Photo: Leo Kenney

Jefferson Salamander

(Ambystoma jeffersonianum) in Ontario

Ontario Recovery Strategy Series

Recovery strategy prepared under the *Endangered Species Act, 2007*

February 2010

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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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, 2007* (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
Environment Canada, Canadian Wildlife Service – Ontario

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*). The strategy was developed with the goal of ensuring that existing threats to populations and habitat of this species are sufficiently removed to allow for long-term persistence and expansion of the Jefferson Salamander 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 *Ambystoma laterale* (Blue-Spotted Salamander)–*jeffersonianum* complex.

Jefferson Salamander populations have a distinctive genetic evolutionary history. Ontario populations coexist with unisexual individuals that are mostly polyploids with a predominance of Jefferson Salamander chromosomes, and which together are referred to as members of the *A. laterale–jeffersonianium* complex. Jefferson Salamander and polyploids use the same habitat, and the polyploids are reproductively dependant on the Jefferson Salamander. That is, the presence of *jeffersonianum*-dominated polyploid eggs necessarily means that Jefferson Salamander 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 Jefferson Salamander and *jeffersonianum*-dominated polyploids. The apparent absence or lack of documentation of a Jefferson Salamander individual is often the result of naturally low relative abundance and/or limited search effort (Bogart and Klemens 2008).

Major threats to the Jefferson Salamander 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 the Jefferson Salamander is well known in comparison to that of 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. Toward this end, this recovery strategy also outlines and prioritizes recovery approaches and programs. Because known Jefferson Salamander 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 to municipalities, developers and other stakeholders where conflicts exist or are anticipated.

It is recommended that the habitat regulation for the Jefferson Salamander include:

- all wetlands or wetland features that provide suitable breeding conditions where the Jefferson Salamander and *jeffersonianum*-dominated polyploids occur;
- terrestrial habitat areas within 300 metres of the edge of 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 kilometre).

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.

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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: Threatened (2004)
COSEWIC Assessment History: Threatened (2000)
SARA Schedule 1: Threatened (June 5, 2003)
CONSERVATION STATUS RANKINGS: GRANK: G4 NRANK: N2 SRANK: S2

The glossary provides definitions for the abbreviations above.

1.2 Species Description and Biology

Species Description

The Jefferson Salamander (*Ambystoma jeffersonianum*) is a relatively large grey to brownish grey salamander (snout to vent length: 65–96 millimetres [mm]). Bishop (1947) described egg masses of this species. The eggs are incorporated in gelatinous masses that are attached to sticks and plant stems. Each egg mass contains 16 to 40 large (2.0–2.5 mm) eggs, which contain a black or dark brown embryo enclosed in a distinct envelope. A loose, watery layer of protective gel surrounds the eggs. The dark melanin pigment and the gel covering (and any algae in it), 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, which contain more than 200 eggs, depending on the size of the female.

Breeding success varies from year to year, depending on spring weather and water-level conditions. However, because Jefferson Salamanders 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 are 10 to 14 millimetres in total length. The 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 varies in duration and can extend into early September.

Species Biology – Genetics

The unusual reproductive biology and genetics of the Jefferson Salamander 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.

Jefferson Salamander populations normally coexist with unisexual individuals that are mostly polyploid with a predominance of Jefferson Salamander chromosomes; together they constitute the *A. laterale–jeffersonianum* complex. The presence of eggs of *jeffersonianum*-dominated polyploids necessarily and absolutely indicates the presence of a breeding pure Jefferson Salamander, 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, the correspondence between pure Jefferson Salamanders and *jeffersonianum*-dominated polyploids is absolute, as is the case in New England and New York (Bogart and Klemens 1997, 2008). Pure Jefferson Salamanders and *jeffersonianum*-dominated polyploids cannot be separated by habitat or in many cases by morphology. Therefore, genetic analysis is often required to distinguish pure Jefferson Salamanders from polyploids, and particularly to distinguish pure female Jefferson Salamanders. Blue-spotted Salamanders (*Ambystoma laterale)* and *laterale*-dominated polyploids are the other members of the complex. Polyploids dominated by the Blue-spotted Salamander are not indicative of Jefferson Salamanders. 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 the Jefferson Salamander and Blue-spotted Salamander (Bogart et al. 2007) and has been matched with that of a Kentucky population of the Streamside Salamander (*Ambystoma barbouri*) (Bogart 2003). The genetic mixing that occurs within the polyploid component of the complex is attributed to an unusual reproductive strategy (gynogenesis) whereby polyploid females lay mostly unreduced eggs (eggs whose number of sets of chromosomes 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 (eggs with only one set of chromosomes) 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 Jefferson Salamanders (Bériault 2005, OMNR 2008). However, *jeffersonianum*-dominated polyploids are much more abundant, normally comprising 90 to 95 percent of local populations (Bogart and Klemens 2008, 1997, OMNR 2008 unpublished data). Therefore, many search efforts focused on finding Jefferson Salamanders using a random sampling of the population would probably encounter only *jeffersonianum*-dominated polyploids.

Because the Jefferson Salamander and *jeffersonianum*-dominated polyploids cannot be separated by habitat, and because the perpetuation of the polyploid component of the complex is dependent on the presence of the Jefferson Salamander, the recommendations in this recovery strategy relating to the identification, description, mapping and protection of habitat apply to both the Jefferson Salamander 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 the Jefferson Salamander is critical to the survival and existence of unisexuals that make up the majority of the population complex and use Jefferson Salamander males as sperm donors.

Jefferson Salamander larvae are voracious aquatic predators that feed on moving prey such as insect larvae, small crustaceans and amphibian larvae. Adults probably are prey for wetland predators, such as snakes, rodents and birds, for example, the Red-shouldered Hawk (*Buteo lineatus*). The Jefferson Salamander 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 the Jefferson Salamander is restricted to southern Ontario, particularly along the Niagara Escarpment World Biosphere Reserve. In the United States, the species 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) (figure 1). For much of this range, genetic data are unavailable, so the continental distribution of pure Jefferson Salamanders and *jeffersonianum*-dominated polyploids is uncertain (Bogart and Klemens 1997).

The current global conservation status rank for the Jefferson Salamander was assigned by the Association for Biodiversity Information (ABI) (NatureServe 2008). Its ranking for the Jefferson Salamander is G4, a level of ranking assigned to species with greater than 100 site occurrences and greater than 10,000 individuals, giving the species an apparently secure ranking globally. NatureServe also applies conservation status ranks at the national (N) and subnational (S) (i.e., provinces or states) levels. Table 1 summarizes the NatureServe rankings for the Canadian and U.S. populations. The species has been designated as imperilled (S2) in Ontario, Illinois and Vermont and is considered to be apparently secure (S4) in only 5 of the 14 states where it is found. Notably, the species is also listed as threatened in Ontario under the *Endangered Species Act, 2007* (ESA 2007) and in Canada under the federal *Species at Risk Act* (SARA).

Table 1. Summary of NatureServe (2008) Conservation Status Ranks for the Jefferson Salamander

Jurisdiction	Conservation Status Rank
Global	G4
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:

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

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

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

SNR – Unranked

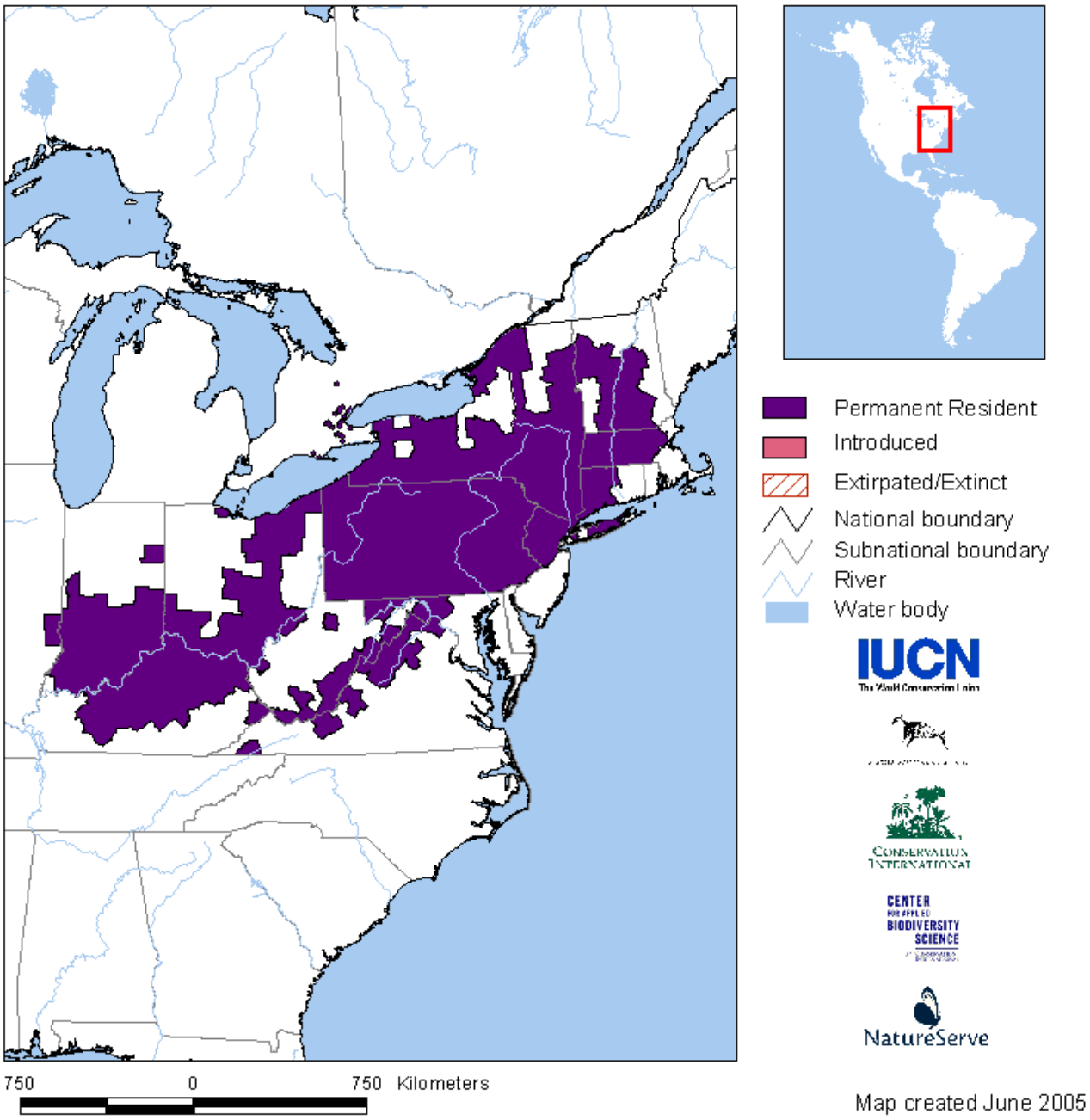

Figure 1. Global range for the Jefferson Salamander (NatureServe 2005)
Note: This map is based on Element Occurrence (EO) records, which represent specific locality data that are developed and maintained by individual provincial and state natural heritage programs. The Canadian distribution is shown as individual occurrences and the U.S. distribution is shown as the watersheds where the occurrences are found.

Canadian Range

The distribution of the Jefferson Salamander in Canada as of October 2008 is based on approximately 328 known breeding ponds representing approximately 27 geographically discrete populations. A geographically discrete population is one that is separated or isolated from other populations by gaps in habitat that limit or prevent gene flow. Distribution data reflect both extant and historic occurrences.

Figure 2 provides the most current locality information for the species. The information is based on a database of all Ontario locations that were compiled by the recovery team and housed at the Natural Heritage Information Centre (NHIC).

The NHIC (2003) has assigned the species a rank of S2 (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 applies only to pure Jefferson Salamanders, which, by virtue of their very low relative abundance within the complex, means they are exceedingly rare.

In Ontario, known extant populations of the Jefferson Salamander occur in:

- Haldimand, Norfolk, Wellington, Brant, Grey and Elgin counties;
- forested habitat along the Niagara Escarpment from the Hamilton area to Orangeville;
- isolated localities in Halton, Peel, Waterloo, York and Niagara regions;
- Dufferin County east of the Niagara Escarpment.

A population in Wellington County, south of Guelph, is probably extirpated. Jefferson Salamanders were last observed at that site in April 1989 (Bogart unpublished data) and the breeding pond was dry in successive years (1990–93). Historically, the Jefferson Salamander was probably much more widely distributed throughout southwestern and south-central Ontario before the clearing of forests for agriculture.

Percentage of the Global Distribution in Canada

Populations of the Jefferson Salamander in Canada are situated at the northern limit of the species' North American range. The Canadian populations probably represent a maximum of 1 to 3 percent of the estimated North American population, based on relative ranges (Rye and Weller 2000) (figure 1).

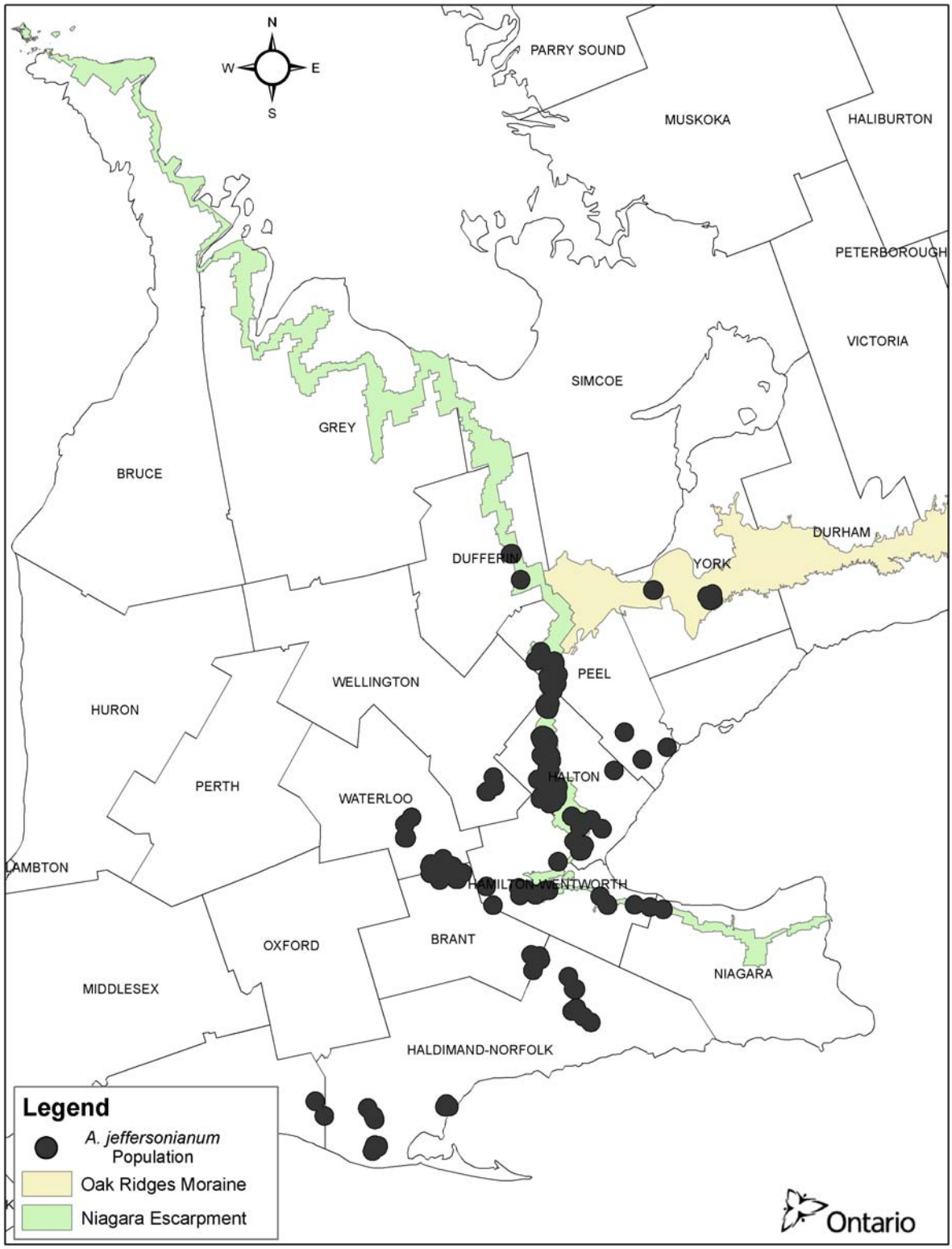

Figure 2. Documented locations of the Jefferson Salamander in Ontario

Population Sizes and Trends

The Jefferson Salamander was first recognized to occur in Canada by Weller and Sprules in 1976. The present knowledge of this species indicates that 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 have led to the isolation of these populations. In the part of the province located south and east of the Canadian Shield, over 70 percent 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 noted above, the Canadian range of this species comprises approximately 27 known populations in Ontario. One breeding pond does not necessarily represent a population; several or many breeding ponds within an area may support 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 conservation status rank is G4 (NatureServe 2008), which indicates that the species is apparently secure within its range. In Ontario, however, threats to the Jefferson Salamander (see section 1.6) are well known, and cumulative loss and impairment of habitat continue.

Temporal trends for this species are not readily available because of the challenges in identifying the Jefferson Salamander and the unisexuals. As stated earlier, *jeffersonianum*-dominated polyploids occur at much greater relative abundance and normally comprise 90 to 95 percent of local populations (Bogart and Klemens 1997, 2008, OMNR 2008 unpublished data). This means that pure Jefferson Salamanders represent only 5 to 10 percent 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 the Jefferson Salamander, as well as available museum records, are, however, not necessarily accurate. Bishop (1947), in his classic book on North American salamanders, lumped all presently recognized members of the complex (Blue-spotted Salamander, Jefferson Salamander and all unisexuals) in a single species, the Jefferson Salamander. Until 1964, most museum curators adhered to Bishop's nomenclature without the benefit of genetic confirmation. It is now understood that distinguishing between most individuals of the complex that are catalogued in major museum collections is not possible.

Uzzell (1964) tried to establish ranges for the Jefferson Salamander by sorting the males into Blue-spotted Salamander and Jefferson Salamander and by using blood-cell size to distinguish diploid and triploid females. Uzzell's ranges for the Jefferson Salamander 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 the Jefferson Salamander in New York and New England through the isozyme screening of 1,006 individuals from 106 sites. That large sample identified only 66 pure Jefferson Salamander individuals (6.59%). The global range (figure 1) is based on limited data, and occurrences in many regions still require genetic confirmation.

Jefferson Salamander individuals occur in all of the populations shown in figure 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 difficulties in genetic identification, the available population data show a declining trend (Rye and Weller 2000).

1.4 Habitat Needs

Breeding Ponds

During the first spring rains in March and April, adult Jefferson Salamanders migrate overland at night to breeding ponds (e.g., vernal pools) where mating and oviposition take place. The species uses a range of wetland types for breeding. Breeding ponds are generally vernal pools that are fed by either groundwater (e.g., springs), snowmelt or surfacewater. 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. Jefferson Salamander individuals demonstrate strong pond fidelity, returning to the same pond each year to breed.

Within breeding ponds the Jefferson Salamander requires low shrubs, twigs, fallen tree branches, submerged riparian vegetation or emergent vegetation to which to attach egg masses.

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 species' use of breeding ponds (Bériault 2005). In central Pennsylvania, one of the few regions in which unisexuals do not coexist with the Jefferson Salamander, embryonic (larval) mortality was high in ponds with a pH below 4.5. Because the Jefferson Salamander larvae are not particularly susceptible to relatively low pH (K. Beriault pers. comm.), mortality was probably affected by the availability of prey (Sadinski and Dunson 1992).

Food must be present in the breeding ponds. Known aquatic prey includes small aquatic invertebrates and amphibian larvae.

For egg masses and juvenile and adult Jefferson Salamanders to survive, breeding ponds must not contain fish that can prey on them.

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

Terrestrial Habitat

Jefferson Salamanders use a number of terrestrial habitats during all parts of their life cycle, including during migration to and from breeding ponds, summer and fall movement and foraging, and overwintering. Most often, these salamanders 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, and so on. Other than during migration and breeding, Jefferson Salamanders reside in this microhabitat, overwintering in deep rock fissures and rodent burrows below the frost line. Summer burrows are horizontal and winter burrows are vertical (Faccio 2003). Jefferson Salamanders are also known to show fidelity to their terrestrial habitat (Thompson et al. 1980, OMNR 2008 unpublished data).

Prey in the terrestrial habitat includes insects, earthworms and other invertebrates.

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

1.5 Limiting Factors

Factors affecting the Jefferson Salamander include the limited availability of the habitats required by the species, namely, 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 and on habitat.

Limiting Factors in Breeding Ponds

For breeding to be successful, suitable egg attachment sites must be available, and the pond must contain an adequate amount of food. At all life stages, the Jefferson Salamander is vulnerable to predation by fish; therefore, ponds containing fish capable

of preying on this species are not suitable as habitat. Many forested wetlands are connected by stream systems that provide access for fish. The lack of vernal pools and fishless wetlands in woodlands is a limiting factor.

Egg and larval mortality have been observed to be high in ponds used by most populations of the Jefferson Salamander, but dead eggs are usually attributed to the polyploids. It is believed that this is a genetic viability issue in some polyploids. Larval mortality is also high among polyploid individuals (Bogart and Licht 1986). In some years, populations can be negatively affected 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, an appropriate soil type and mammal burrows to support feeding, moisture retention and the avoidance of predators.

1.6 Threats to Survival and Recovery

The following threats to the 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 other resource development are the most significant threats to Jefferson Salamanders in southern Ontario. The range of this species 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; stormwater management and increases in impervious cover that alter natural hydroperiod regimes; alteration of the water balance of adjacent wetlands and the 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 Jefferson Salamander habitat.

Roads

Some roads (and urbanization) can create barriers that limit salamander dispersal and abundance and fragment habitat. Vehicles frequently kill Jefferson Salamanders as they

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

Changes in Ecological Dynamics

Relevant to this discussion is an examination of why Jefferson Salamanders were not found in some sites in recent years. Perhaps the species is extirpated in these populations. Again, data are limited, but the species' absence is probably due to habitat changes associated with anthropogenic disturbance. 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 watercourses for snowmelt and runoff. The reduction of vernal pond "envelopes" and buffer zones also has been suggested as contributing to the reduction and possible elimination of species of *Ambystoma* salamanders (Calhoun and Klemens 2002).

Forestry Activities

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

Recreation and Trails

Heavy use by hikers, cyclists and all-terrain vehicle users of recreational trails near breeding pools and terrestrial habitat may also result in salamander mortality or habitat degradation.

Unauthorized Collection and Introduced Species

Collection of amphibians and reptiles for the pet trade is a growing concern and may be a threat to the Jefferson Salamander. Knowledge of the species' whereabouts is not widespread in the general public since adult Jefferson salamanders migrate and breed during very few rainy nights early in spring, and juveniles migrate in late summer or early fall. A bigger human-related threat is the addition to breeding ponds of carnivorous fish, which prey on all life stages of the salamander.

1.7 Knowledge Gaps

Key knowledge gaps relating to the Jefferson salamander include (but are not limited to) the following:

- the effectiveness of mitigation efforts to address threats and means of reducing road mortality
- the refinement of the species' distribution and range, particularly in portions of the Oak Ridges Moraine Plan Area and the Greenbelt Plan Area
- juvenile dispersal patterns, timing and distances
- fall migration
- overwintering sites

These knowledge gaps have been grouped below in terms of the research requirements for clarifying threats and increasing biological/ecological information.

Threat Clarification Research Requirements

To date, little research has focused directly on natural and human threats to this species. Direct threats, such as habitat loss and degradation associated with resource development and urbanization, need to be quantified and evaluated within the context of cumulative impacts on the distribution and abundance of the Jefferson Salamander. Indirect threats (e.g., development activities that cause changes to wetland hydrology on adjacent lands) require detailed investigation and monitoring to determine cause-and-effect relationships and to evaluate the effectiveness of proposed mitigation. All potential threats to the Jefferson Salamander 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 Jefferson Salamanders. It is theorized that juveniles probably disperse farther than adults to establish new breeding ponds and/or populations when the carrying capacity has been reached in existing breeding ponds (J. Bogart pers. comm.).

All radio-telemetry studies completed to date have focused on the spring/summer migration of adults. Future radio-telemetry studies are required to learn more about fall migration. They would help in obtaining more information on Jefferson Salamander overwintering sites, use of terrestrial habitat and microhabitats, communal or individual use of sites, and so on.

1.8 Recovery Actions Completed or Under Way

Work on several of the recovery objectives (see table 2) has begun, and a number of studies on the species have been completed.

Research on Habitat Use and Spatial Requirements (Recovery Objective 2)

In 2004, the University of Guelph initiated radio-telemetry studies of a southern Ontario Jefferson Salamander population (K. Bériault 2005). These studies focused on the movement and habitat use of LJJ[1] polyploids (sample size of 16). To increase the sample size of radio-tagged salamanders and to investigate additional questions relating to habitat use, movements and population demographics, the Ontario Ministry of Natural Resources (OMNR) continued and expanded the study in 2005. 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, OMNR conducted additional radio-telemetry monitoring of both polyploids and pure Jefferson Salamanders 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 the Jefferson Salamander and *jeffersonianum*-dominated polyploids. These findings, in addition to other studies cited in this document, provide the basis for the recommendations for habitat regulations in section 2.5.

Monitoring Extant Occurrences and Searching for New Breeding Ponds (Recovery Objectives 1 and 5)

In 2002 and 2003, the recovery team worked with the Regional Municipality of York to determine whether Jefferson Salamander populations existed in York Region. Field investigations revealed four populations of Jefferson Salamander. They are the only ones known in York Region and represent the easternmost population 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 Jefferson Salamander and polyploid occurrences. Since 2003, more than 100 wetlands with the potential to support *Ambystoma* species have been searched to determine whether the Jefferson Salamander is present. Fifteen new breeding sites have been documented, while at some of the historical breeding locations the species has been confirmed to be extirpated because of habitat disturbance or loss. Because of the elusive nature of this species, the limited window of time in which 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 the Jefferson Salamander, particularly in areas that are not located on the Niagara Escarpment.

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

Also in 2003/04, the Niagara Escarpment Biosphere Reserve, in partnership with Ontario's Niagara Escarpment (ONE) Monitoring Program staff and the University of Guelph, and under the direction of the recovery team, undertook a study to examine the location and habitat conditions of Jefferson Salamander breeding sites along the Niagara Escarpment. The study focused on historically known breeding locations that the University of Guelph had documented in 1990 and 1991. One historic breeding pond could not be located; whether this was due to inaccurate location information or whether the pond was no longer present could not be determined. Eleven historic breeding ponds (at four geographically discrete locations) were located and searched for egg masses. The presence of the Jefferson Salamander was confirmed at one of the sites. At two sites, egg masses were collected but did not survive genotyping. At one historic site, none of the ponds that were searched contained Jefferson Salamander or polyploid egg masses. The presence of the Jefferson Salamander was confirmed at one new location in Halton Region where the species was not previously documented. In accordance with the recommendations in this recovery strategy, the seven sites where the Jefferson Salamander was not found should be revisited to confirm the presence or absence of the species.

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

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

Species and Ploidy Identification

At the University of Guelph, microsatellite molecular markers for the Jefferson Salamander (Julian et al. 2003) have been and continue to be used effectively to identify diploid Jefferson Salamanders 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 (Recovery Objective 4)

Many members of the recovery team are associated with or work for regional conservation groups or authorities. In May 2003, OMNR ran workshops in Halton Region and Waterloo Region that provided instruction on egg mass identification and

outlined the protocol for obtaining samples for genetic analyses. Recovery team members attended these workshops.

Aurora District OMNR has produced *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 the Jefferson Salamander. OMNR 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 of the Jefferson Salamander are sufficiently removed to allow for the long-term persistence and expansion of the species 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 the Jefferson Salamander by ensuring that no further loss or degradation of known habitat or potentially suitable habitat (recovery habitat) occur. **Habitat protection is critical to the survival of the species.** Protection of existing habitat should have priority over compensation for lost habitat (i.e., the creation of habitat). Consistent with general principles of conservation biology for species at risk, compensatory measures such as habitat creation and species relocation efforts should be undertaken only as a last resort and when other measures (e.g., mitigation) have proved unsuccessful.

Protection, restoration and enhancement of existing Jefferson Salamander habitat are the priority recovery planning recommendations. Habitat alterations that would adversely affect the species should be discouraged.

At present, there is no basis for protecting 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 that Jefferson Salamanders use.

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

Table 2. Protection and recovery objectives

No.	Protection or Recovery Objective
1.	Identify and monitor extant populations of the Jefferson Salamander in Canada
2.	Apply research findings on the species' movements and habitat use to ensure protection of habitat
3.	Identify historic populations/sites with the potential for enhancement or restoration (e.g., recovery habitat)
4.	Develop a communication strategy to inform municipalities, planners, the development industry, property managers and other stakeholders of the habitat mapping and protection requirements for the Jefferson Salamander under the *ESA 2007* and other recovery planning initiatives
5.	Develop and evaluate mitigation and restoration techniques employed to address threats

2.3 Approaches to Recovery

Table 3. Approaches to recovery of the Jefferson Salamander in Ontario

Priority	Objective Number	Broad Approach/ Strategy	Specific Steps	Measurable Outcomes
Urgent	1, 3	Identification of populations	• Verify and document extant, historic and potential populations	• Provision of accurate data for subsequent research, monitoring and mapping

Urgent	1	Population and habitat monitoring	• Develop and implement a standardized monitoring protocol and a five-year monitoring schedule that will focus on:
			  • the presence/absence of salamanders
			  • site-specific and cumulative impacts
			  • range expansion/retraction
			  • assessment of trends in habitat condition
				• Site-specific information for each population in Canada
				• A measure of the success of the species' recovery
				• A central repository and data custodian for information collected

Urgent	1	Population and habitat monitoring/ research	• Select at least one long-term control site and conduct annual monitoring • Prioritize monitoring frequency of locations on the basis of current and potential threats	• Consistent baseline information to compare against effects noted at other sites
Urgent	2, 3	Description of habitat recommended for regulation under the ESA 2007	• Describe and identify aquatic and terrestrial habitat for extant populations • Identify and describe recovery habitat (historic locations and presently unoccupied areas with suitable habitat)	• Provision of advice to government to inform the habitat regulation process under the ESA 2007
Urgent	4	Habitat protection	• Work with planning authorities to encourage integration of the habitat regulation into official plans and other relevant planning processes	• Percentage of the reviewed official plans that integrate protection of the areas prescribed in the habitat regulation
Urgent	4	Communications	• Identify communication needs and products that will provide information and resources to landowners, property managers, the 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 • Production of a list of stakeholders involved in active stewardship and monitoring projects

Priority	Objective Number	Broad Approach/ Strategy	Specific Steps	Measurable Outcomes
High	5	Restoration and enhancement of historic sites	• At historic sites, identify factors that probably caused the loss of the population (e.g., water-level fluctuations, addition of fish, loss of egg attachment sites) • Prioritize potential sites for restoration activity • Evaluate restoration and mitigation techniques	• A number of re-established populations and/or resumption of breeding and successful recruitment • Demonstrated effectiveness and subsequent assessment of mitigation techniques
High	2	Research	• Continue research on species ecology, juvenile dispersion, population biology and parameters consistent with conservation biology planning, using control sites to provide benchmark data for comparison with other locations	• Research providing 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	5	Research	• Investigate the species' tolerance to environmental and cultural stressors (e.g., environmental contaminants, agricultural activities, urban development, resource extraction)	• Detailed information regarding stressors that negatively affect populations, which will be used in addressing and mitigating threats and in assessing impacts
High	5	Research	• Conduct research on the hydrology of breeding habitat	• Improved understanding of hydrological characteristics (specifically the hydroperiod) and sensitivity of breeding habitat to changes in the quantity and quality of water • Identification methods to study, assess and characterize the hydroperiod 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 performance measures will also indicate the extent to which the objectives have been met. They include:

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

2.5 Area for Consideration in Developing a Habitat Regulation

Under the ESA 2007, a recovery strategy must include a recommendation to the Minister of Natural Resources on the area that should be considered in developing a habitat regulation. A habitat regulation is a legal instrument that prescribes an area that will be protected as the habitat of the species. The recommendation provided below by the author will be one of many sources considered by the Minister when developing the habitat regulation for this species.

The following is a description of the area that is recommended to be prescribed in the regulation as habitat for the Jefferson Salamander.

Breeding Habitat

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

All such wetlands and features have sites for egg attachment and a sufficient combination of hydroperiod, 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 activity and success from one year to next. For this reason, surveys intended to determine the presence of Jefferson Salamanders in new locations may need to be conducted for up to three years to ensure that adequate effort has gone into investigating the species' presence. In the case of historic locations, a minimum of three consecutive years of surveys that fail to indicate the presence of the Jefferson Salamander must be conducted to confirm the extirpation of the species from that specific historic site. All life stages of the Jefferson Salamander are vulnerable to predation by fish; therefore, ponds containing fish that can prey on Jefferson Salamanders are not suitable breeding habitat.

Terrestrial Habitat

The terrestrial component of Jefferson Salamander 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 metres from the edge of the breeding pond. The 300 metre distance is based on the findings of telemetry studies (Bériault 2005, OMNR 2008 unpublished data) and is calculated as the habitat area used by 90 percent of the adult population for each breeding location, identified on the basis of 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 of 1 kilometre 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 metres of a breeding pond
- major roads within 300 metres of a breeding pond that present barriers to migration and dispersion (e.g., highways, major arterial roads)
- open areas such as agricultural fields that are within 300 metres of a breeding pond but that do not directly separate it from forested areas and therefore do not serve as corridors between habitats and/or breeding areas

Newly Discovered Occurrences

New occurrences of the Jefferson Salamander are expected to be discovered. For the purposes of investigating the presence of this species at previously unsurveyed locations, appropriate surveys for up to three consecutive years may be required to document its presence. This is because breeding success may be intermittent due to 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

Jefferson Salamanders occasionally breed in old farm ponds and human-created depressions that have reached a substantial state of wetland succession (probably after decades) and that occur within or close 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 the Jefferson Salamander uses some naturalized human-created depressions as breeding habitat, which should be included within the habitat regulation.

Artificial Habitat Creation/Rehabilitation

At present there is no basis for protecting 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 that the Jefferson Salamander uses.

GLOSSARY

Extant population: A population that has been confirmed in the last 20 years.

Historic population: A population that has not been confirmed in the last 20 years but is not yet confirmed as extirpated.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): The committee responsible for assessing and classifying species at risk in Canada.

Committee on the Status of Species at Risk in Ontario (COSSARO): The committee established under section 3 of the *Endangered Species Act, 2007* that is responsible for assessing and classifying species at risk in Ontario.

Conservation status rank: A rank assigned to a species or ecological community that primarily conveys the degree of rarity of the species or community at the global (G), national (N) or subnational (S) level. These ranks, termed G-rank, N-rank and S-rank, are not legal designations. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by the letter G, N or S reflecting the appropriate geographic scale of the assessment. The numbers mean the following:

1 = critically imperilled
2 = imperilled
3 = vulnerable
4 = apparently secure
5 = secure

Control site: A study site against which all other study sites will be compared. In the case of the Jefferson Salamander, a control site is one where conditions are known to be typical for the species and where there is a lack of disturbance.

Element occurrence: As used by NatureServe conservation data centres, an occurrence of an element of biodiversity (e.g., species or ecological community) on the landscape; an area of land and/or water on/in which an element is or was present. The NHIC uses a 1 kilometre radius to define element occurrences of the Jefferson Salamander in Ontario.

Endangered Species Act, 2007 (ESA 2007): The provincial legislation that provides protection to species at risk in Ontario.

Hydroperiod: The duration of time in which water is present in a vernal pool or other wetland.

Polyploid: [Of] An organism that contains more than two sets of chromosomes (e.g., triploid – three sets of chromosomes, tetraploid – four sets of chromosomes).

Examples within the *Ambystoma laterale–jeffersonianum* complex include LJJ, LLJ, LJJJ, and so on.

Species at Risk Act (SARA): The federal legislation that provides protection to species at risk in Canada. This act establishes Schedule 1 as the legal list of wildlife species at risk to which the SARA provisions apply. Schedules 2 and 3 contain lists of species that at the time the act came into force needed to be reassessed. After species on Schedule 2 and 3 are reassessed and found to be at risk, they undergo the SARA listing process to be included in Schedule 1.

Species at Risk in Ontario (SARO) List: The regulation made under section 7 of the *Endangered Species Act, 2007* that provides the official status classification of species at risk in Ontario. This list was first published in 2004 as a policy and became a regulation in 2008.

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

Unisexual: A female member of the *Ambystoma laterale–jeffersonianum* complex that uses a form of reproduction whereby sperm is required to stimulate egg development but the male's genes are not incorporated. The offspring are genetically identical to their mothers.

Vernal pool: Also known as an "ephemeral wetland," a landform depression that temporarily fills with water following snowmelt in the spring and heavy rainfall 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 by the middle of the summer; some vernal pools, however, may dry only every couple of years.

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