Photo: Leo Kenney

Jefferson Salamander

(Ambystoma jeffersonianum) in Ontario

Ontario Recovery Strategy Series

DRAFT

Natural. Valued. Protected.

Ministry of Natural Resources

Ontario

About the Ontario Recovery Strategy Series

This series presents the collection of recovery strategies that are prepared or adopted as advice to the Province of Ontario on the recommended approach to recover species at risk. The Province ensures the preparation of recovery strategies to meet its commitments to recover species at risk under the Endangered Species Act, 2007 (ESA, 2007) and the Accord for the Protection of Species at Risk in Canada.

What is recovery?

Recovery of species at risk is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a recovery strategy?

Under the ESA, 2007, a recovery strategy provides the best available scientific knowledge onwhat is required to achieve recovery of a species. A recovery strategy outlines the habitat needs and the threats to the survival and recovery of the species. It also makes recommendations on the objectives for protection and recovery, the approaches to achieve those objectives, and the area that should be considered in the development of a habitat regulation. Sections 11 to 15 of the ESA, 2007 outline the required content and timelines for developing recovery strategies published in this series.

Recovery strategies are required to be prepared for endangered and threatened species within one or two years respectively of the species being added to the Species at Risk in Ontario list. There is a transition period of five years (until June 30, 2013) to develop recovery strategies for those species listed as endangered or threatened in the schedules of the ESA, 2007. Recovery strategies are required to be prepared for extirpated species only if reintroduction is considered feasible.

What's next?

Nine months after the completion of a recovery strategy a government response statement will be published which summarizes the actions that the Government of Ontario intends to take in response to the strategy. The implementation of recovery strategies depends on the continued cooperation and actions of government agencies, individuals, communities, land users, and conservationists.

For more information

To learn more about species at risk recovery in Ontario, please visit the Ministry of Natural Resources Species at Risk webpage at: **www.ontario.ca/speciesatrisk**

RECOMMENDED CITATION

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Cover illustration: Leo Kenney, Vernal Pool Association

AUTHORS

The recovery strategy was developed by the Jefferson Salamander Recovery Team (Table 4).

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DECLARATION

The Ontario Ministry of Natural Resources has led the development of this recovery strategy for the Jefferson Salamander in accordance with the requirements of the *Endangered Species Act* (ESA 2007). This recovery strategy has been prepared as advice to the Government of Ontario, other responsible jurisdictions and the many different constituencies that may be involved in recovering the species.

The recovery strategy does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation or the official positions of the organizations with which the individuals are associated.

The goals, objectives and recovery approaches identified in the strategy are based on the best available knowledge and are subject to revision as new information becomes available. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy.

RESPONSIBLE JURISDICTIONS

Ontario Ministry of Natural Resources
Canadian Wildlife Service

EXECUTIVE SUMMARY

This recovery strategy outlines the objectives and strategies necessary for the protection and recovery of Canadian populations of the Jefferson Salamander, *Ambystoma jeffersonianum*. This recovery strategy was developed with the goal of ensuring that existing threats to populations and habitat are sufficiently reversed to allow for long term persistence and expansion of *A. jeffersonianum* within its existing Canadian range. The strategy is based on a comprehensive review of current and historical population census data and research in addition to genetic analyses that provide accurate identifications of this salamander species and members of the *A. laterale – jeffersonianum* complex.

Ambystoma jeffersonianum populations have a distinctive genetic evolutionary history. Ontario populations coexist with unisexual individuals that are mostly polyploidy with a predominance of *A. jeffersonianum* chromosomes; and which together are referred to as members of the *A. laterale – jeffersonianium* complex. *Ambystoma jeffersonianum* and polyploids utilize the same habitat and the polyploids are reproductively dependant on *A. jeffersonianum*. That is, the presence of *jeffersonianum*-dominated polyploid eggs necessarily means that *A. jeffersonianum* is present as a sperm donor for those unisexual polyploids. For these reasons, the recommendations in this recovery strategy relating to the identification, mapping and protection of habitat apply to both *A. jeffersonianum* and *jeffersonianum*-dominated polyploids. The apparent absence or non-documentation of an *A. jeffersonianum* individual is often the result of naturally low relative abundance and/or limited search effort (Bogart and Klemens 2008).

Major threats to *A. jeffersonianum* in Ontario include: habitat loss, habitat fragmentation and degradation/alteration, road mortality, impairment of wetland/hydrologic function and the introduction of fish to breeding ponds.

The conservation biology of *A. jeffersonianum* is well known in comparison to other species at risk in Ontario. This recovery strategy provides the scientific basis with which to establish habitat protection guidelines and make recommendations to protect this species in Ontario. Towards this end, this recovery strategy also outlines and prioritizes recovery approaches and programs. Because known *A. jeffersonianum* populations exist in areas that are presently under development pressure, there is an urgent need to implement the recovery approaches and to communicate the recovery goals with municipalities, developers, and other stakeholders where conflicts exist or are anticipated.

It is recommended that the habitat regulation for *A. jeffersonianum* include:

- all wetlands or wetland features that provide suitable breeding conditions where *A. jeffersonianum* and *jeffersonianum*-dominated polyploids occur,
- terrestrial habitat areas within 300 m from the edge of the breeding ponds that provide conditions required for foraging, dispersal, migration, and hibernation, and

- corridors that provide contiguous connections between breeding locations (up to a maximum distance of 1 km).

Any newly discovered breeding locations and associated terrestrial habitat as well as extirpated and historical locations where suitable habitat remains should also be included within the regulation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 BACKGROUND INFORMATION

1.1 Species Assessment and Classification

COMMON NAME: Jefferson Salamander
SCIENTIFIC NAME: *Ambystoma jeffersonianum*
SARO List Classification: Threatened
SARO List History[1]: Threatened (2004)
COSEWIC Assessment History: Threatened (2000)
RANKINGS[2]: GRANK: G4 NRANK: N2 SRANK: S2

[1] The first Species at Risk in Ontario (SARO) list was published in 2003.
[2] G4 – Apparently Secure (i.e., uncommon but not rare), N2 – Imperiled (i.e., extremely rare or especially vulnerable), S2 – Imperiled (NatureServe 2008)

1.2 Species Description and Biology

Species Description

Ambystoma jeffersonianum is a relatively large (65 to 96 mm Snout to Vent Length) grey to brownish-grey salamander. *Ambystoma jeffersonianum* egg masses were described by Bishop (1947). The eggs are incorporated in gelatinous masses that are attached to sticks and plant stems. Each egg mass contains 16 to 40 large (2.0 to 2.5 mm) eggs. The individual eggs contain a black or dark brown embryo that is enclosed by a distinct envelope. The eggs are surrounded by a loose, watery protective gel layer. The dark melanin pigment and the jelly covering (and any algae within), along with dissolved organic matter in the water, protect the developing embryos from damage through exposure to ultraviolet -B radiation (Licht 2003). Individual females lay several such egg masses with a complete complement of more than 200 eggs depending on female size.

Breeding success can be variable from year to year depending on spring weather and water level conditions. However, because *A. jeffersonianum* are long lived (up to 30 years) populations can be resilient to such variable reproductive output. Eggs complete their development in two to four weeks (depending primarily on water temperature). Hatchlings have a total length of 10 to 14 mm. Transformation from larvae to adults normally occurs in July and August when juveniles move out of the pond and seek shelter in the forest litter. The larval stage can be variable, and can extend into early September.

Species Biology - Genetics

The unusual reproductive biology and genetics of the *A. jeffersonianum* have presented a number of challenges in formulating recovery recommendations. The summary below is intended to explain the main aspects of the *A. laterale* (blue-spotted salamander) – *jeffersonianum* complex.

Ambystoma jeffersonianum populations normally coexist with unisexual individuals that are mostly polyploid with a predominance of *A. jeffersonianum* chromosomes; and which together are referred to as members of the *A. laterale* – *jeffersonianum* complex. The presence of the eggs of *jeffersonianum*-dominated polyploids necessarily and absolutely indicates the presence of breeding pure *A. jeffersonianum* which is required as a sperm donor to initiate egg development of *jeffersonianum*-dominated polyploids (Bogart and Klemens 1997; 2008, Rye and Weller 2000, OMNR 2008 unpublished data). In Ontario, there is absolute correspondence between pure *A. jeffersonianum* and *jeffersonianum*-dominated polyploids, as is the case in New England and New York (Bogart and Klemens 1997; 2008). Pure *jeffersonianum* and *jeffersonianum*-dominated polyploids can not be separated by habitat or in many cases by morphology. Therefore, genetic analysis is often required to distinguish pure *jeffersonianum* from polyploids and particularly pure female *jeffersonianum*. *Ambystoma laterale* and *laterale*-dominated polyploids are the other members of the complex. Polyploids dominated by the *A. laterale* are not indicative of *A. jeffersonianum*. Polyploid members of the complex are generally triploid, but tetraploid and pentaploid individuals have also been documented (Bogart 2003).

Contrary to earlier theories, there is no evidence of past or present hybridization among the members of the *A. laterale – jeffersonianium* complex (Bogart 2003). Mitochondrial DNA from polyploid females predates that of *A. jeffersonianum* and *A. laterale* (Bogart et al. 2007), and has been matched with that of a Kentucky population of *Ambystoma barbouri* (Bogart 2003). The genetic mixing which occurs within the polyploid component of the complex is attributed to an unusual reproductive strategy (gynogenesis) where polyploid females lay mostly unreduced eggs (eggs whose ploidy is equivalent to that of the parent's somatic cells), and where sperm from a diploid male is required solely to initiate egg development (Elinson et al. 1992). Occasionally, reduced eggs will be present in an egg mass, and genetic material from sperm can be incorporated into the embryos (Bogart 2003).

Jeffersonianum-dominated polyploids demonstrate the same ecology and use of habitat as pure *A. jeffersonianum* (Bériault 2005, OMNR 2008). However, *jeffersonianum*-dominated polyploids occur at much greater relative abundance, normally comprising 90 – 95% of local populations (Bogart and Klemens 2008; 1997, OMNR 2008 unpublished data). Therefore, many search efforts focused on finding *A. jeffersonianum* using a random sampling of the population would likely encounter only *jeffersonianum*-dominated polyploids. Because *A. jeffersonianum* and *jeffersonianum*-dominated polyploids can not be separated by habitat, and because the perpetuation of the polyploid component of the complex is dependent on the presence of *A. jeffersonianum*;

the recommendations in this recovery strategy relating to the identification, description, mapping, and protection of habitat apply to both *A. jeffersonianum* and *jeffersonianum*-dominated polyploids. The state of Connecticut has gone one step further and has afforded equal protection to polyploids (Bogart and Klemens 2008).

Ecological Role

The presence of *A. jeffersonianum* is critical to the survival and existence of unisexuals that make up the majority of the population complex and utilize *A. jeffersonianum* males as sperm donors.

Larvae of *A. jeffersonianum* are voracious aquatic predators that feed on moving prey items such as insect larvae, small crustaceans, and amphibian larvae. Adults are likely prey items for wetland predators, such as snakes, rodents, and birds like the Red-shouldered Hawk. *A. jeffersonianum* plays an important role in channeling nutrients between the aquatic environment and the upland wooded environment and is an indicator species of high quality vernal pools.

1.3 Distribution, Abundance and Population Trends

Global Range

The Canadian range of *A. jeffersonianum* is restricted to southern Ontario, particularly along the Niagara Escarpment World Biosphere Reserve. In the United States, A. jeffersonianum ranges from New York and New England south and southwestward to Indiana, Kentucky, West Virginia, and Virginia. An ecological isolate occurs in east-central Illinois (Petranka 1998) (Fig. 1). For much of this range, genetic data are unavailable so the continental distribution of pure *A. jeffersonianum* and *jeffersonianum*-dominated polyploids is uncertain (Bogart and Klemens 1997).

The current Global Natural Heritage Status Rank for *A. jeffersonianum* was assigned by the Association for Biodiversity Information (ABI) (NatureServe 2008). Their ranking for *A. jeffersonianum* is “G4”, a level of ranking assigned to species with greater than 100 site occurrences and greater than 10,000 individuals, giving the species a secure rating globally. NatureServe also applies Natural Heritage Status rankings at the national (N) and sub-national (S) (i.e., provinces or states) level. Rankings for the Canadian and U.S. populations are summarized in Table 1. Notably, in addition to being listed as threatened in Ontario and Canada, the species has been designated as imperiled (S2) in Illinois and Vermont and is only considered to be secure (S4) in five of the 14 states where it is found.

Table 1. Summary of NatureServe (2008) Natural Heritage Status Rankings for *Ambystoma jeffersonianum*

Level	Heritage Status Rank
Global	G4
United States	N4
Canada	N2
Ontario	S2
United States	N4
Connecticut	S3
Illinois	S2
Indiana	S4
Kentucky	S4
Maryland	S3
Massachusetts	S2S3
New Hampshire	S2S3
New Jersey	S3
New York	S4
Ohio	SNR
Pennsylvania	S4
Vermont	S2
Virginia	S4
West Virginia	S3

Legend:

G2/N2/S2 –Imperiled (i.e., extremely rare or especially vulnerable)

G3/N3/S3 – Vulnerable to extirpation or extinction (i.e., rare and uncommon)

G4/N4/S4 – Apparently Secure (i.e., uncommon but not rare)
SNR – Unranked

* **Source:** NatureServe (2008)

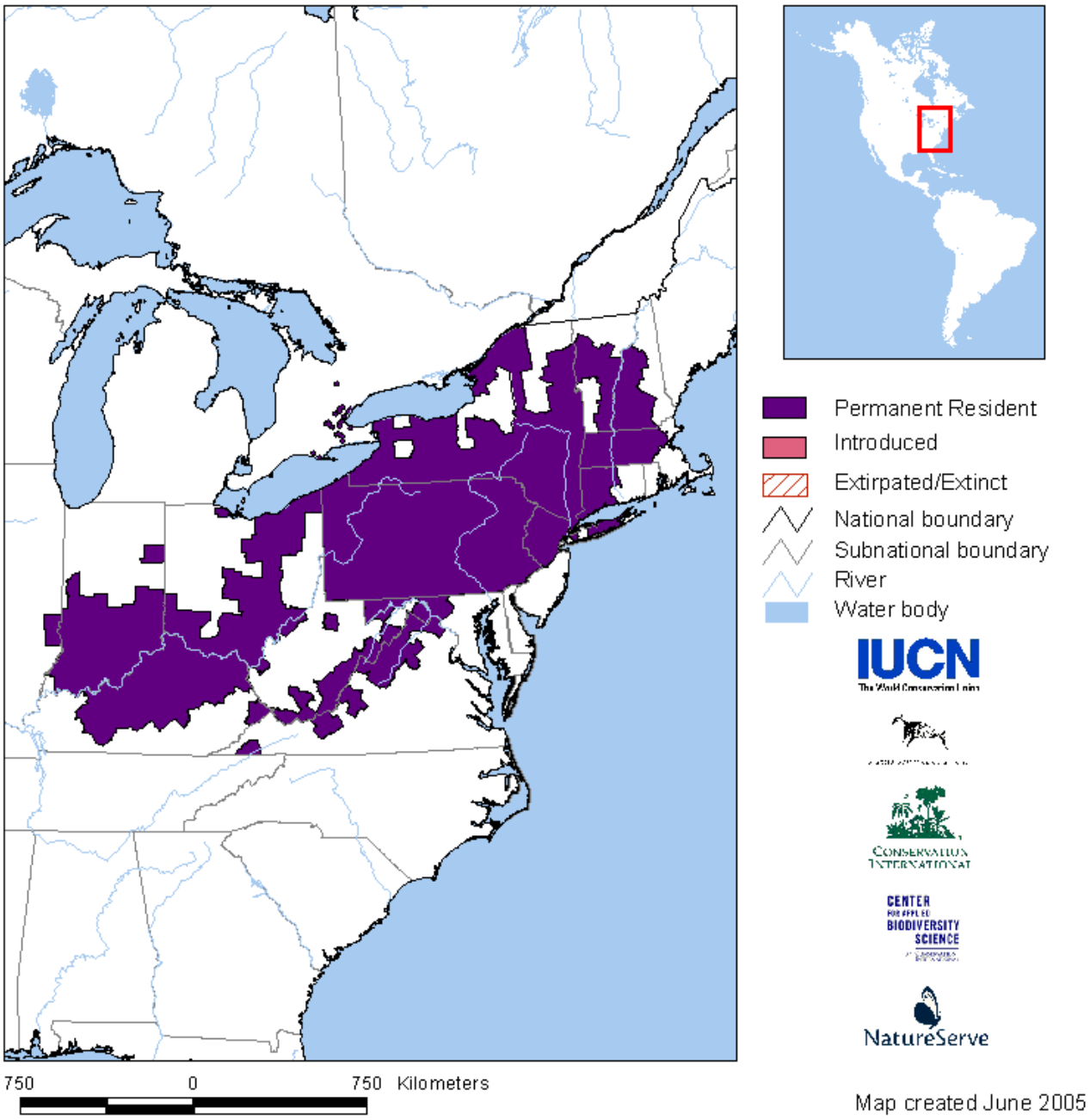

Figure 1. Range Map for *Ambystoma jeffersonianum* (NatureServe 2005).

Canadian Range

The distribution of *A. jeffersonianum* in Canada as of October 2008 is based on approximately 328 breeding ponds representing approximately 27 discrete populations. This data is based on both extant and historic occurrences.

Figure 2 provides the most current locality information based on a compilation of databases. COSEWIC and COSSARO have both assigned the species a "threatened" status to the species. The National Heritage Information Center (NHIC 2003) has assigned it an "S2" rank (i.e. very rare in Ontario; usually between 5 and 20 element occurrences in the province, or few remaining hectares, or with many individuals in fewer occurrences; often susceptible to extirpation). The S-rank only applies to pure *A. jeffersonianum*, which, by virtue of their very low relative abundance within the complex, means they are exceedingly rare.

In Ontario, known extant populations of *A. jeffersonianum* occur in:

1) Haldimand - Norfolk Region;
2) forested habitat along the Niagara Escarpment from the Hamilton area to Orangeville;
3) isolated localities in Halton and Peel Regions;
4) Dufferin County East of the Escarpment;
5) in Waterloo Region; and
6) a few isolated ponds in York Region and on the Oak Ridges Moraine.

A population in Wellington County, South of Guelph is likely extirpated. The last salamanders were observed at that site in April 1989 (Bogart unpublished) and the breeding pond was dry in successive years (1990 – 1993). Historically, *A. jeffersonianum* was probably much more widely distributed throughout southwestern and south-central Ontario prior to the clearing of forests for agriculture.

Percent Global Distribution in Canada

Populations of *A. jeffersonianum* in Canada are situated at the northern limit of the species' North American range. The Canadian populations probably represent a maximum of 1-3 % of the estimated North American population based on relative ranges (Rye and Weller 2000) (Figure 1).

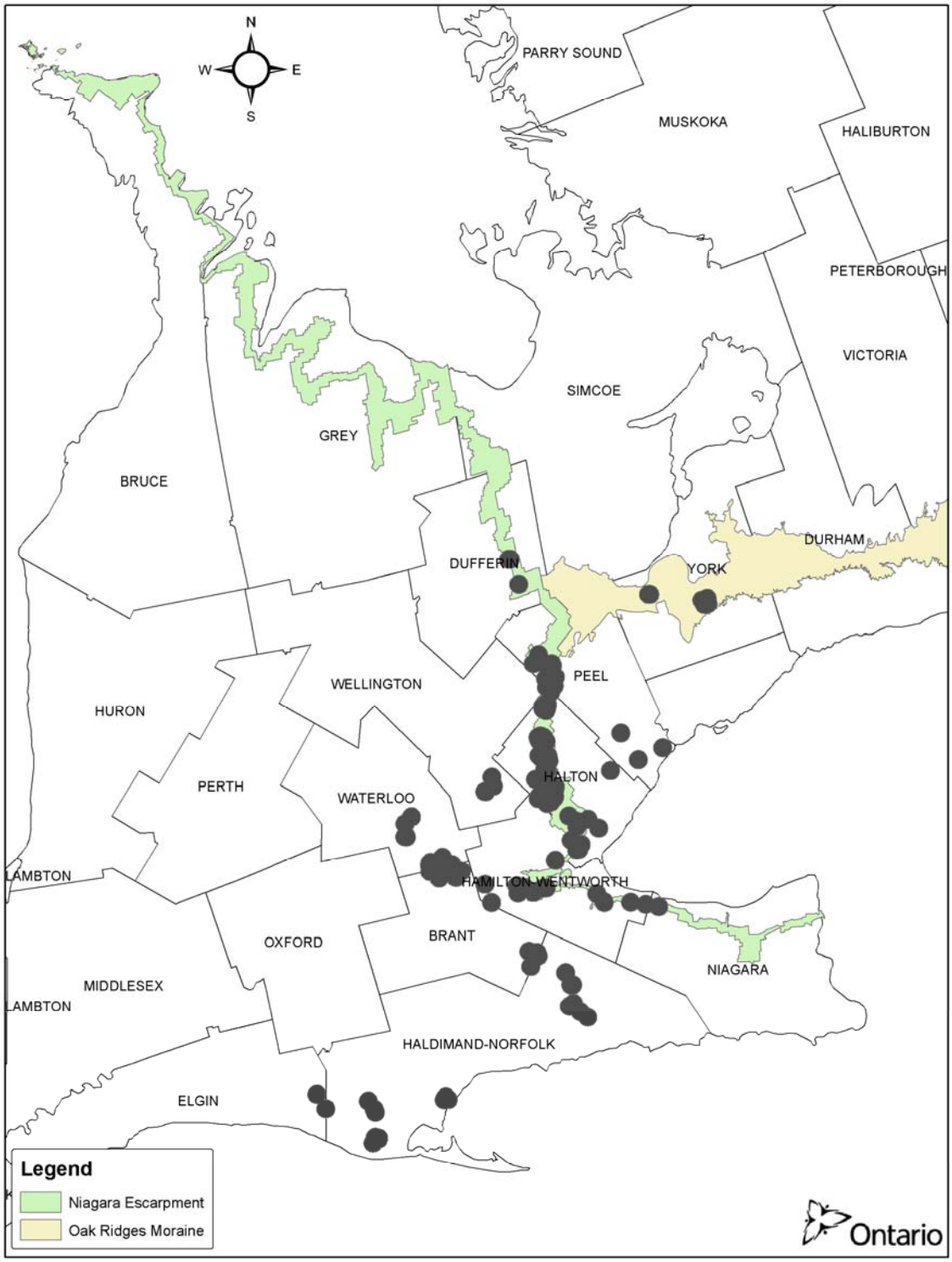

Figure 2. Documented Locations of *Ambystoma jeffersonianum* in Ontario.

Population Sizes and Trends

A. jeffersonianum was first recognized to occur in Canada by Weller and Sprules in 1976. Based on our present knowledge, the current isolated populations are remnants of what was once a more extensive, (i.e., continuous) range throughout southern Ontario. Fragmentation and loss of habitat has led to the isolation of these populations. In the part of the province located south and east of the Canadian Shield, over 70% of the original woodlands have been lost since European settlement (Riley and Mohr 1994). Habitats have been further lost and fragmented as a result of large scale agriculture, urbanization, road networks, and resource development activities, such as aggregate extraction.

As denoted in Section 1.3, Canadian Range; there are approximately 27 known populations of *A. jeffersonianum* in Ontario. One breeding pond does not necessarily represent a population; there may be several or many breeding ponds within an area that supports a discrete population. Populations are represented by one or more breeding ponds within an area of contiguous suitable habitat.

Available population census information does not permit an assessment of global abundance trends for this species. Its current Global Natural Heritage Status Ranking is “G4” (NatureServe 2008) which indicates that the species is apparently secure within its range. However, in Ontario, threats to *A. jeffersonianum*, discussed in Section 1.6, are well known and cumulative loss and impairment of habitat continues.

Temporal trends for this species are not readily available because of the identification challenges of *A. jeffersonianum* and the unisexual nuclear hybrids. As stated earlier, *jeffersonianum*-dominated polyploids occur at much greater relative abundance, normally comprising 90 – 95% of local populations (Bogart and Klemens 1997; 2008, OMNR 2008 unpublished data). This means that pure *A. jeffersonianum* represents only 5-10% of the relative abundance of the population (Bogart and Klemens 2008).

Normally, estimations of distribution of vertebrate species may be obtained from museum records and voucher specimens. Such historical identifications of *A. jeffersonianum* as well as available museum records are, however, not necessarily accurate. Bishop (1947), in his classic book on North American salamanders, lumped all of the presently recognized members of the complex (*A. laterale*, *A. jeffersonianum* and all of the unisexuals) in a single species, *A. jeffersonianum*. Until 1964, most museum curators adhered to Bishop’s nomenclature without the benefit of genetic confirmation. However, it is now understood that it is not possible to distinguish most individuals of the complex that are catalogued in major museum collections.

Uzzell (1964) tried to establish ranges for *A. jeffersonianum* by sorting the males into *A. laterale* and *A. jeffersonianum* and by using blood cell size to distinguish diploid and triploid females. Uzzell’s ranges for *A. jeffersonianum* were based on very few individuals (8 from Massachusetts; 1 from New Jersey; 37 from New York; and 1 from Vermont). Bogart and Klemens (1997) provided a more accurate range of *A.*

jeffersonianum in New York and New England through the isozyme screening of 1,006 individuals from 106 sites. That large sample only provided 66 pure *A. jeffersonianum* individuals (6.59%). The global range (Fig. 1) is based on limited data and many regions still require genetic confirmation.

A. jeffersonianum individuals occur in all of the populations shown in Fig. 2 (Bogart 1982; Bogart and Cook 1991; Lamond 1994; Bogart unpublished information), but some of these localities have not been revisited for more than 10 years.

Despite genetic identification difficulties, the available population data shows a declining trend (Rye and Weller 2000).

1.4 Habitat Needs

Breeding Ponds

During the first spring rains in March and April, adults migrate overland to breeding ponds (e.g., vernal pools) at night where mating and oviposition take place. *A. jeffersonianum* use a range of wetland types for breeding. Breeding ponds are generally vernal pools that are either fed by groundwater (e.g., springs), snowmelt or surface waters. These types of ponds normally dry in mid to late summer. Other types of wetlands used for breeding may have permanent or semi-permanent water. The ponds are generally located within a woodland or in proximity to a woodland. *A. jeffersonianum* individuals demonstrate strong pond fidelity, returning to the same pond each year to breed.

Low shrubs, twigs, fallen tree branches, submerged riparian vegetation or emergent vegetation are required for egg mass attachment.

Research has shown that the depth of the water, water temperature, pH, and other water chemistry and water quality parameters are not good predictors of the use of breeding ponds by *A. jeffersonianum* (Bériault 2005). In central Pennsylvania, one of the few regions in which the unisexuals do not co-exist with *A. jeffersonianum*, embryonic (larval) mortality was high in ponds below pH 4.5. Because *A. jeffersonianum* larvae are not particularly susceptible to relatively low pH (Beriault pers. comm.), mortality was probably affected by the availability of prey items (Sadinski and Dunson 1992).

Food (prey items) must be present in the ponds. Known aquatic prey items include small aquatic invertebrates and amphibian larvae.

Breeding ponds must not contain fish that are capable of preying upon *A. jeffersonianum* in order for egg masses, juveniles and adult *A. jeffersonianum* to be successful.

The hydrologic and hydrogeologic integrity of breeding habitat must be maintained. This requires that both surface water hydrology and groundwater contributions are not disrupted, altered or diminished. Hydrologic assessments are required for any adjacent land use that may impact ground or surface water supporting the breeding pond.

Terrestrial Habitat

Terrestrial habitat is used by *A. jeffersonianum* during all parts of its life cycle including migrating to and from breeding ponds, summer and fall movement and foraging, and overwintering. A number of terrestrial habitats are used by *A. jeffersonianum*. Most often, *A. jeffersonianum* are associated with deciduous or mixed woodlands. Terrestrial habitat must contain microhabitat, such as rodent burrows, rock fissures, downed woody debris, tree stumps and buttresses, leaf litter, logs, etc. Other than during migration and breeding, this microhabitat is where *A. jeffersonianum* reside. *A. jeffersonianum* overwinter in the ground below the frost line (deep rock fissures and rodent burrows). Summer burrows are horizontal and winter burrows are vertical (Faccio 2003). *A. jeffersonianum* are also known to show fidelity to their terrestrial habitat (Thompson et al. 1980, OMNR 2008 unpublished data).

Food (prey items) in the terrestrial habitat include insects, earthworms and other invertebrates.

Migratory movements occur in a variety of habitats including woodlands, plantations, agricultural fields, early successional areas, and across roads. Radio tracking studies have documented that the migratory distance of adults of the *jeffersonianum* complex can range from hundreds of metres up to 1 km from the breeding pond into surrounding habitat (Bériault 2005, Faccio 2003, Semlitsch 1998, OMNR 2008 unpublished data). However, radio telemetry studies in Ontario also found that 90% of adults reside in suitable habitat within 300 m surrounding their breeding pond (Bériault 2005, OMNR 2008 unpublished data).

1.5 Limiting Factors

Factors affecting *A. jeffersonianum* include the limited availability of the habitats required by the species, i.e., vernal pools or fishless wetlands in woodlands for breeding, and loose, moist soils in deciduous or mixed woodlands in terrestrial sites for burrowing.

Climate change may also have an effect on the timing and success of the breeding season.

Limiting Factors in Breeding Ponds

In order for breeding to be successful, there needs to be an adequate amount of suitable egg attachment sites. There also needs to be an adequate amount of food (prey items) within the pond. All life stages of *A. jeffersonianum* are vulnerable to

predation by fish; therefore, ponds containing predatory fish capable of preying upon *A. jeffersonianum* are not suitable as habitat. Many forested wetlands are connected by stream systems that provide access for fish. Therefore, the limited occurrence of vernal pools and fishless wetlands in woodlands is in itself, a limiting factor.

Egg and larval mortality have been observed to be high in ponds used by most populations of *A. jeffersonianum*, but these dead eggs are usually attributed to the polyploids. Larval mortality is also high among polyploid individuals (Bogart and Licht 1986). In some years, populations can be impacted by ponds drying or freezing completely when adult salamanders are breeding or prior to larval transformation.

Limiting Factors in the Terrestrial Habitat

The terrestrial habitat must have an adequate humus layer, leaf litter, stumps, logs, root holes, rock fissures, appropriate soil type, and mammal burrows for feeding, moisture retention, and predator avoidance.

1.6 Threats to Survival and Recovery

The following threats to Jefferson salamander are presented in order of priority.

Habitat Loss or Degradation

Anthropogenic threats include development activities that result in the cumulative loss and degradation of habitat and fragmentation of breeding ponds and woodlands. Activities associated with urbanization, aggregate extraction and resource development are the most significant threats to *A. jeffersonianum* in southern Ontario. The range of *A. jeffersonianum* is concentrated along the Niagara Escarpment which is a significant aggregate extraction area.

Impacts from development include; site clearing and grading that alter cover, topography and drainage patterns; storm water management and increases in impervious cover that alter natural hydroperiod regimes; water balance of adjacent wetlands and moisture content of soils; and silt fencing that prevents and/or hinders migration of salamanders. Urbanization, aggregate extraction and roads can result in the loss, impairment and fragmentation of habitat. In addition to direct habitat loss and fragmentation, any resource development activity that may alter the water table or cause a disruption or modification to groundwater flow has the potential to alter wetland hydroperiods and breeding habitat, water balance, wetland function, and soil moisture regimes in adjacent *A. jeffersonianum* habitat.

Roads

Roads (and urbanization) can create barriers that limit salamander dispersal and abundance and fragment habitat. Individuals are frequently killed by vehicles while

crossing roads, and curbs and catch basins may act as barriers and traps, respectively, for salamanders. Roads also are a source of chemicals and pollutants (e.g., salt) that degrade adjacent aquatic and terrestrial habitat. Roads create zones of disturbance that are characterized by noise and light pollution, and contribute to desiccation of migrating adults and increased vulnerability to predators.

Changes in Ecological Dynamics

Relevant to this discussion is an examination of why *A. jeffersonianum* were not found in some sites in recent years. Perhaps the species is extirpated in these populations. Data again are limited, but habitat changes associated with anthropogenic disturbance likely are factors. Premature drying of ponds can result from the removal of a part of the protective canopy, drawing down the water table in developed areas, or altering water courses for snow melt and runoff. The reduction of vernal pond “envelopes” and buffer zones also have been suggested as contributing to the reduction and possible elimination of species of *Ambystoma* (Calhoun and Klemens 2002).

Forestry Activities

As *A. jeffersonianum* is generally associated with deciduous woodlands, the terrestrial habitat of the species is vulnerable to forestry activities. Forestry activities and the equipment used may result in the filling of vernal pools, alteration of vernal pool hydrology, sedimentation, removal or alteration of associated upland habitat (canopy cover, removal of stumps, logs and leaf litter, and altering nutrient inputs by leaves), pollution, and fragmentation or isolation of vernal pools from the terrestrial habitat.

Recreation and Trails

High traffic recreation trails in proximity to breeding pools and terrestrial habitat may also result in salamander mortality or habitat degradation from trampling by hikers, cyclists, and All Terrain Vehicles.

Unauthorized Collections and Introduced Species

Collection for the pet trade of amphibians and reptiles is a growing concern and may be a threat to *A. jeffersonianum*. Knowledge of the species’ whereabouts by the general public is not widespread, and nocturnal migration and breeding activities occur during very few rainy nights early in the spring and in late summer/early fall for juveniles. A bigger incidental human threat is the addition of carnivorous fish to breeding ponds which are predators on all life stages.

1.7 Knowledge Gaps

Key knowledge gaps include (but are not limited to):

1. Effectiveness of mitigation efforts to address threats and means of reducing road mortality
2. Refinement of distribution and range particularly in portions of the Oak Ridges Moraine and the Greenbelt
3. Juvenile dispersal patterns, timing and distances
4. Fall migration
5. Information on overwintering sites

These five knowledge gaps have been grouped under two headings:

Threat Clarification Research Requirements

To date, there has been insufficient research focused directly on natural and human threats to this species. Direct threats, such as habitat loss associated with resource development and urbanization, need to be quantified and evaluated within the context of cumulative impacts on the distribution and abundance of *A. jeffersonianum*. Indirect threats (e.g., development activities that cause changes to wetland hydrology on adjacent lands) require detailed investigations and monitoring to determine cause and affect relationships and to evaluate the effectiveness of proposed mitigations. All potential threats to *A. jeffersonianum* should be investigated empirically and weighted against other threats. Threats are often difficult to manage; therefore, it is important to amass empirical data to support recovery planning in consultation with planning authorities, developers and stakeholders.

Biological/Ecological Research Requirements

Little is known about the dispersal patterns of juvenile *A. jeffersonianum*. It is theorized that juveniles would potentially disperse further than adults to establish new breeding ponds and/or populations when the carrying capacity has been reached in existing breeding ponds (Bogart pers. com.).

All of the telemetry studies completed to date have focused on the spring/summer migration of adults. Future telemetry studies are required to research the fall migration. This would also help with obtaining more information on *A. jeffersonianum* overwintering sites and terrestrial habitat use. Information such as microhabitat use, communal or individual use of sites, etc. would be explored.

1.8 Recovery Actions Completed or Underway

Work on several of the recovery objectives has been initiated and a number of studies on the species have been completed.

Research on Habitat Use and Spatial Requirements (Recovery Objective II)

In 2004, radio telemetry studies of a southern Ontario *A. jeffersonianum* population were initiated by the University of Guelph (Bériault 2005). These studies focused on the movement and habitat use of LJJ[3] polyploids (sample size of 16). In order to increase the sample size of radio-tagged salamanders and to investigate additional questions relating to habitat use, movements and population demographics, the study was continued and expanded in 2005 by MNR. Radio transmitters were implanted in 17 additional polyploids from the same location and in 9 and 10 individuals respectively at two different sites in Peel Region. In 2007 and 2008, MNR conducted additional radio telemetry monitoring of both polyploids and pure *A. jeffersonianum* at a site in Halton Region. With an additional 59 salamanders monitored, for a total sample size of 111, these studies have generated extensive data on the movements and terrestrial habitat use of *A. jeffersonianum* and *jeffersonianum*-dominated polyploids. These findings, in addition to other referenced studies, provide the basis for the recommendations for habitat regulations found in Section 2.5.

Monitoring Extant Occurrences and Searching for New Breeding Ponds (Recovery Objectives I and V)

In 2002 and 2003, the recovery team worked with the Regional Municipality of York to determine whether *A. jeffersonianum* populations existed within York Region. Field investigations revealed four populations of *A. jeffersonianum*. These four populations are the only ones known in York Region and represent the most eastern distribution of this species in Ontario.

In 2003, the recovery team formed a partnership with the University of Guelph to update the database of all known *A. jeffersonianum* and polyploid occurrences. Since 2003, more than 100 wetlands with the potential to support *Ambystoma* sp. have been searched for *A. jeffersonianum*. Fifteen new breeding sites have been documented while some of the historical breeding locations have been confirmed to be extirpated because of habitat disturbance or loss. Because of the elusive nature of this species, the limited window of time to find them, and the fact that they may not breed every year if conditions are not appropriate, it is difficult to determine with certainty that a breeding location is extirpated. These findings highlight the rarity of *A. jeffersonianum*, particularly in areas off the Niagara Escarpment.

Also in 2003-2004, the Niagara Escarpment Commission, in partnership with the University of Guelph, and under the direction of the recovery team, undertook a study to examine the location and habitat conditions of *A. jeffersonianum* breeding sites along the Niagara Escarpment. The study focused on historically known breeding locations that had been documented by the University of Guelph in 1990 and 1991. Eighteen

[3] LJJ: A member of the *A. laterale* - *jeffersonianum* complex with a predominance of *A. jeffersonianum* chromosomes.

Escarpment sites were searched for *A. jeffersonianum* egg masses by staff from Ontario's Niagara Escarpment (ONE) Monitoring Program. Three sites were confirmed to have *A. jeffersonianum* with the remaining 15 sites no longer supporting A*. jeffersonianum* or polyploids.

In 2004, also under the direction of the recovery team, a number of Conservation Authorities (including Grand River Conservation Authority, Hamilton Conservation, Conservation Halton, Credit Valley Conservation, and Toronto and Region Conservation) continued to contribute to the recovery process and recovery planning by allocating staff time and resources to revisit vernal pools previously known to support *A. jeffersonianum* and to investigate other potential habitats within their watersheds.

In 2006, and continuing in 2007, University of Toronto at Mississauga, Evergreen, EcoSource Mississauga and Credit Valley Conservation have, under direction of the recovery team, partnered to assess both habitat conditions and potential human-related impacts to an *A. jeffersonianum* breeding pond in Peel Region. Information gathered through this project will contribute to the understanding of ground water contributions to the breeding pond, and of habitat impacts associated with recreational trails.

Species and Ploidy Identification

At the University of Guelph, microsatellite molecular markers for *A. jeffersonianum* (Julian *et al*. 2003) have been and continue to be effectively used to identify diploid *A. jeffersonianum* and distinguish polyploid members of the complex. These markers may also address other questions regarding population dynamics and genetics that involve the unisexual part of the complex.

Public Contact and Education (Objectives IV)

Many of the recovery team members are associated with or work for regional conservation groups or authorities. In May 2003, workshops were run by MNR in Halton Region and Waterloo Region. These workshops were attended by Recovery Team members and provided instruction on egg mass identification and outlined the protocol for obtaining samples for genetic analyses.

Aurora District MNR has produced a *Guideline for Applicants for Wildlife Scientific Collectors Authorizations* (2007). This guideline includes detailed direction on collection methodologies and study design requirements that are directly applicable to *A. jeffersonianum*. MNR and the recovery team have worked extensively with a number of consultants, the aggregates industry and conservation authorities in providing direction on collection methodologies and protocols.

2.0 RECOVERY

2.1 Recovery Goal

The recovery goal is to ensure that existing threats to populations and habitat are sufficiently reversed to allow for long-term persistence and expansion of the Jefferson Salamander, *A. jeffersonianum,* within its existing Canadian range.

2.2 Protection and Recovery Objectives

The priority of the short-term recovery objectives, and the overall recovery goal, is the protection of existing populations of *A. jeffersonianum* by ensuring no further loss of known habitat or potentially suitable habitat (recovery habitat). **Habitat protection is critical to the survival of the species.** Protection of existing habitat should have priority over compensation for lost habitat (i.e., created habitat). Consistent with general principles of conservation biology for species at risk, compensatory measures such as habitat creation and relocation efforts should only be undertaken as a last resort and when other measures have proved unsuccessful.

Protection, restoration, and enhancement of existing *A. jeffersonianum* habitat are the priority recovery planning recommendations. Habitat alterations which would adversely impact *A. jeffersonianum* should be discouraged.

At present, there is no basis for protection of newly created features (e.g., breeding ponds) because colonization and use of such features has not been sufficiently documented. Created habitat cannot immediately replace existing habitat utilized by *A. jeffersonianum*.

In addition, long-term forest and wetland restoration or remediation proposals (i.e., potentially decades) intended to compensate for losses of existing habitat are not in keeping with recovery planning for species at risk.

Table 2. Protection and Recovery Objectives

No.	Protection or Recovery Objective
1.0	Identify and monitor extant populations in Canada
2.0	Apply research findings on movements and habitat use to ensure protection of habitat
3.0	Identify historic populations with the potential for enhancement or restoration (e.g., recovery habitat)
4.0	Develop a communication strategy to inform municipalities, planners, the development industry and other stakeholders of the habitat mapping and protection requirements for *A. jeffersonianum* under the *ESA 2007* and other recovery planning initiatives
5.0	Develop and evaluate mitigation and restoration techniques employed to address threats to existing habitat

2.3 Approaches to Recovery

Table 3. Specific Approaches to Recovery for *Ambystoma jeffersonianum*

Priority	Objective No.	Broad Approach/ Strategy	Specific Steps	Measurable Outcomes
Urgent	I, III	Identify Populations	• Verify and document extant, historic and potential element occurrences	• Provision of accurate data for subsequent research, monitoring and mapping

Urgent	I	Population and Habitat Monitoring	• Develop and implement a standardized monitoring protocol and a 5-year monitoring schedule which will focus on:
			  • Presence/absence (of salamanders)
			  • Site specific and cumulative impacts
			  • Range expansion/retraction
				• Site specific information for each population in Canada
				• Measure of the success of the species' recovery
				• A central repository and data custodian for information collected

Urgent	I	Population and Habitat Monitoring/ Research	• Select at least one long-term control site and conduct annual monitoring • Prioritize monitoring frequency of locations based on current and potential threats	• Consistent baseline information to compare against effects noted at other sites
Urgent	II, III	Describe habitat recommended for regulation under *ESA 2007*	• Describe and identify aquatic and terrestrial habitat for extant populations. • Identify and describe recovery habitat	• Provision of advice to government to inform the habitat regulation process under the ESA 2007
Urgent	IV	Habitat Protection	• Work with planning authorities to encourage integration of habitat regulation into Official Plans and other relevant planning processes	• Proportion of Official Plan review process' resulting in adoption of habitat regulation
Urgent	IV	Communications	• Identify communication needs and products that will provide information and resources to landowners, property managers, aggregate industry, local stewardship councils, local conservation authorities and other stakeholders to assist in the recovery effort and promote land stewardship • Support monitoring by stakeholders	• Early inclusion/consideration of recovery plan recommendations in higher order planning documents • A list of stakeholders involved in active stewardship and monitoring projects will be produced
High	V	Restore and Enhance Historic Sites	• Identify factors at historic sites that were probable factors that caused the loss of the population (e.g., water level fluctuations,	• Number of re-established populations and/or resumption of breeding and successful recruitment

Priority	Objective No.	Broad Approach/ Strategy	Specific Steps	Measurable Outcomes
			addition of fishes, loss of egg attachment sites etc.) • Prioritize potential sites for restoration activity • Evaluate restoration and mitigation techniques	• Demonstrated effectiveness and subsequent assessment of mitigation techniques
High	II	Research	• Continue research on species ecology, juvenile dispersion, population biology and parameters consistent with conservation biology planning. Control sites will provide benchmark data for comparison with other locations	• Research will provide additional data and products that will assist in the refinement of the recovery strategy and contribute to improved understanding of the ecology/biology of this species
High	V	Research	• Investigate the species' tolerance to environmental and cultural stressors (e.g., environmental contaminants, agricultural activities, urban development, and resource extraction)	• Detailed information regarding stressors that negatively impact populations. This information will be used to address/mitigate threats/impact assessment
High	V	Research	• Conduct research on the hydrology of breeding habitat	• Improved understanding of hydrological characteristics and sensitivity of breeding habitat (quantity and quality) • Identification methods to study, assess and characterize hydrology of breeding habitat

2.4 Performance Measures

Performance measures have been identified that will evaluate the success and progress of the recovery approaches set out in this strategy. These measures will also indicate the extent to which the objectives have been met. Examples include:

- population trends (increase/decrease) and confirmation of breeding activity
- quantify new/extirpated populations
- consistent baseline information generated from the long-term control site
- number and participation of stakeholders involved in related stewardship and monitoring
- number of locations for which identified threats have been reduced, mitigated or eliminated
- assessment of mitigation techniques (e.g., culverts, silt fencing, artificial recharge)
- increased knowledge of aquatic and terrestrial habitat (e.g., telemetry research)
- number of municipalities that adopt habitat regulation and protection policies in their Official Plans
- recommendations used to inform the habitat regulation process under the ESA 2007
- identification of methods to study, assess and characterize hydrology of breeding habitat

2.5 Area for Consideration in Developing a Habitat Regulation

Habitat is defined in the ESA 2007 as an area on which the species depends, directly or indirectly, to carry on its life processes, including life processes such as reproduction, rearing, hibernation, migration or feeding. Specifically, for *A. jeffersonianum*, the following is a description of the area that is recommended for inclusion in the habitat regulation.

Breeding Habitat

All wetlands or wetland features that provide suitable breeding conditions for *A. jeffersonianum* and *jeffersonianum*-dominated polyploids such as vernal pools, woodland pools, deciduous swamps, spring fed pools, ground water supported wetlands, sloughs, old deepened or created ponds or ditches where breeding *A. jeffersonianum* occur should be included within the habitat regulation.

All such wetlands and features have egg attachment sites, and have a sufficient combination of hydro-period, temperature and productivity to support the deposition and development of eggs and larvae. However, breeding habitat can be dynamic and conditions variable from year to year depending on precipitation and water levels. This can result in variable breeding success and activity from year to year. For this reason, surveys intended to determine the presence of *A. jeffersonianum* in new locations may

need to be conducted for up to three years to ensure adequate effort in investigating presence. In the case of historic locations, a minimum of three consecutive years of negative surveys must be conducted to confirm the extirpation of *A. jeffersonianum* from that specific historic site. Breeding habitat typically does not support fish which are capable of eating the eggs or larvae of *A. jeffersonianum*.

Terrestrial Habitat

The terrestrial component of *A. jeffersonianum* habitat consists of woodlands, upland forests, swamps, successional areas, meadows, old fields, agricultural fields and other vegetated areas that provide conditions required for foraging, dispersal, migration, growth and hibernation. Terrestrial habitat includes all of the areas and features described above that extend radially 300 m from the edge of the breeding pond. The 300 m distance is based on the findings of telemetry studies (Bériault 2005, OMNR 2008 unpublished data) and is calculated as the habitat area utilized by 90% of the adult population for each breeding location based on the movements of tracked individuals. Terrestrial habitat that meets these requirements should be included within the habitat regulation.

Corridors that provide contiguous connections between breeding locations can extend up to a maximum 1 km and should also be included within the habitat regulation. Non-vegetated open areas such as agricultural fields may be used as migratory corridors between the breeding pond and forested areas.

Exclusions

The following features should not be included within the habitat regulation:

- Existing houses, buildings, structures and quarries (and other pre-existing industrial land uses) that are within 300 m of a breeding pond.
- Major roads within 300 m of a breeding pond which present barriers to migration and dispersion (e.g. highways).
- Open areas such as agricultural fields that are within 300m of a breeding pond but which do not directly separate breeding ponds from forested areas and therefore do not serve as corridors between habitats and /or breeding areas.

Newly Discovered Occurrences

New occurrences for *A. jeffersonianum* are anticipated. For the purposes of investigating the presence of *A. jeffersonianum* at previously un-surveyed locations, appropriate surveys for up to 3 consecutive years may be required in order to document the presence of *A. jeffersonianum*. This reflects intermittent breeding success associated with variable conditions.

Any newly discovered breeding locations and associated terrestrial habitat as well as extirpated and historical locations where suitable habitat remains should also be included within the regulation.

Human Created Features

A. jeffersonianum occasionally breed in old farm ponds and human-made depressions that have reached a substantial state of wetland succession (likely decades) and which occur within or in close proximity to existing forested or other naturally vegetated areas. Most of these ponds/depressions occur in locations where wetlands had originally existed or where portions of wetlands have been deepened. The vast majority of wetlands on the landscape that existed before agricultural conversion have been eliminated, and therefore some naturalized human-made depressions are used by *A. jeffersonianum* as breeding habitat and should be included within the habitat regulation.

Artificial Habitat Creation/Rehabilitation

At present there is no basis for protection of newly created features (e.g., breeding ponds) within a habitat regulation because colonization and use of such features has not been sufficiently documented. Created habitat cannot immediately replace existing habitat utilized by *A. jeffersonianum*.

GLOSSARY OF TERMS

Extant populations: Populations that have been confirmed within the last 20 years.

Historic Populations: Populations that have not been confirmed in the last 20 years but are not yet confirmed as extirpated.

Control site: A study site against which all other study sites will be compared; where conditions are known to be 'typical' for *A. jeffersonianum* and where there is a lack of disturbance.

Element Occurrence: A term used by Conservation Data Centres and NatureServe that refers to an occurrence of an element of biodiversity on the landscape; an area of land and/or water on/in which an element (e.g., species or ecological community) is or was present. For *A. jeffersonianum* Ontario's Natural Heritage Information Centre (NHIC) uses a 1 km radius to define element occurrences.

Polyploidy: More than two sets of chromosomes (e.g., triploid – three sets of chromosomes, tetraploid – four sets of chromosomes, etc.).

Snout to Vent Length (SVL): A standard measurement of body length. The measurement is from the tip of the nose (snout) to the cloaca (vent), and excludes the tail.

Vernal Pools: Also known as ephemeral wetlands, are landform depressions that temporarily fill with water following heavy rainfalls, snowmelt in the spring, or as a result of a high water table. Vernal pools vary in their size, shape, depth, timing and duration of flooding, and the types of species that are able to use them. A defining feature of vernal pools is that they usually dry up by the middle of the summer; however, some vernal pools may only dry up every couple of years.

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RECOVERY STRATEGY DEVELOPMENT TEAM MEMBERS

Table 4. Recovery Strategy Development Team Members

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