35.51	37.40	0.37	3.25	1.00	4.40	-	11.49	13.33	14.37	-	0.02	0.00	0.01	-
Disp_2500	Winter_3000	-	-	221.90	36.01	34.60	0.33	1.00	4.26	-	-	10.27	22.56	-	-	0.00	0.00	-	-
Winter_1000	Surv_5000	-	-	222.10	36.21	34.30	0.35	1.00	4.00	-	-	20.27	34.07	-	-	0.00	0.00	-	-
Disp_2500	Winter_3000	Surv_1000	-	222.66	36.77	34.40	0.32	1.00	4.26	1.00	-	6.41	32.84	0.13	-	0.01	0.00	0.72	-
Disp_2500	Winter_1000	Surv_5000	-	224.32	38.43	35.10	0.36	1.81	1.00	4.03	-	1.60	19.47	22.28	-	0.61	0.00	0.00	-
Surv_5000	Urban_3000	-	-	225.40	39.51	33.40	0.36	3.67	1.28	-	-	16.76	28.37	-	-	0.00	0.00	-	-
Disp_1000	Winter_3000	-	-	226.04	40.15	34.90	0.33	2.87	4.28	-	-	9.22	37.78	-	-	0.04	0.00	-	-
Disp_1000	Winter_500	Surv_5000	-	226.60	40.71	35.60	0.35	3.73	1.00	3.89	-	9.20	16.97	36.01	-	0.08	0.00	0.00	-
Disp_1000	Winter_3000	Surv_1000	-	226.99	41.10	33.30	0.32	3.28	2.09	1.00	-	8.66	42.89	2.12	-	0.07	0.00	0.15	-
Disp_1000	Urban_3000	-	-	227.00	41.11	32.40	0.35	3.46	1.00	-	-	13.18	55.89	-	-	0.01	0.00	-	-
Winter_3000	Surv_1000	-	-	227.00	41.11	34.00	0.31	4.06	3.06	-	-	38.99	7.10	-	-	0.00	0.09	-	-
Surv_2500	Urban_3000	-	-	227.50	41.61	32.00	0.34	3.84	1.00	-	-	14.48	42.62	-	-	0.01	0.00	-	-
Disp_5000	Winter_1000	Surv_2500	-	227.60	41.71	33.90	0.32	2.97	1.00	3.30	-	14.17	14.92	5.52	-	0.01	0.00	0.25	-
Disp_5000	Winter_1000	-	-	228.50	42.61	31.40	0.30	2.62	1.00	-	-	28.04	14.62	-	-	0.00	0.00	-	-
Surv_1000	Urban_3000	-	-	229.40	43.51	31.20	0.33	3.70	1.00	-	-	11.90	52.46	-	-	0.03	0.00	-	-
Disp_5000	Winter_1000	Surv_1000	-	229.78	43.89	31.00	0.29	2.65	1.00	1.00	-	24.01	14.27	0.02	-	0.00	0.00	0.90	-
Winter_500	Surv_5000	-	-	230.30	44.41	31.80	0.33	1.00	4.15	-	-	16.37	39.44	-	-	0.00	0.00	-	-
Winter_3000	-	-	-	231.10	45.21	31.00	0.28	4.13	-	-	-	44.20	-	-	-	0.00	-	-	-
Disp_2500	Winter_500	Surv_5000	-	231.96	46.07	32.90	0.33	1.98	1.00	4.19	-	2.57	15.66	24.56	-	0.47	0.00	0.00	-
Disp_5000	Winter_500	Surv_2500	-	232.97	47.08	32.50	0.30	3.28	1.00	3.35	-	18.07	11.90	5.43	-	0.00	0.00	0.27	-
Disp_5000	Winter_500	-	-	233.90	48.01	29.90	0.28	2.83	1.00	-	-	33.08	11.79	-	-	0.00	0.00	-	-
Disp_5000	Winter_500	Surv_1000	-	235.50	49.61	29.70	0.28	2.93	1.00	1.26	-	28.28	11.55	0.11	-	0.00	0.00	0.92	-
Urban_3000	-	-	-	237.10	51.21	26.60	0.30	1.00	-	-	-	61.60	-	-	-	0.00	-	-	-
Disp_1000	Winter_1000	Surv_2500	-	237.50	51.61	31.30	0.29	3.74	1.00	3.27	-	8.41	24.85	17.29	-	0.12	0.00	0.00	-

Winter_1000	Surv_2500	-	-	239.50	53.61	28.10	0.27	1.00	3.86	-	-	23.74	21.18	-	-	0.00	0.00	-	-
Disp_5000	Surv_5000	-	-	240.40	54.51	31.00	0.30	3.64	4.28	-	-	15.20	14.10	-	-	0.01	0.01	-	-
Disp_2500	Winter_1000	Surv_2500	-	241.40	55.51	28.80	0.28	1.66	1.00	3.67	-	2.03	21.20	9.45	-	0.40	0.00	0.07	-
Disp_2500	Winter_1000	-	-	245.40	59.51	24.60	0.24	1.00	1.00	-	-	15.77	20.33	-	-	0.00	0.00	-	-
Disp_2500	Winter_1000	Surv_1000	-	246.20	60.31	24.30	0.23	1.00	1.00	1.00	-	11.14	19.76	0.02	-	0.00	0.00	0.90	-
Disp_5000	Surv_2500	-	-	249.90	64.01	26.90	0.24	3.83	3.42	-	-	23.57	6.29	-	-	0.00	0.21	-	-
Disp_5000	-	-	-	251.40	65.51	24.10	0.23	3.36	-	-	-	44.03	-	-	-	0.00	-	-	-
Disp_1000	Winter_500	Surv_2500	-	251.50	65.61	26.90	0.24	3.53	1.00	3.52	-	6.09	18.67	18.53	-	0.25	0.00	0.00	-
Disp_1000	Winter_1000	Surv_1000	-	251.60	65.71	24.50	0.22	3.29	1.00	1.00	-	9.98	26.31	2.32	-	0.04	0.00	0.13	-
Winter_500	Surv_2500	-	-	251.70	65.81	24.30	0.23	1.00	3.92	-	-	18.11	23.63	-	-	0.00	0.00	-	-
Disp_5000	Surv_1000	-	-	251.80	65.91	23.90	0.22	3.42	1.00	-	-	36.30	0.05	-	-	0.00	0.83	-	-
Disp_2500	Winter_500	Surv_2500	-	252.20	66.31	25.50	0.24	1.84	1.00	3.66	-	3.26	15.56	8.95	-	0.21	0.00	0.09	-
Winter_1000	Surv_1000	-	-	253.50	67.61	23.40	0.22	1.00	3.40	-	-	25.63	10.40	-	-	0.00	0.04	-	-
Disp_1000	Surv_5000	-	-	254.40	68.51	26.50	0.27	3.71	4.16	-	-	5.61	42.51	-	-	0.26	0.00	-	-
Surv_5000	-	-	-	255.00	69.11	23.50	0.26	4.26	-	-	-	53.84	-	-	-	0.00	-	-	-
Disp_1000	Winter_1000	-	-	255.40	69.51	23.10	0.22	2.92	1.00	-	-	9.79	26.66	-	-	0.03	0.00	-	-
Disp_2500	Surv_5000	-	-	255.60	69.71	24.30	0.26	1.36	4.06	-	-	3.53	24.95	-	-	0.18	0.00	-	-
Disp_2500	Winter_500	-	-	256.10	70.21	21.30	0.21	1.08	1.00	-	-	20.22	14.78	-	-	0.00	0.00	-	-
Disp_2500	Winter_500	Surv_1000	-	256.42	70.53	21.00	0.20	1.00	1.00	1.00	-	14.34	14.29	0.02	-	0.00	0.00	0.88	-
Winter_1000	-	-	-	260.93	75.04	19.10	0.18	1.00	-	-	-	30.46	-	-	-	0.00	-	-	-
Disp_1000	Winter_500	Surv_1000	-	266.90	81.01	19.40	0.17	3.08	1.00	1.00	-	8.32	19.73	2.12	-	0.07	0.00	0.15	-
Winter_500	Surv_1000	-	-	267.24	81.35	19.00	0.17	1.00	3.41	-	-	19.85	11.58	-	-	0.00	0.03	-	-
Disp_1000	Winter_500	-	-	270.66	84.77	17.90	0.17	2.50	1.00	-	-	9.96	19.65	-	-	0.02	0.00	-	-
Disp_2500	Surv_2500	-	-	275.70	89.81	16.80	0.16	1.41	3.41	-	-	9.14	8.40	-	-	0.01	0.09	-	-
Winter_500	-	-	-	276.80	90.91	14.10	0.13	1.00	-	-	-	24.33	-	-	-	0.00	-	-	-
Disp_2500	Surv_1000	-	-	278.30	92.41	13.40	0.13	1.00	1.00	-	-	24.55	0.02	-	-	0.00	0.89	-	-
Disp_2500	-	-	-	278.70	92.81	13.50	0.14	1.00	-	-	-	34.47	-	-	-	0.00	-	-	-
Surv_2500	-	-	-	279.40	93.51	15.00	0.15	4.14	-	-	-	35.62	-	-	-	0.00	-	-	-
Disp_1000	Surv_2500	-	-	281.50	95.61	15.00	0.15	1.00	4.14	-	-	0.00	23.26	-	-	0.96	0.00	-	-
Surv_1000	-	-	-	299.15	113.26	8.20	0.07	3.42	-	-	-	18.25	-	-	-	0.00	-	-	-
Disp_1000	Surv_1000	-	-	299.20	113.31	8.44	0.07	2.91	1.00	-	-	9.66	2.07	-	-	0.04	0.15	-	-
Disp_1000	-	-	-	303.50	117.61	6.58	0.06	1.98	-	-	-	2.46	-	-	-	0.00	-	-	-

9.2 Appendix B – Piecewise Regression Results

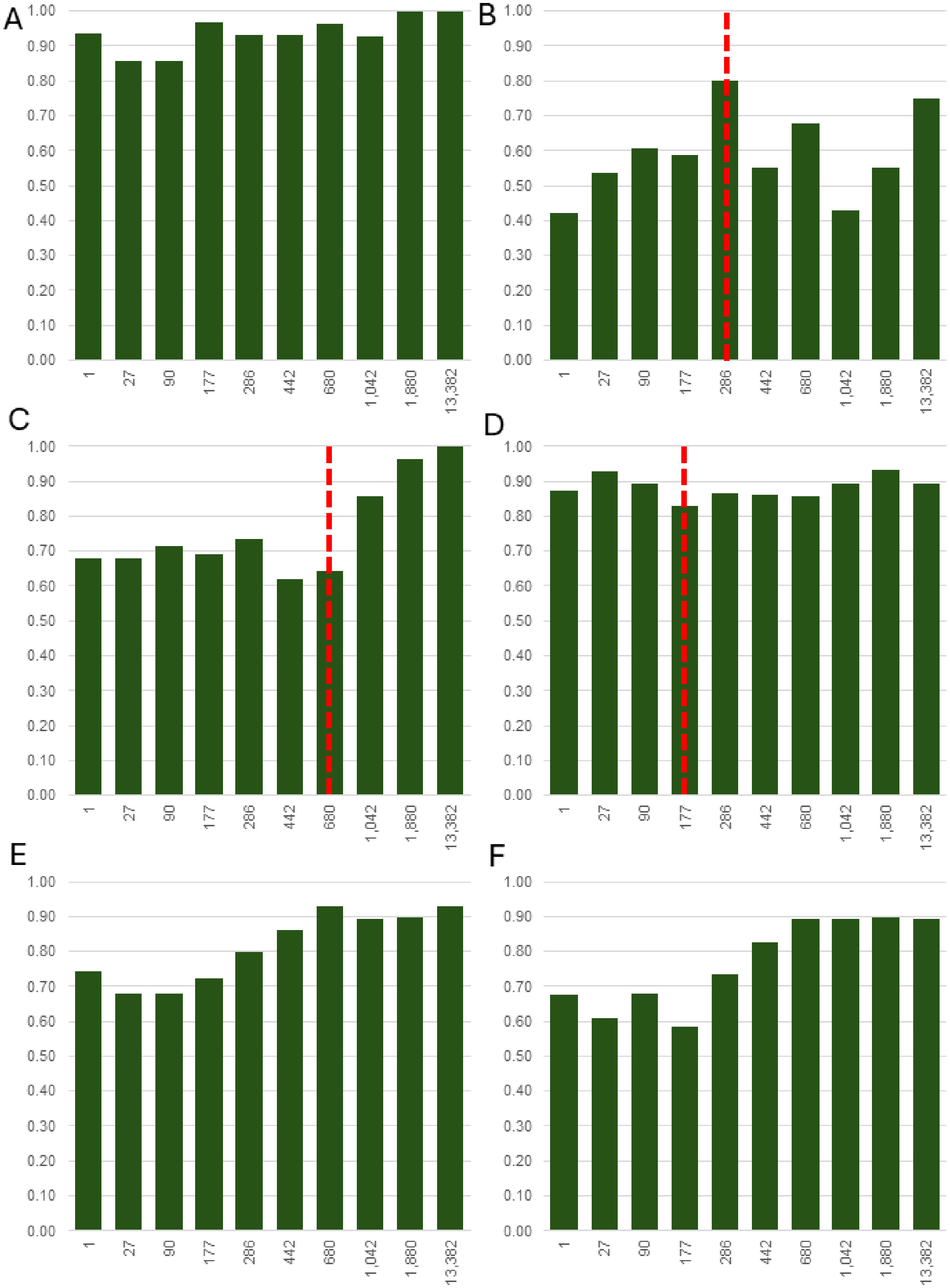

Figure 1: Deciles for Surv_1000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

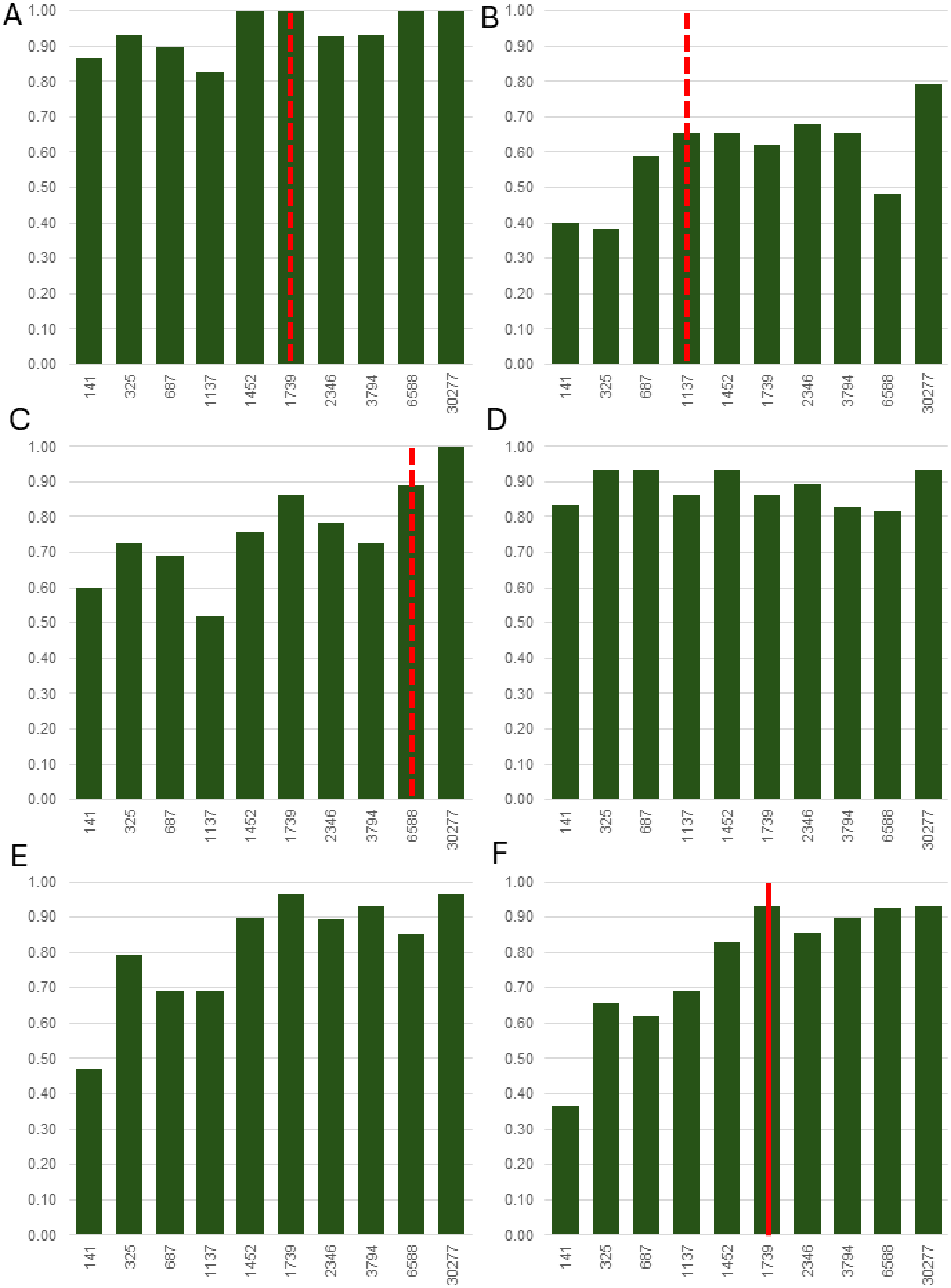

Figure 2: Deciles for Surv_2500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

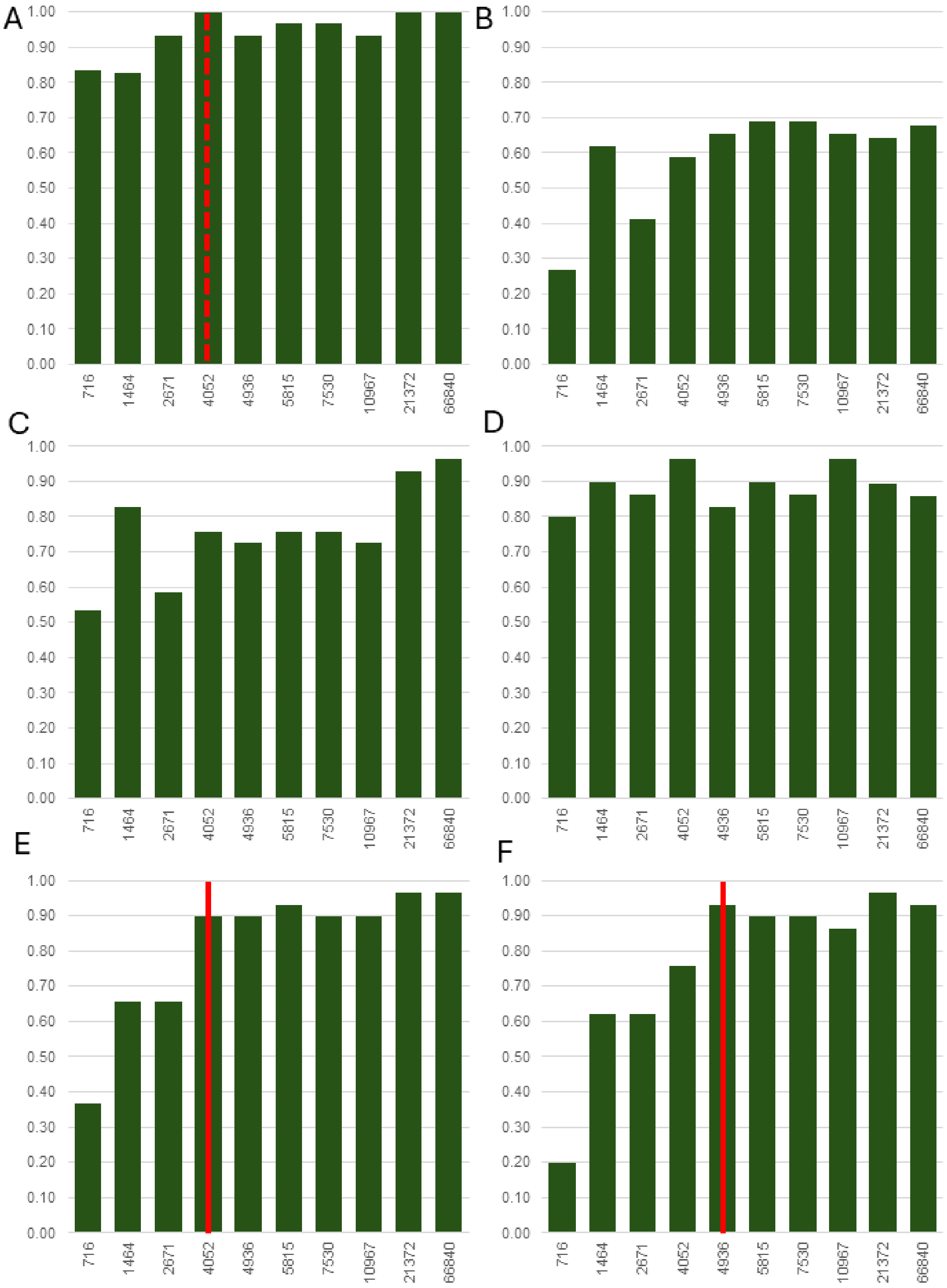

Figure 3: Deciles for Surv_5000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

Figure 4: Deciles for Overwinter_500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

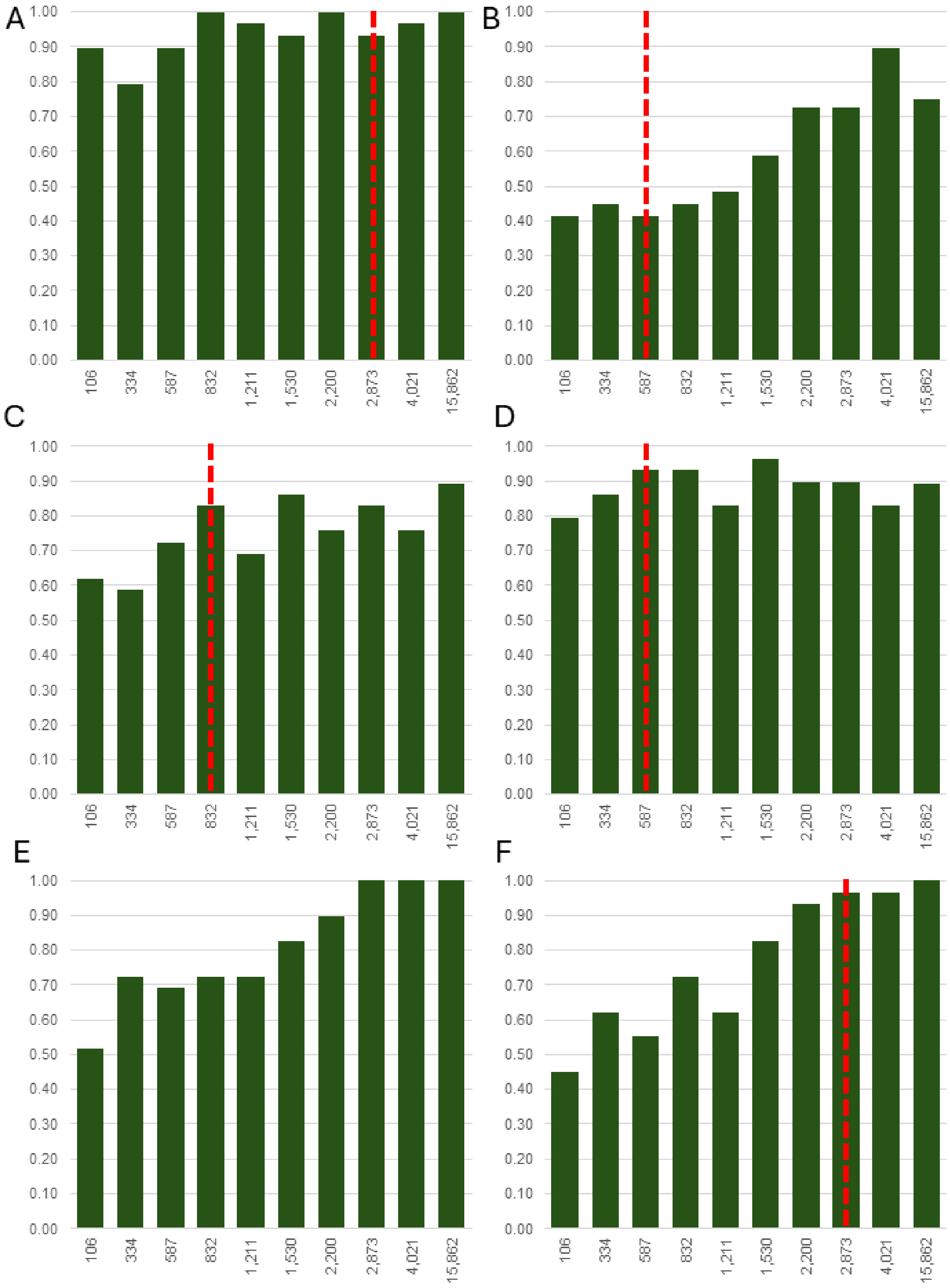

Figure 5: Deciles for Overwinter_1000 for A) Green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

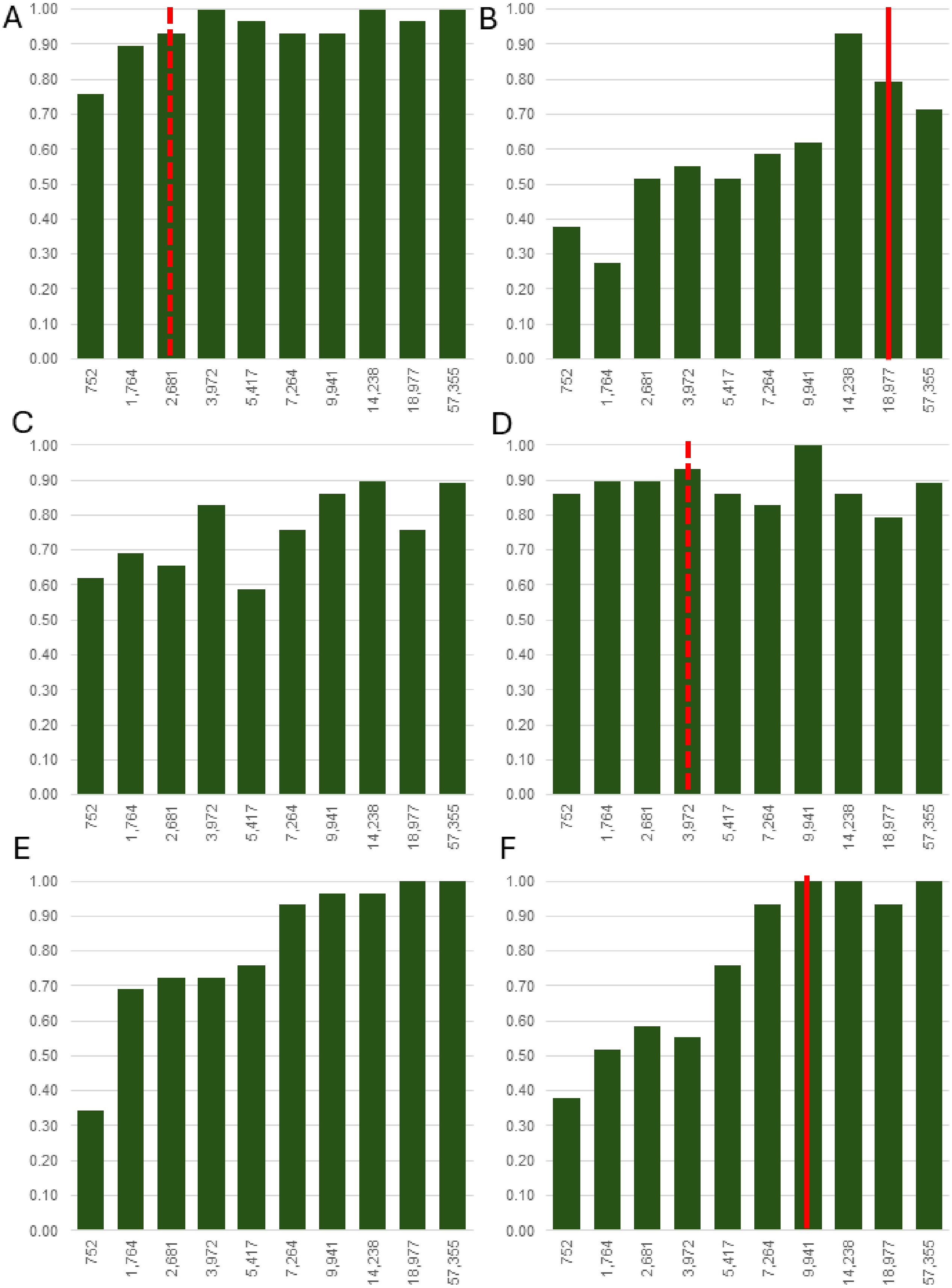

Figure 6: Deciles for Overwinter_3000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

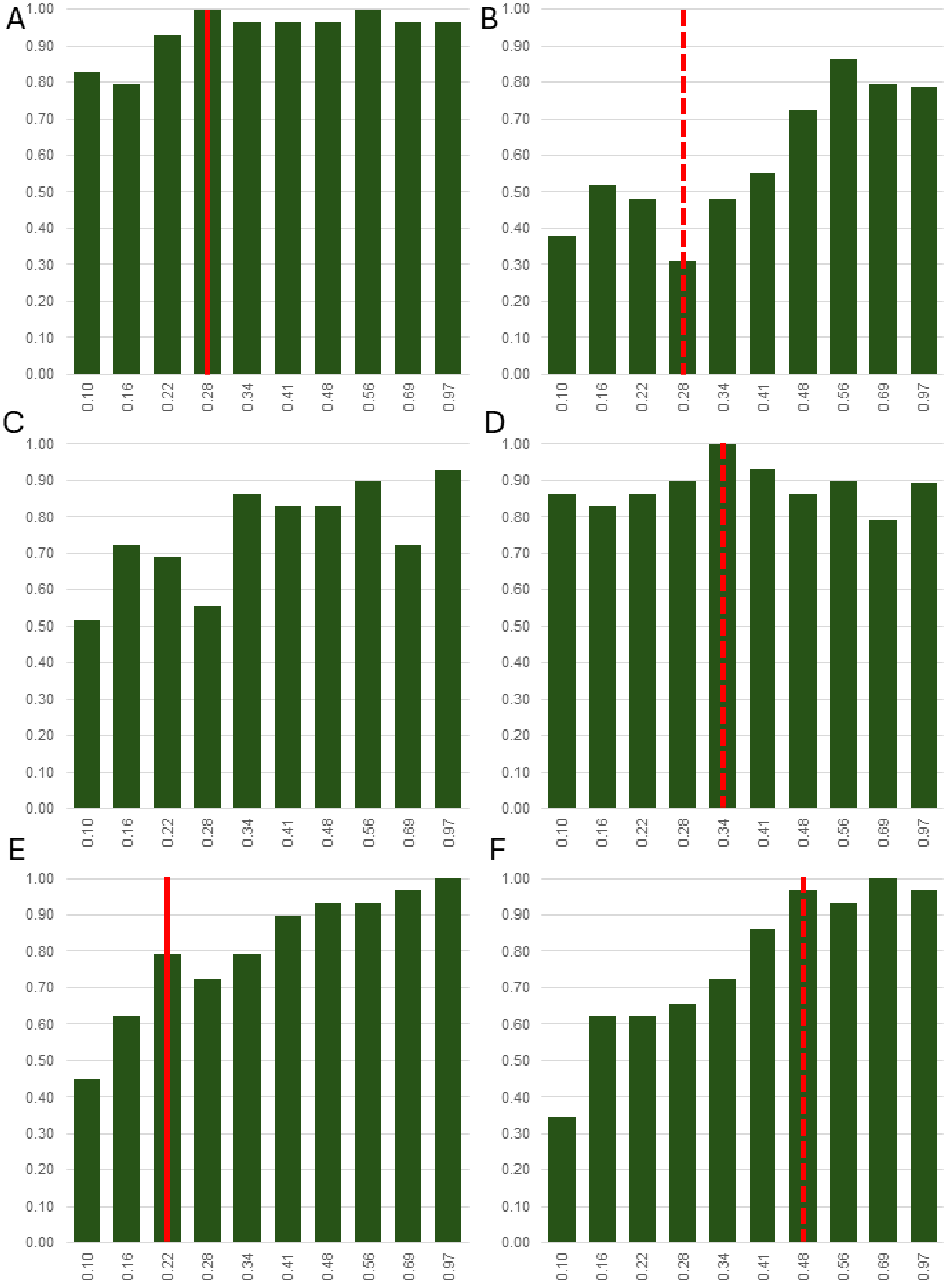

Figure 7: Deciles for ForWet_500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

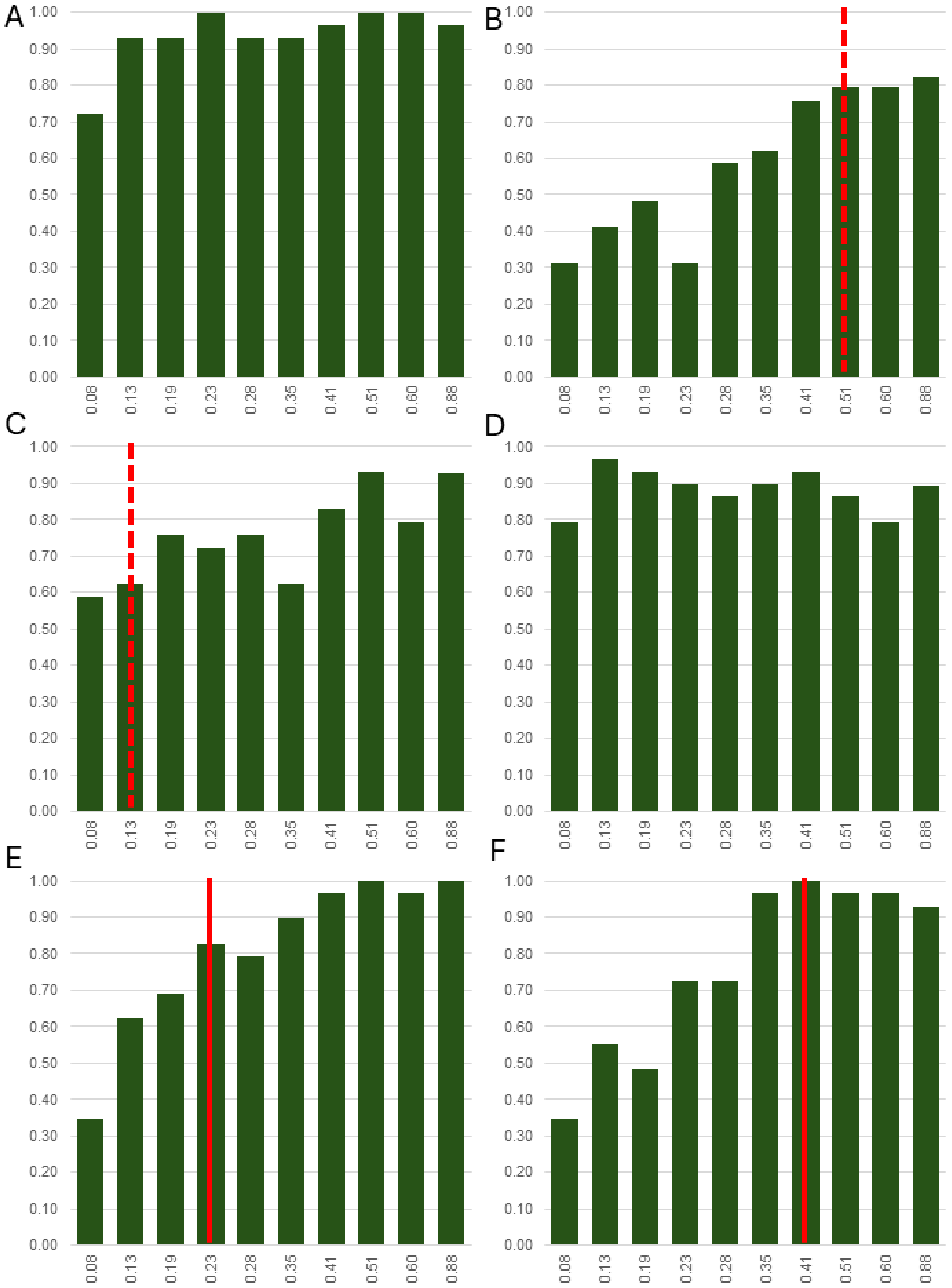

Figure 8: Deciles for ForWet_1000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

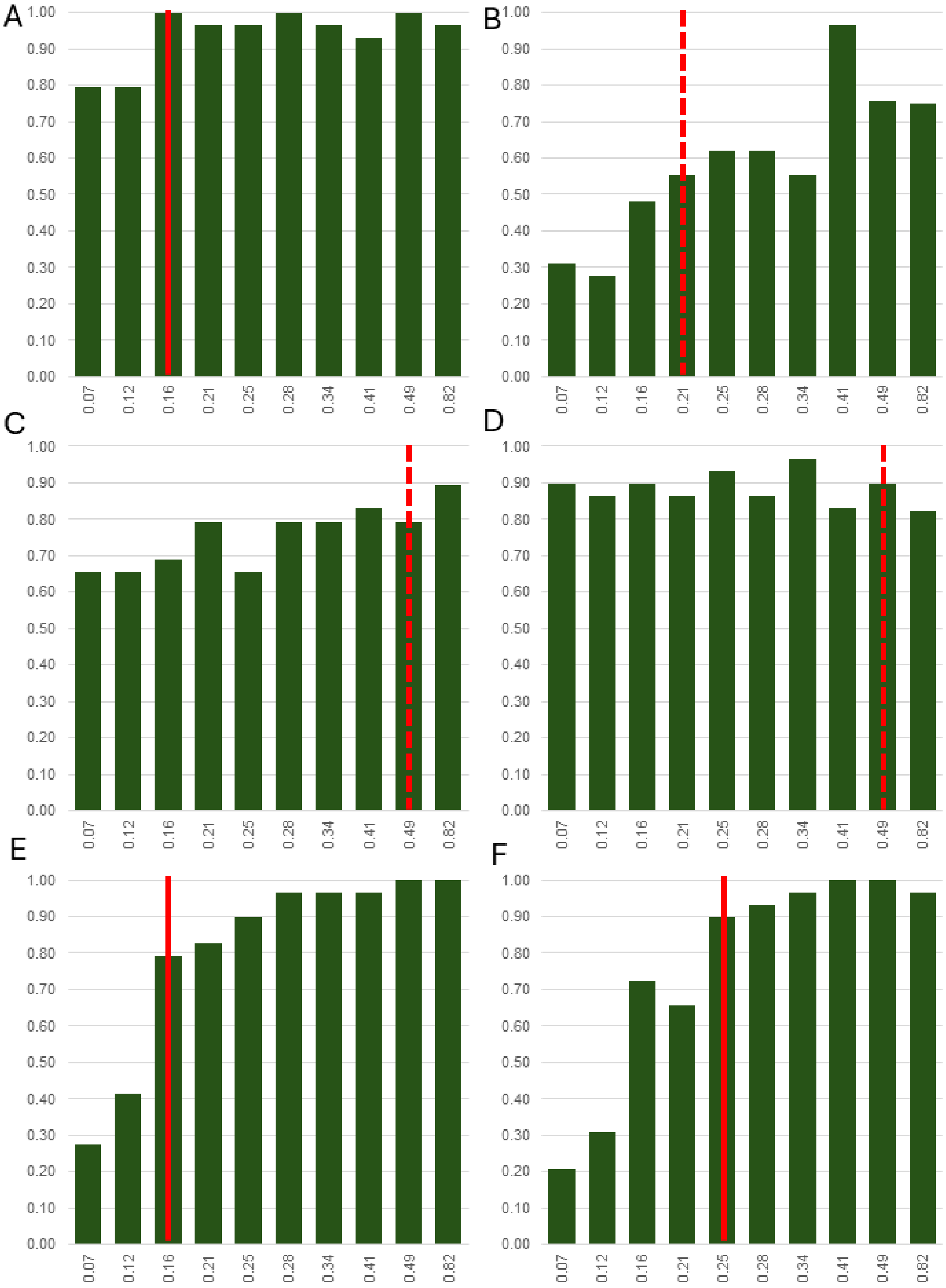

Figure 9: Deciles for ForWet_3000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

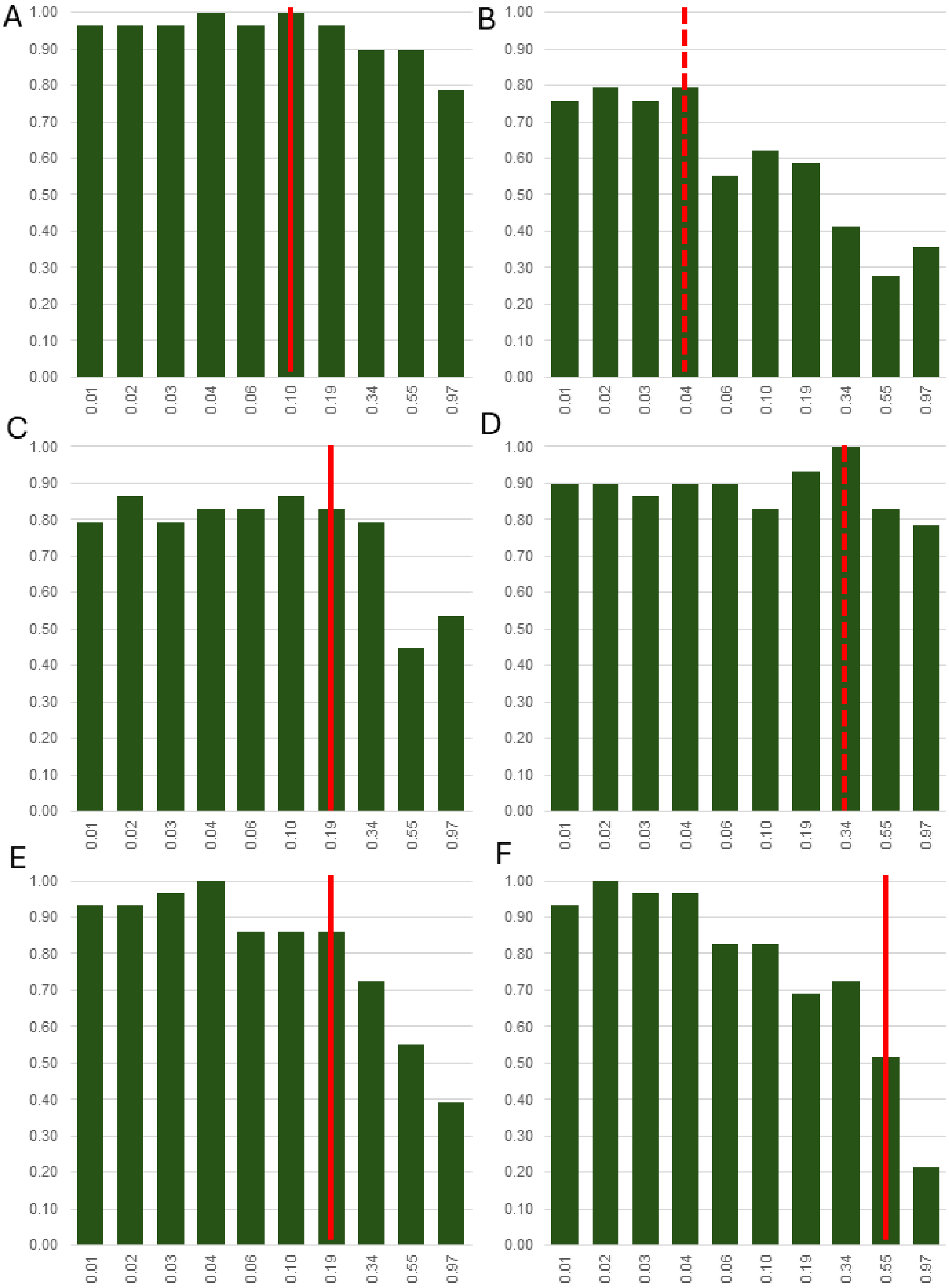

Figure 10: Deciles for Urban_500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

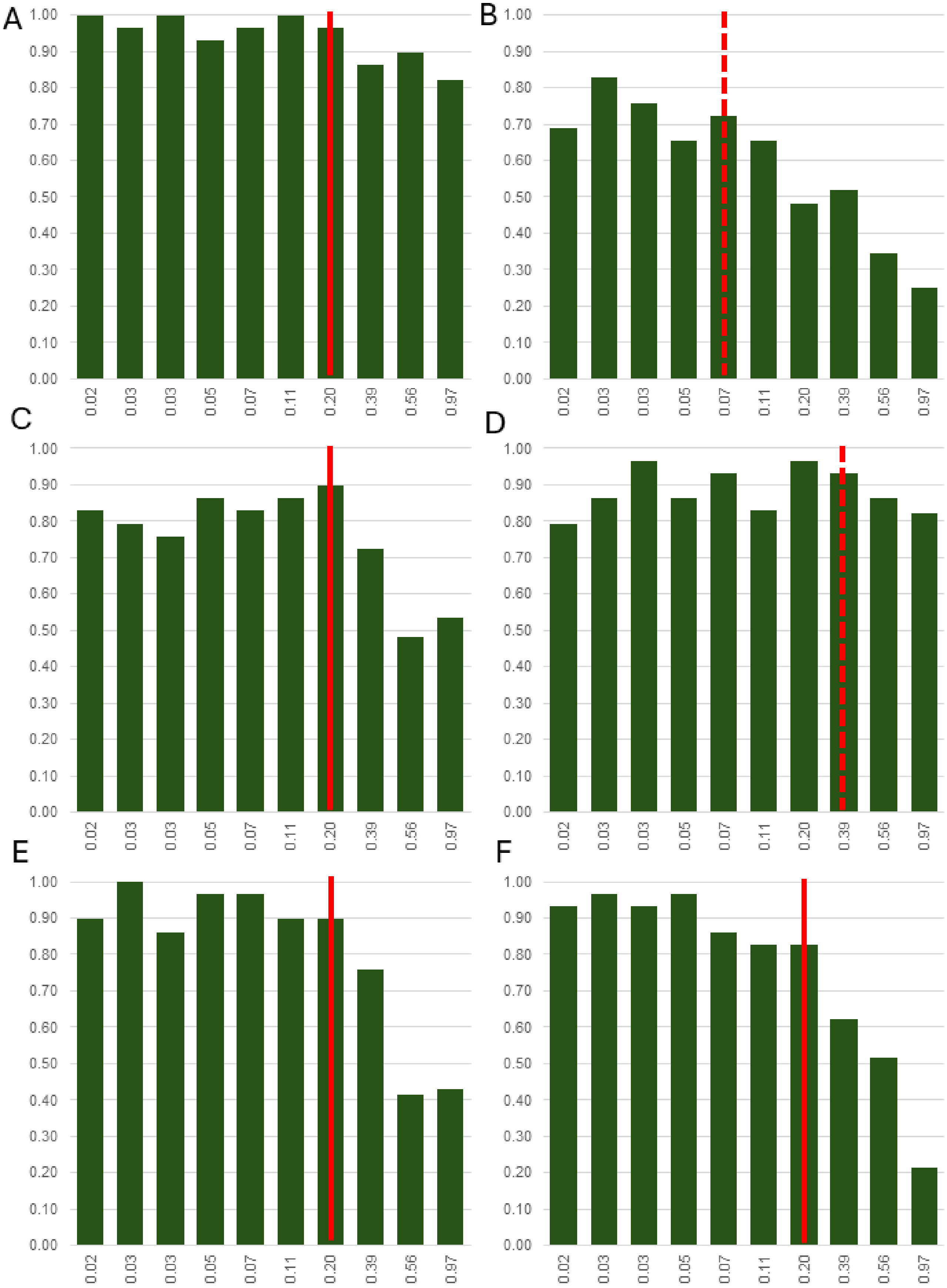

Figure 11: Deciles for Urban_1000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

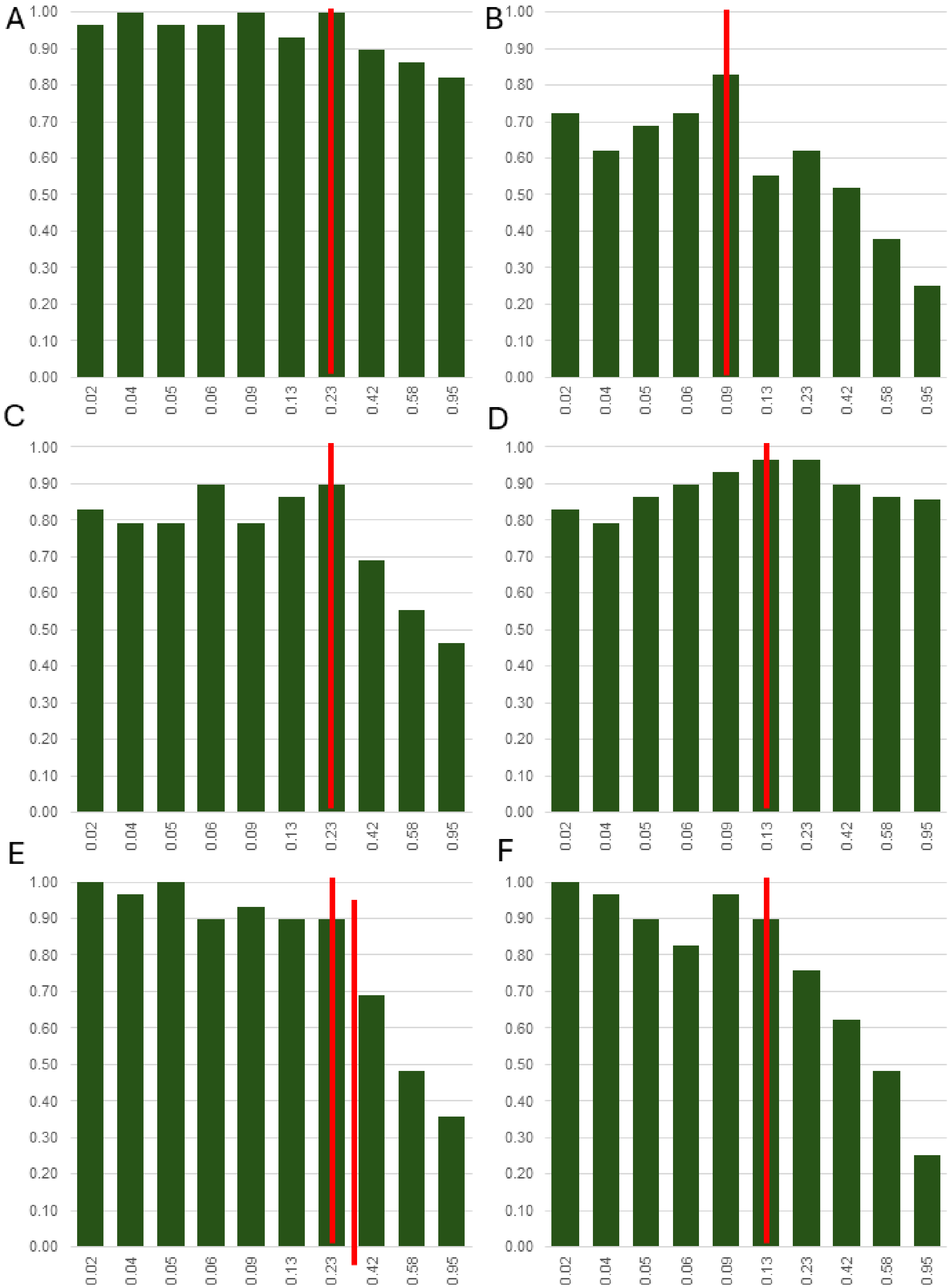

Figure 12: Deciles for Urban_3000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

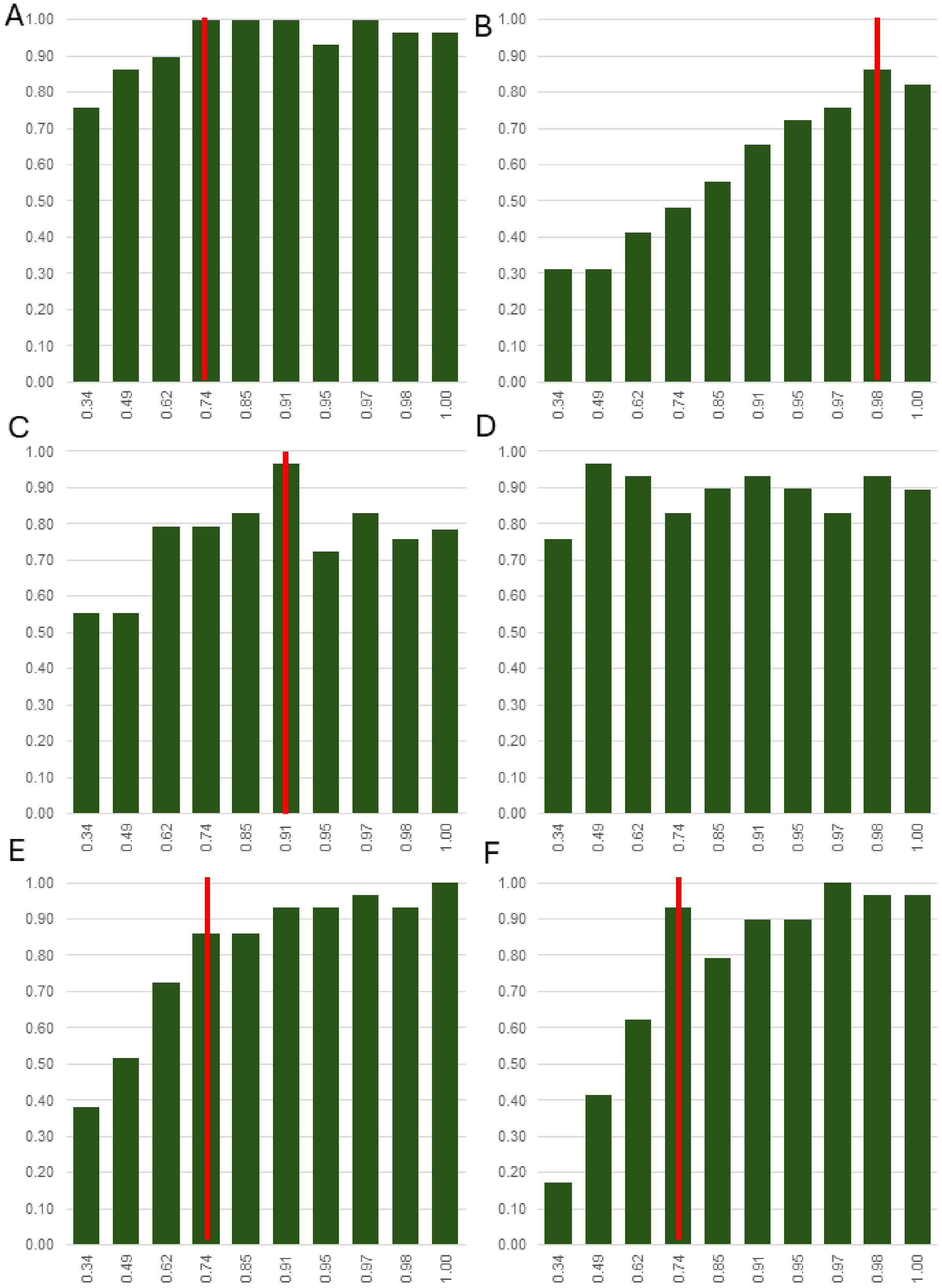

Figure 13: Deciles for NatAgri_500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

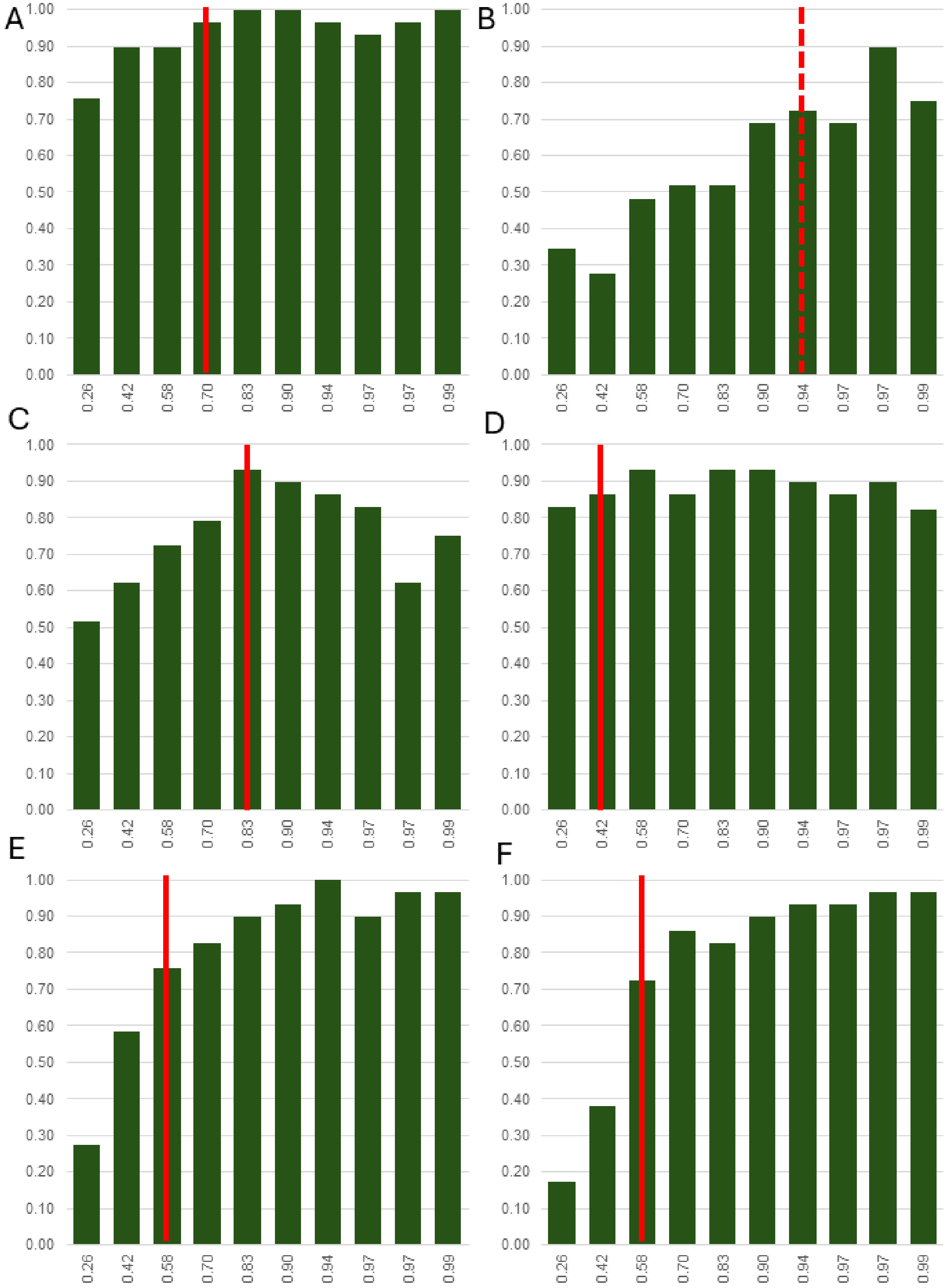

Figure 14: Deciles for NatAgri_1000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

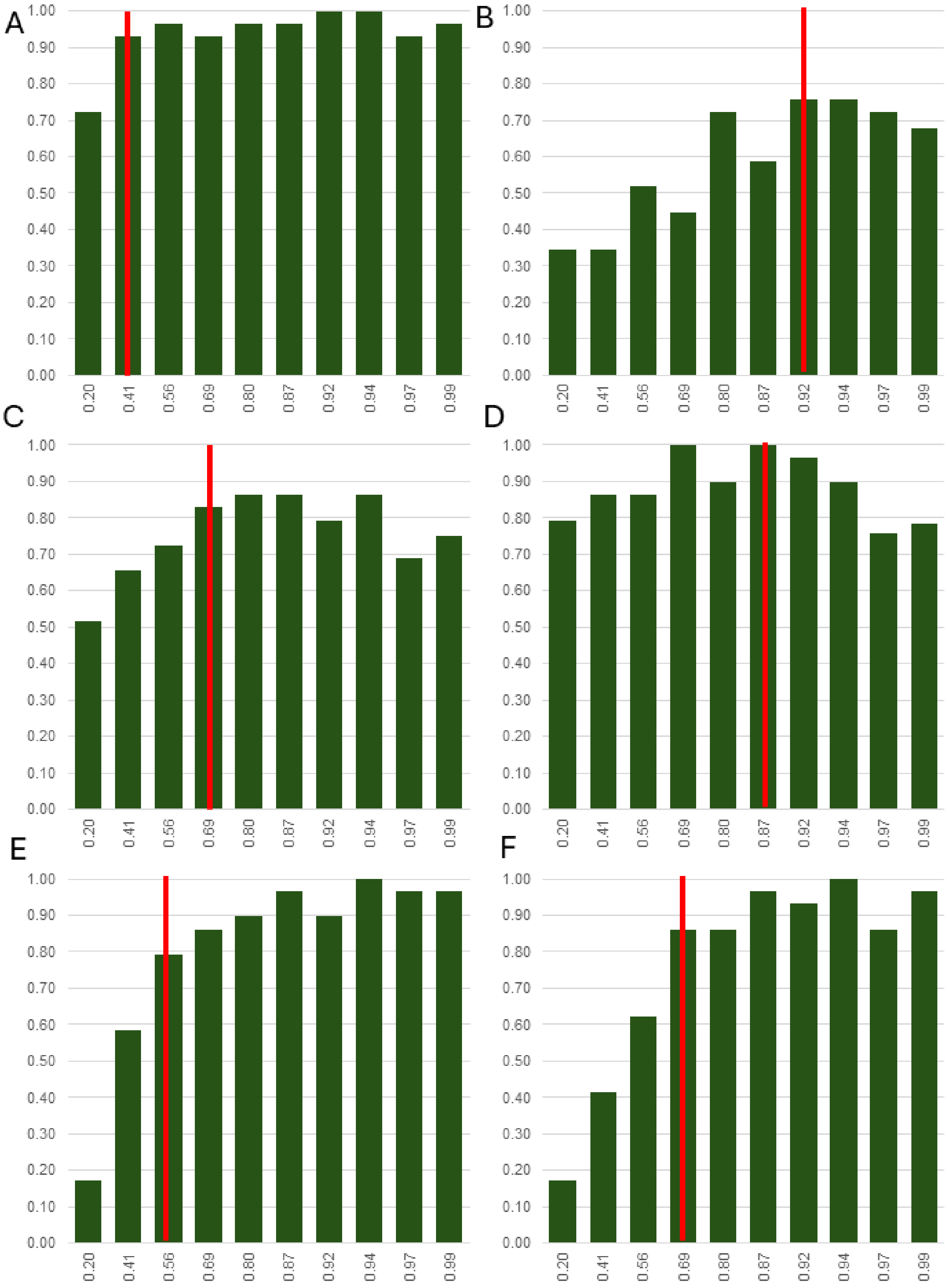

Figure 15: Deciles for Urban_3000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

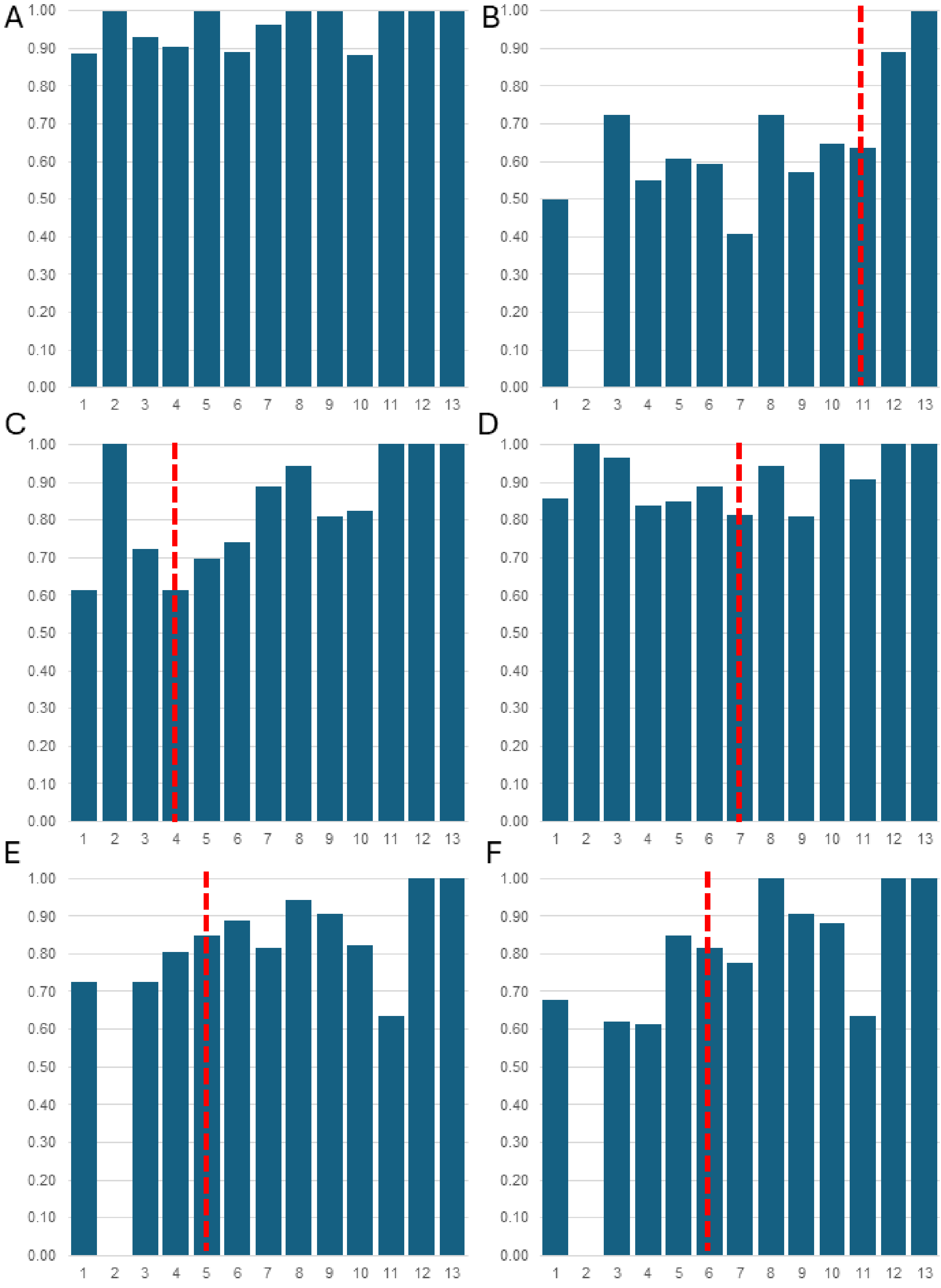

Figure 16: Quantiles (n=13) for Disp_1000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

Figure 17: Quantiles (n=13) for Disp_2500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

Figure 18: Quantiles (n=13) for Disp_5000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

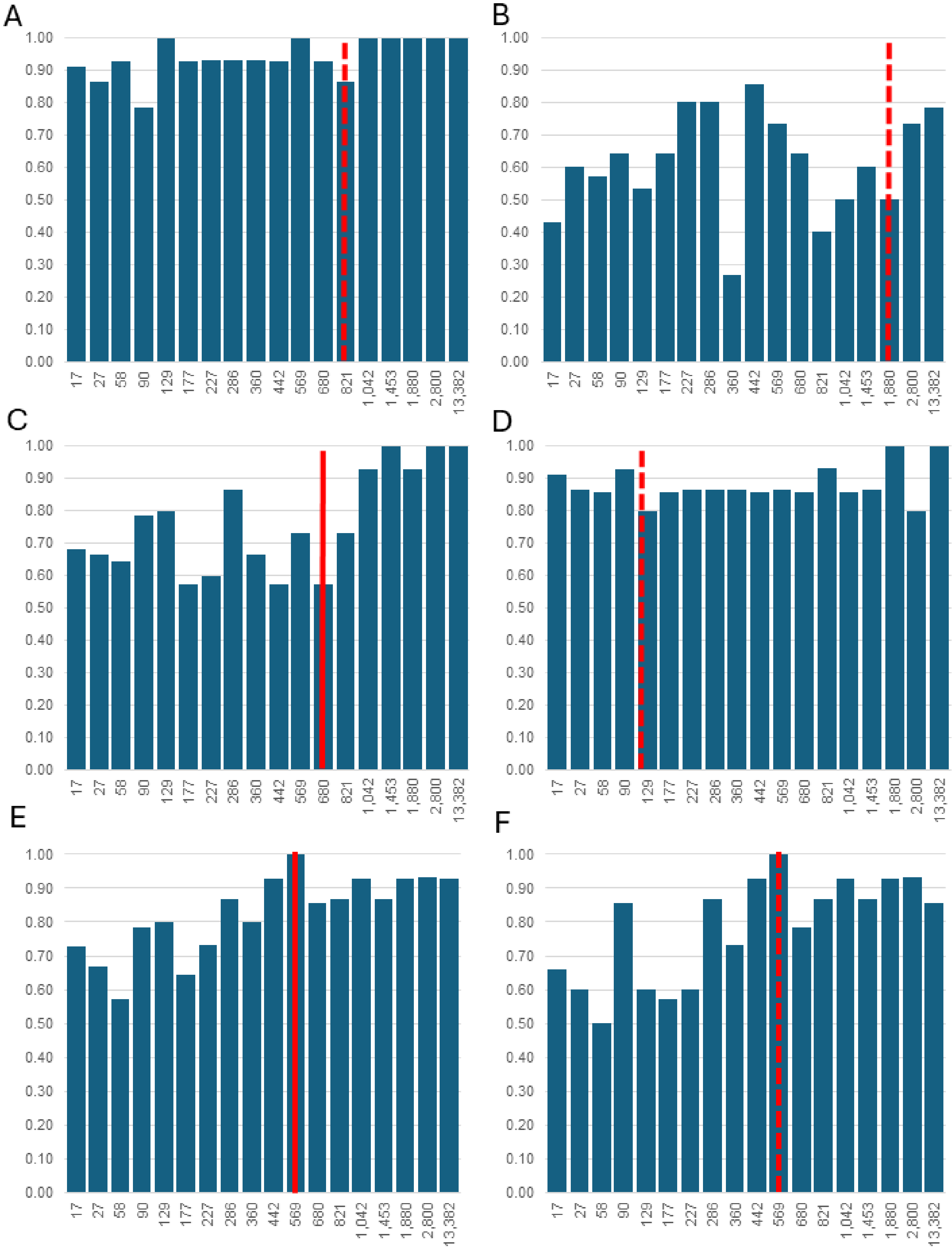

Figure 19: Quantile (n=20) for Surv_1000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

Figure 20: Quantiles (n=20) for Surv_2500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

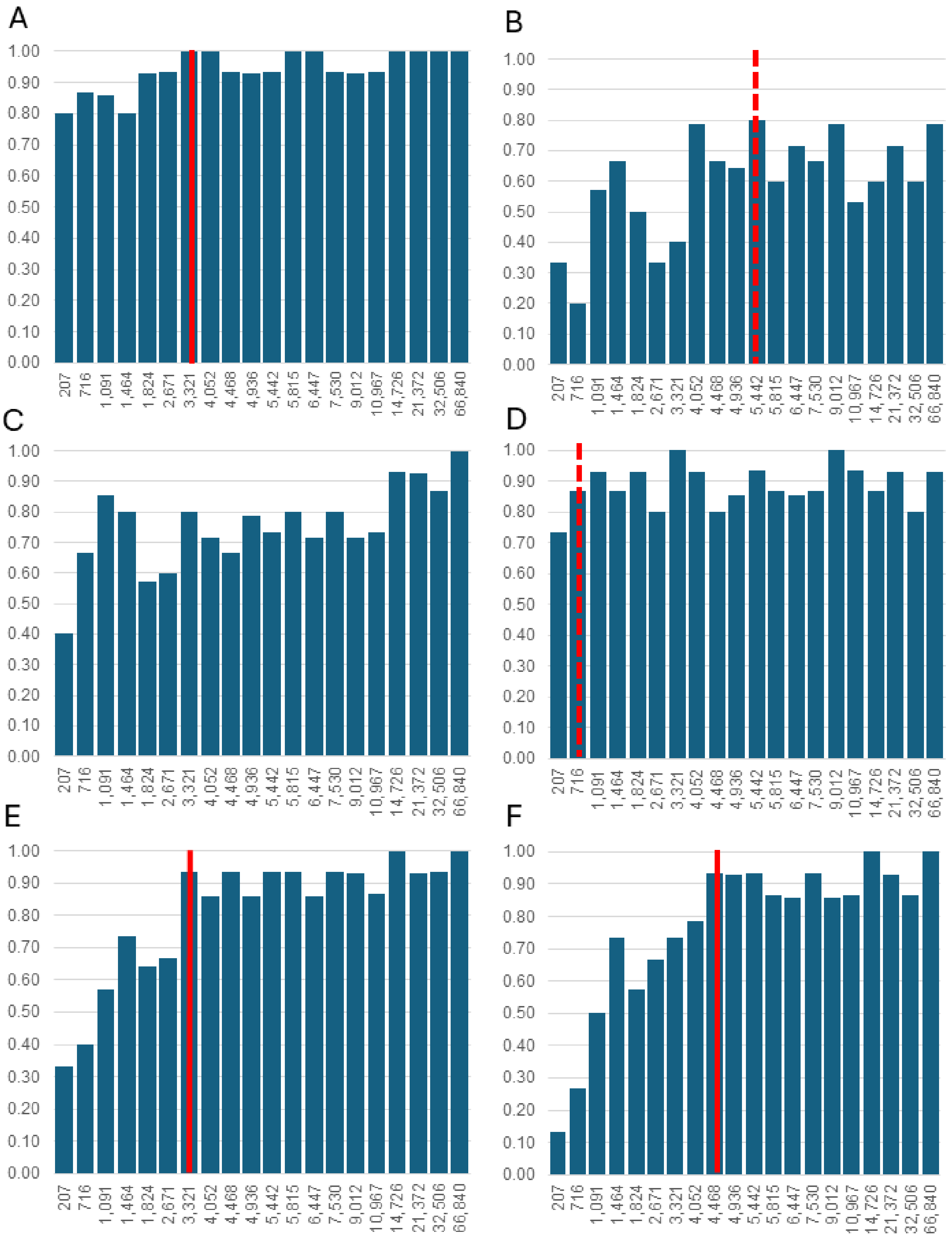

Figure 21: Quantiles (n=20) for Surv_5000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

Figure 22: Quantiles (n=20) for Overwinter_500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

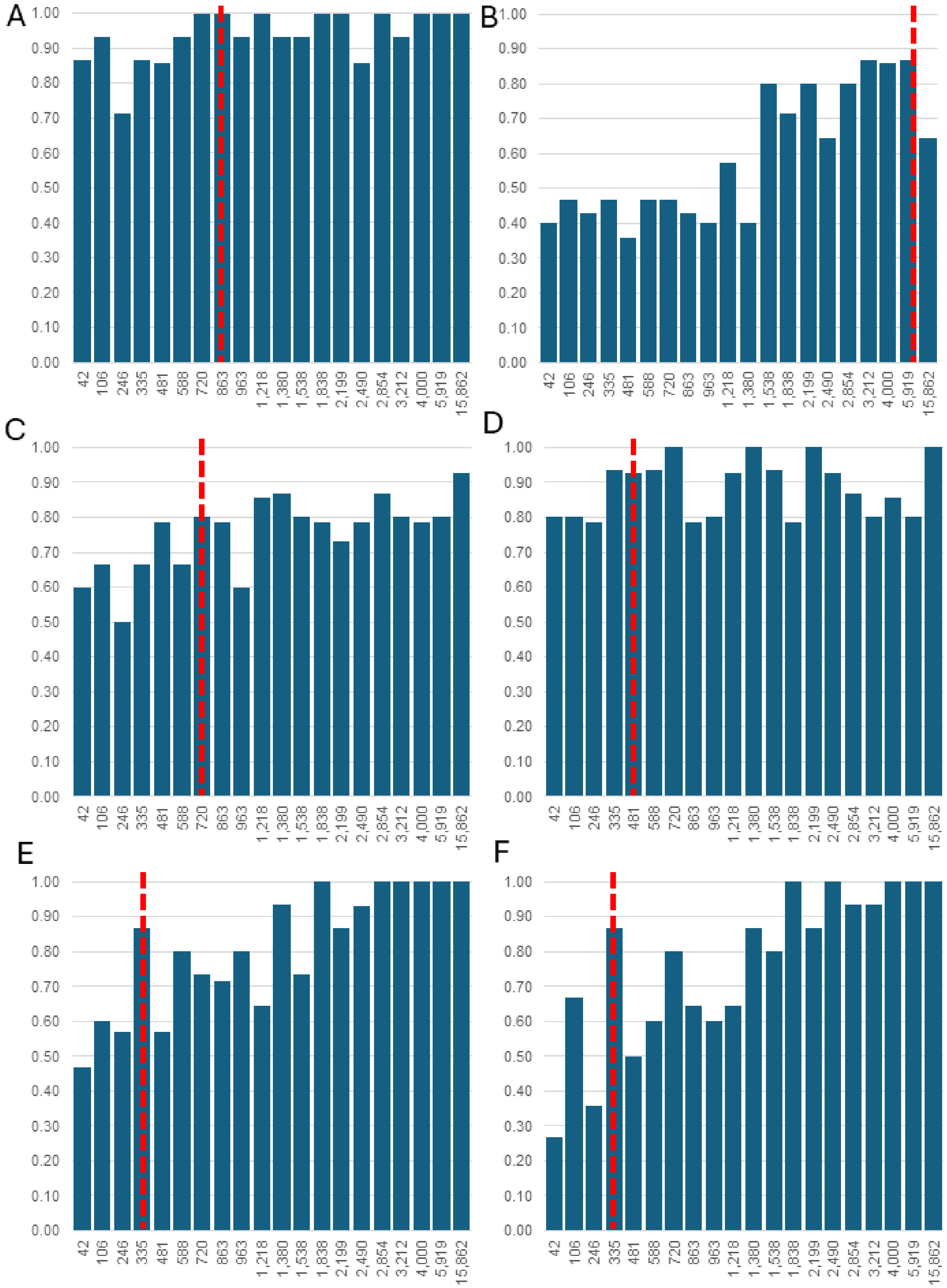

Figure 23: Quantiles (n=20) for Overwinter_1000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

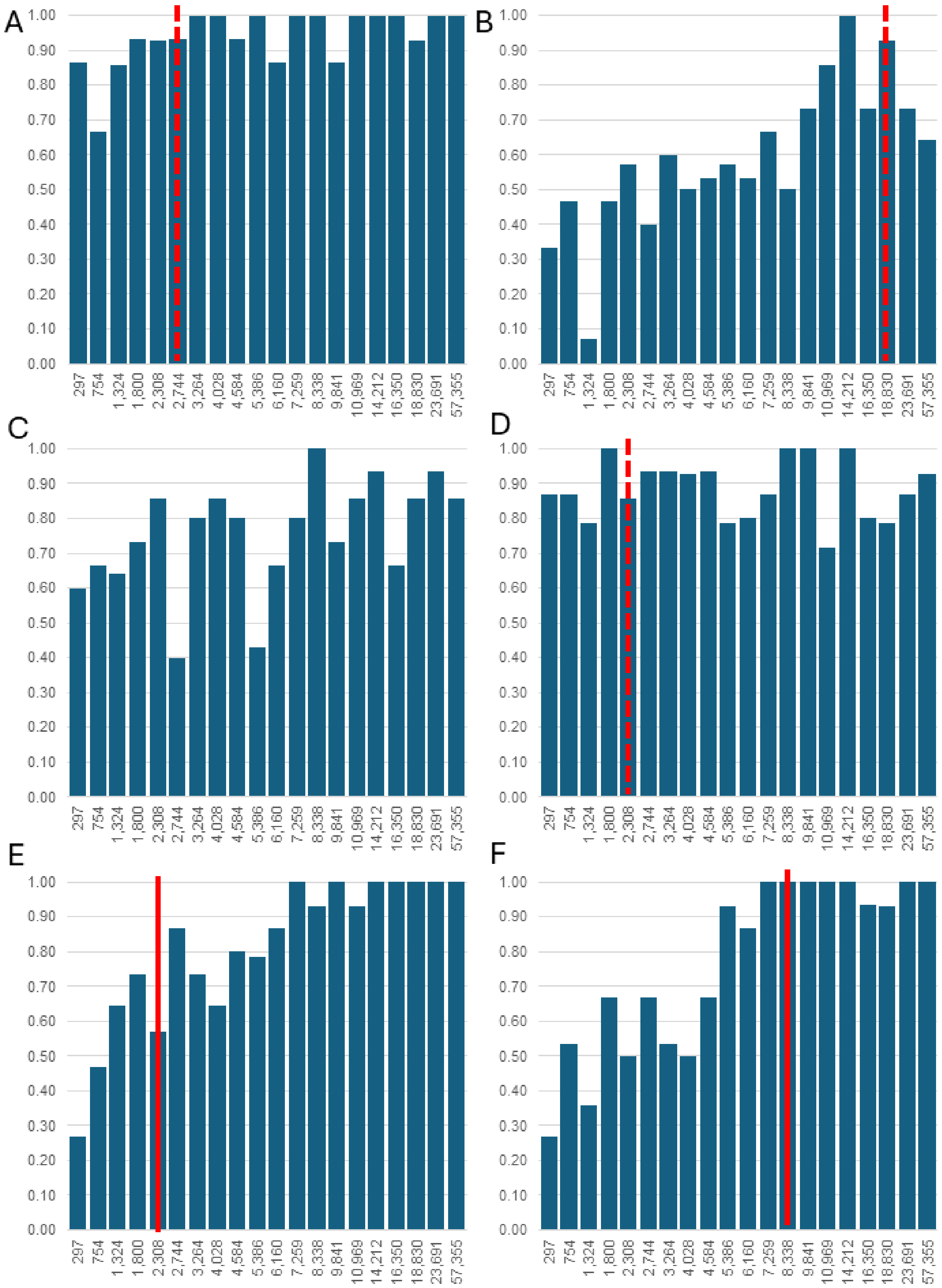

Figure 24: Quantiles (n=20) for Overwinter_3000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

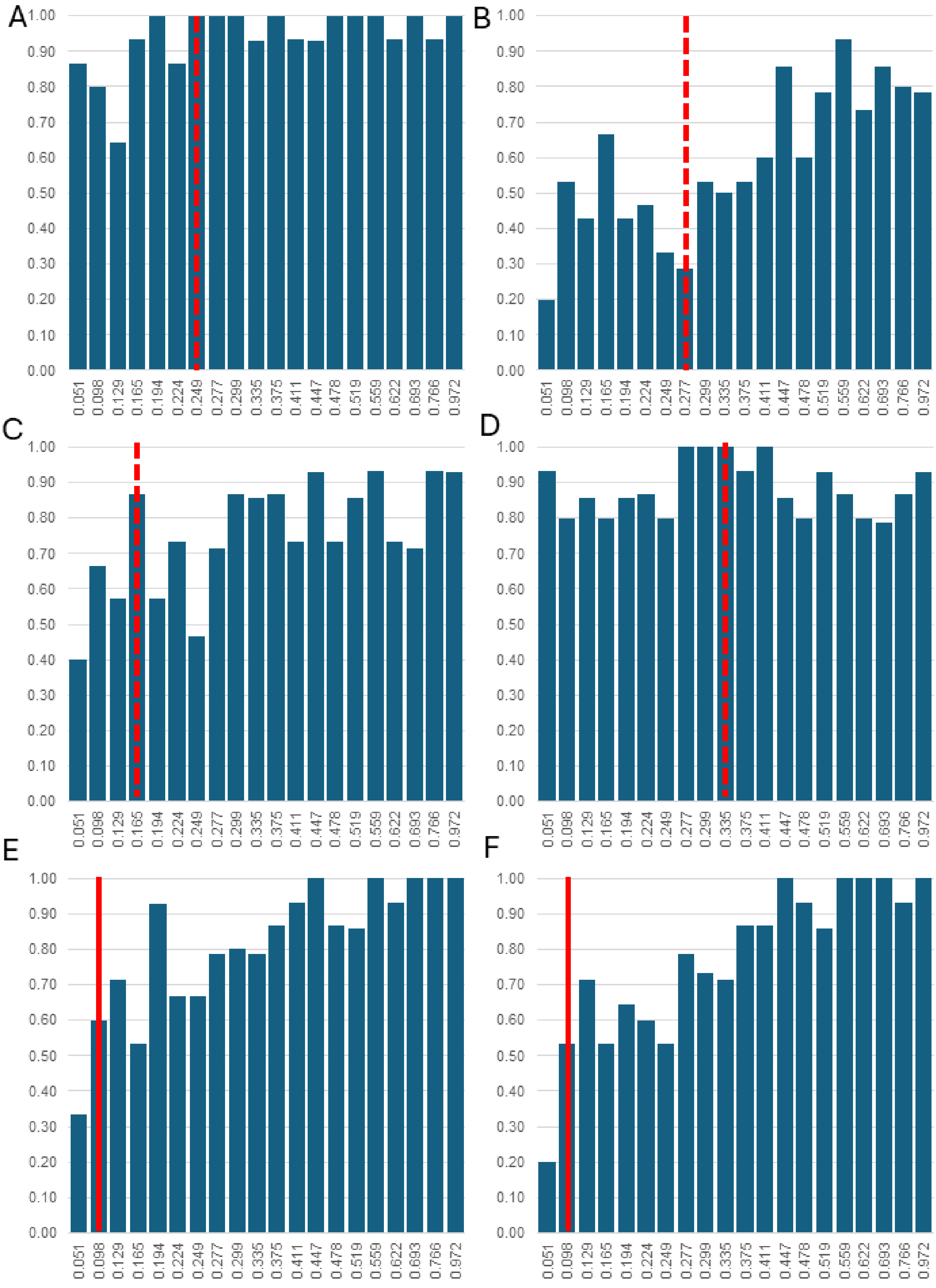

Figure 25: Quantiles (n=20) for ForWet_500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

Figure 26: Quantiles (n=20) for ForWet_1000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

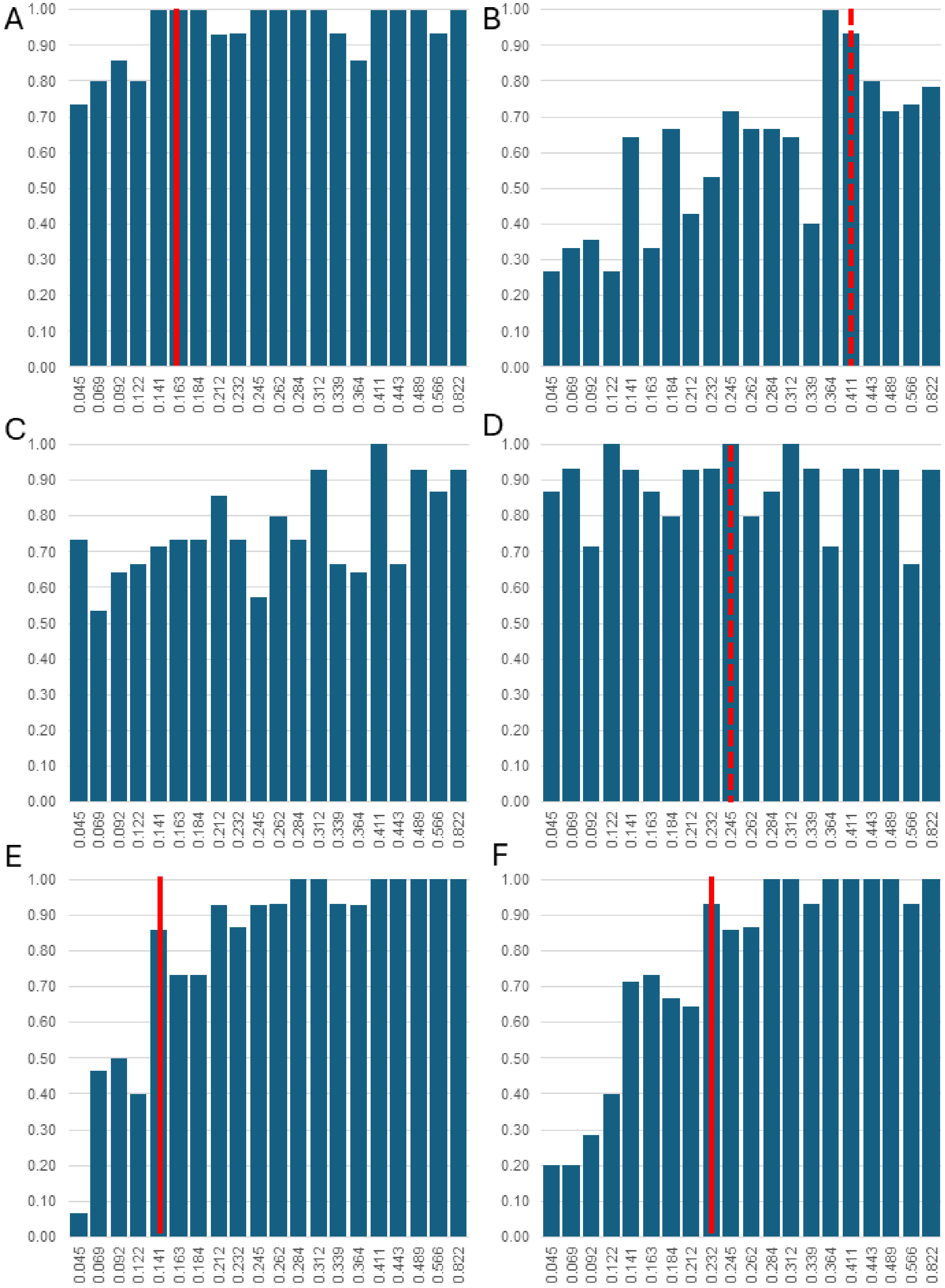

Figure 27: Quantiles (n=20) for ForWet_3000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

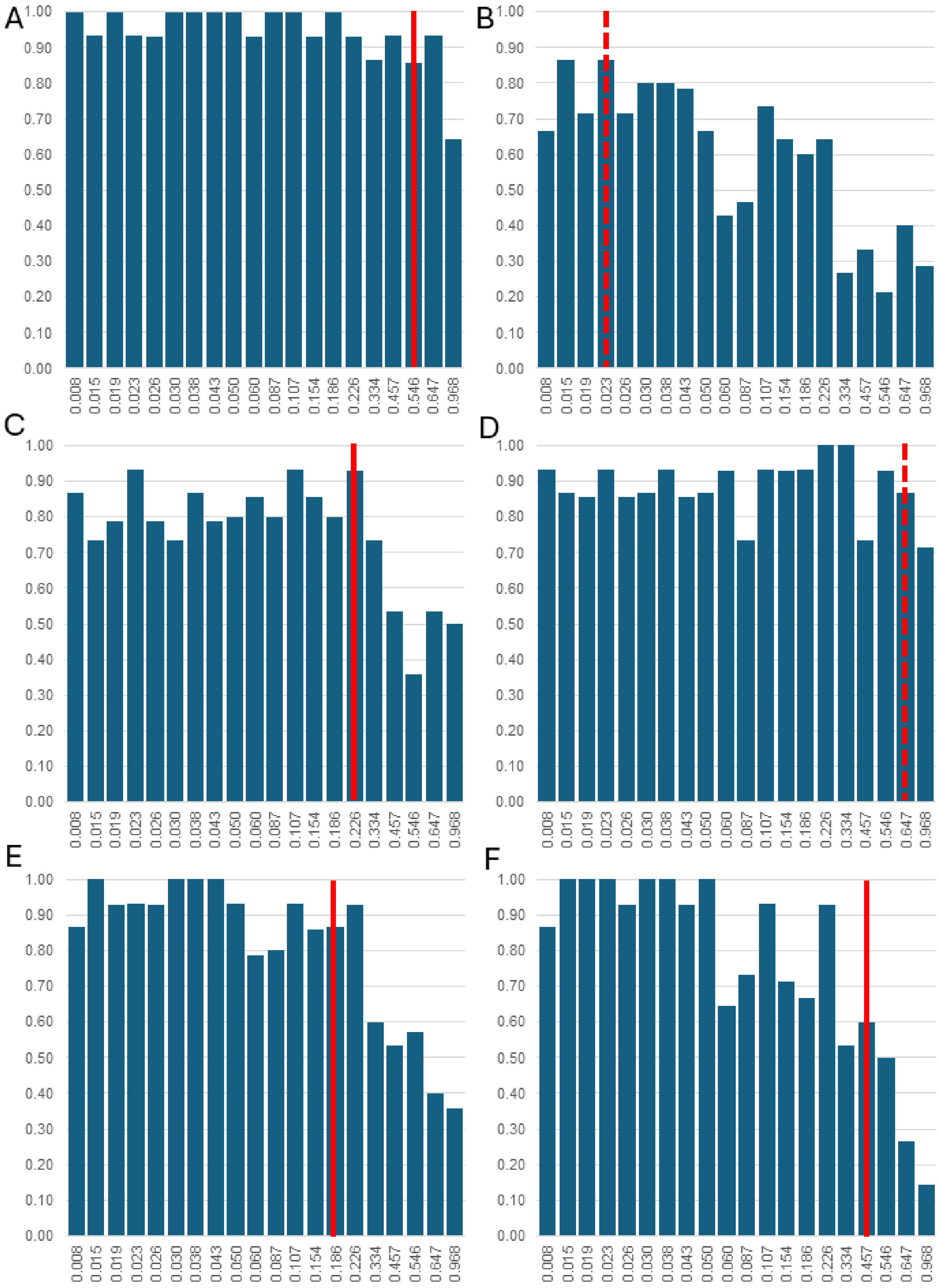

Figure 28: Quantiles (n=20) for Urban_500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

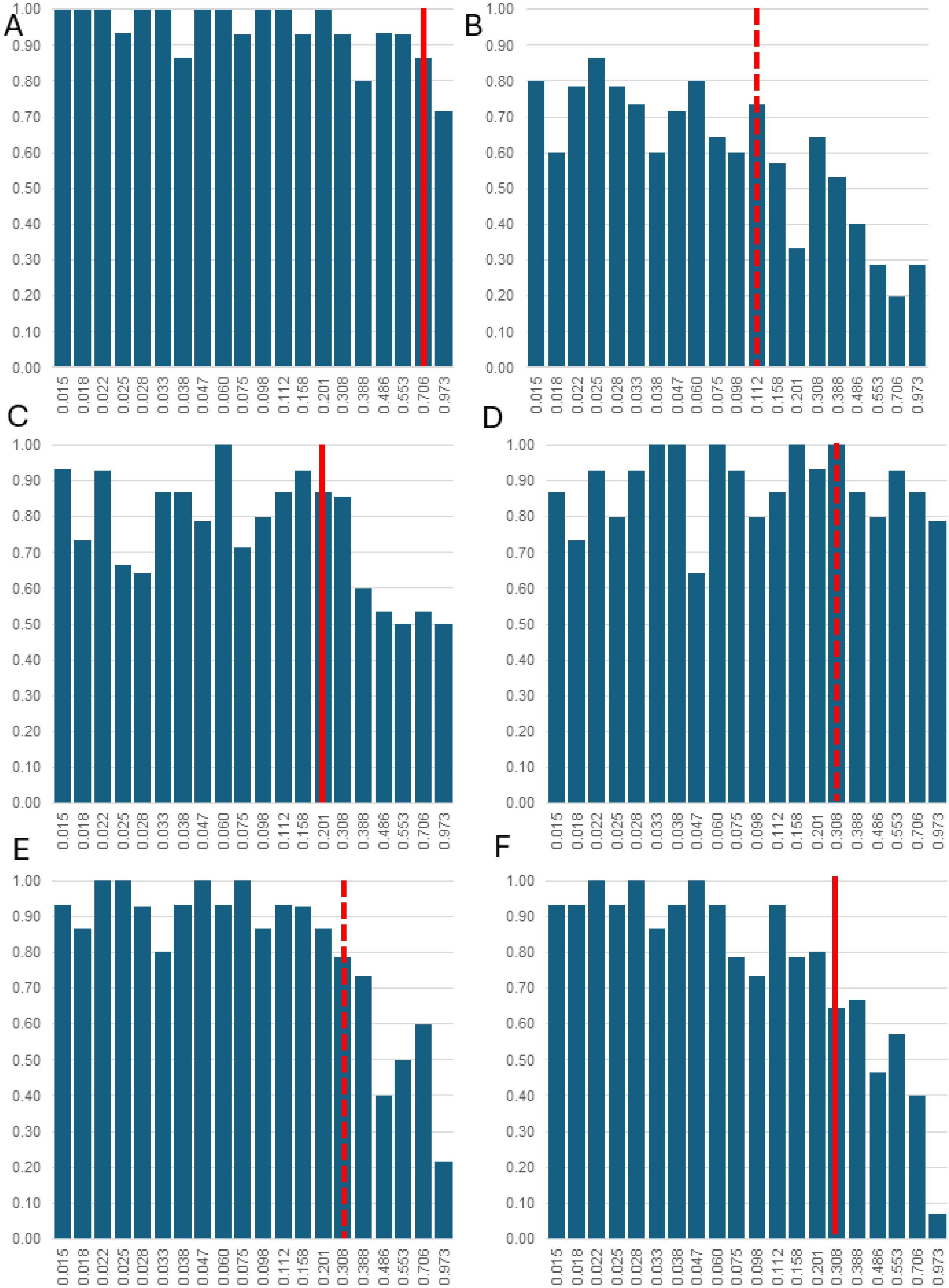

Figure 29: Quantiles (n=20) for Urban_1000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

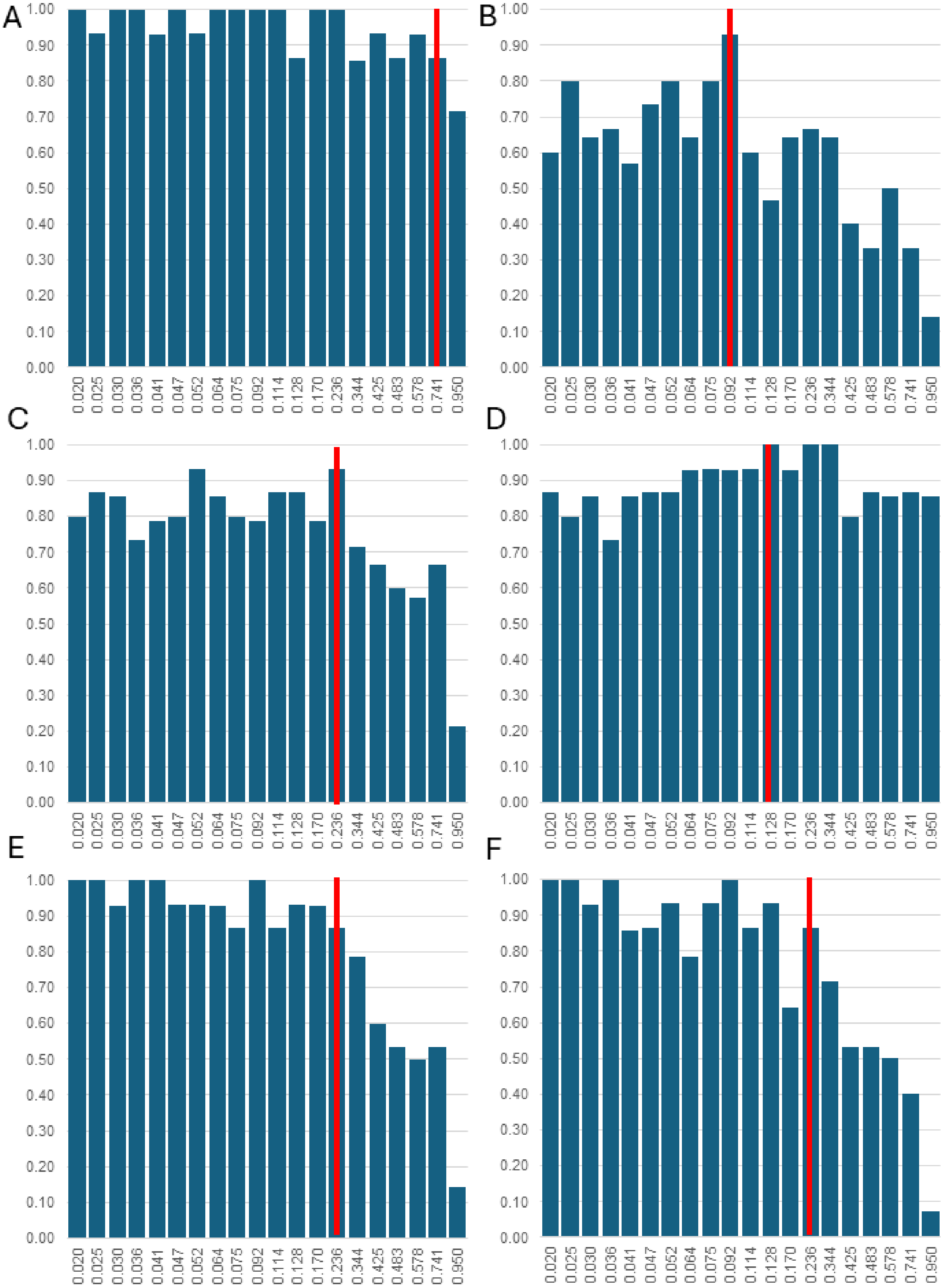

Figure 30: Quantiles (n=20) for Urban_3000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

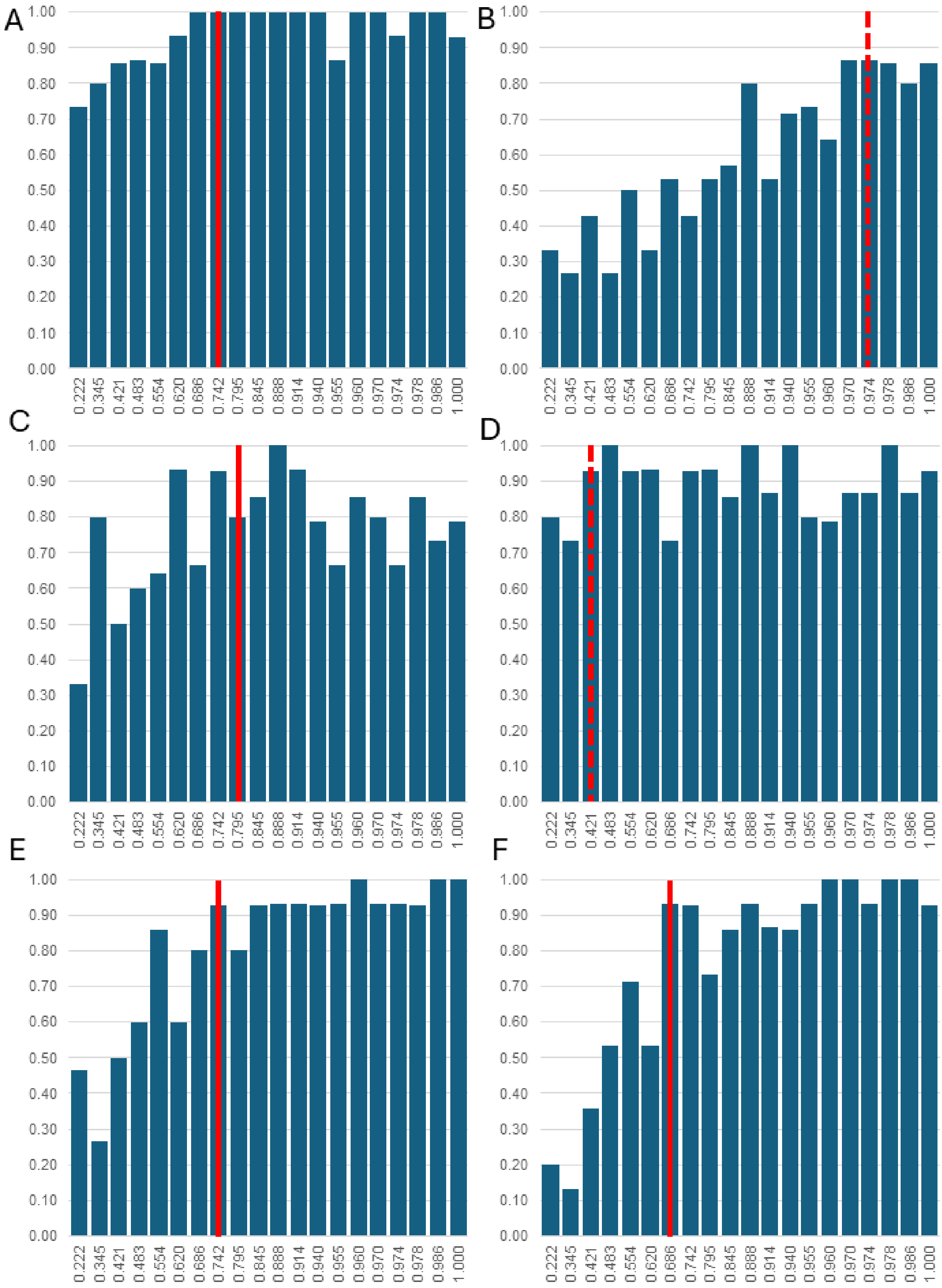

Figure 31: Quantiles (n=20) for NatAgri_500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

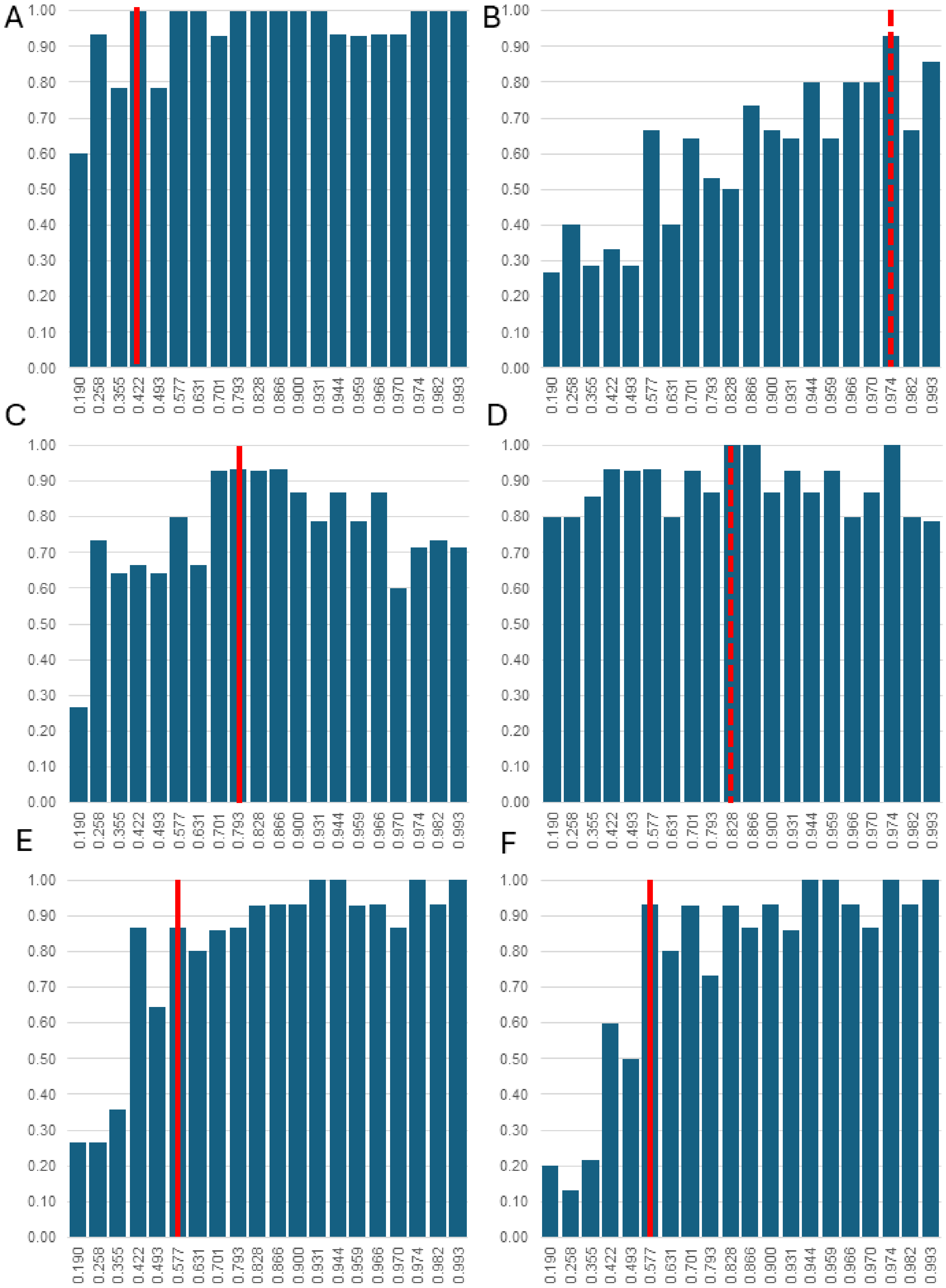

Figure 32: Quantiles (n-20) for NatAgri_500 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.

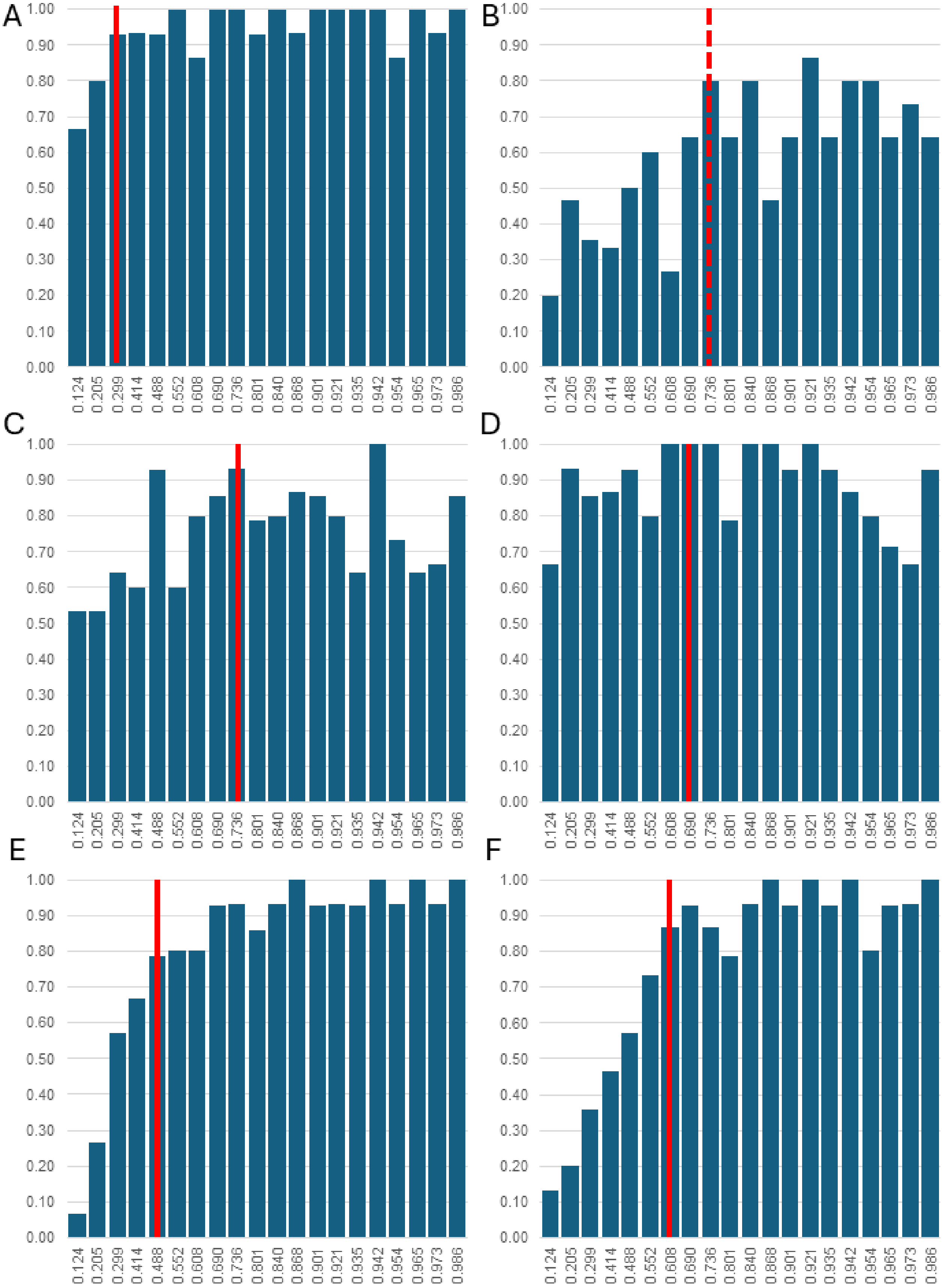

Figure 33: Quantiles (n=20) for NatAgri_3000 for A) green frog, B) wood frog, C) Northern leopard frog, D) American toad, E) spring peeper, and F) gray treefrog. Dashed red lines indicate the location of non-significant breakpoints identified by the r.segmented piecewise regression. Bold red lines indicate the location of significant breakpoints. Y-axis is the proportion of sites with confirmed presence.