

**Hine's Emerald Dragonfly
(*Somatochlora hineana*)**

**Status Review:
Summary and Evaluation**



**U.S. Fish and Wildlife Service
Illinois/Iowa Field Office
Moline, Illinois
12/16/2024**

STATUS REVIEW

Species reviewed: Hine’s emerald dragonfly (*Somatochlora hineana*)

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STATUS REVIEW

Hine's Emerald Dragonfly (*Somatochlora hineana*)

GENERAL INFORMATION

Species: Hine's emerald dragonfly

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Date of listing publication: January 26, 1995

FR citation(s): Original listing, FR notice: 60 FR 5267-5273, Date listed: January 26, 1995

Classification: Endangered

Critical habitat rule: Designation of Critical Habitat, FR notice: 72 FR 51101-51152, Date designated: September 5, 2007.

Revised Designation of Critical Habitat, FR notice: 75 FR 21393-21453, Date designation revised: April 23, 2010

Methodology used to complete the review: Public notice was given in the Federal Register (89 FR 804) requesting new scientific or commercial data and information that may have a bearing on the Hine's emerald dragonfly (*Somatochlora hineana*) classification of endangered status. Pertinent data was obtained from the Recovery Plan and from recent reports, species experts and scientific journals. This 5-year review was completed by Kristopher Lah, Endangered Species Coordinator, Illinois/Iowa Ecological Services Field Office. The U.S. Fish and Wildlife Service did not carry out a formal peer review of the 5-year review because scientific uncertainty or controversy is not high. The focus of this 5-year review is to evaluate whether new information indicates a change in the listing classification of the species is necessary and to summarize the current status of the Hine's emerald dragonfly.

In accordance with section 4(c)(2) of the Endangered Species Act of 1973, as amended (Act), the purpose of a status review is to assess each threatened species or endangered species to determine whether its status has changed and if it should be classified differently or removed from the Lists of Threatened and Endangered Wildlife and Plants. The U.S. Fish and Wildlife Service evaluated the biology and status of the Hine's emerald dragonfly (*Somatochlora hineana*) to inform this status review.

FR Notice citation announcing the species is under active review: January 5, 2024, FR 89, No. 804

Review History:

U.S. Fish and Wildlife Service. 2013. Hine's Emerald Dragonfly, *Somatochlora hineana* (Odonata: Corduliidae) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region, Chicago Ecological Services Field Office, Barrington, Illinois. 51pp.

U.S. Fish and Wildlife Service. 2019. Hine's Emerald Dragonfly, *Somatochlora hineana* (Odonata: Corduliidae) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Midwest Region, Chicago Ecological Services Field Office, Barrington, Illinois. 11pp.

REVIEW ANALYSIS

Recovery Criteria

Recovery Plan or Outline: U.S. Fish and Wildlife Service. 2001c. Hine's Emerald Dragonfly (*Somatochlora hineana*) Recovery Plan. Fort Snelling, MN. 120 p.

Criterion 1. Each of the two Recovery Units contains a minimum of two populations, each composed of at least three subpopulations (i.e., $2 \times 2 \times 3 = 12$ total subpopulations). Each subpopulation contains a minimum of 500 sexually mature adults (i.e., 1,500 per population) for 10 consecutive years.

Based on Museum records, the Hine's emerald dragonfly was known to occur in at least seven states: Alabama, Illinois, Indiana, Michigan, Missouri, Ohio, and Wisconsin. The species is believed to be extirpated in Alabama, Indiana, and Ohio. In terms of recovery objectives, Hine's emerald dragonfly's current distribution is split into two recovery units. The North and South Recovery units are based on ecoregions from Bailey (1995), and as modified by Keys et al. (1995). The two divisions used from Bailey's ecoregions were the Warm and Hot Continental Divisions (Figure 1).

Northern Recovery Unit

Hine's emerald dragonfly populations are distinguished from each other by distances of 31 miles (50 km) or more and which indicates a low probability of genetic exchange (U.S. Fish and Wildlife Service 2001, p.7). Based on these parameters, we estimate that the Northern Recovery Unit consists of six populations: Northern Wisconsin, Western Upper Peninsula of Michigan, Eastern Upper Peninsula of Michigan, Northwest Lower Peninsula of Michigan, Northeast Lower Peninsula of Michigan, and the Middle Western Lower Peninsula of Michigan. Within the six populations there are 17 subpopulations unevenly distributed. Surveys to estimate population size do not exist within the Northern recovery Unit or are no longer current. The Northern Wisconsin population (Door and Kewaunee Counties, WI) has eight subpopulations. Based on earlier records, the Northern Wisconsin population likely exceeds 1,500 adults but recent estimates are not available. The Western Upper Peninsula population (Menominee County, MI) consists of one subpopulation (a single site) and the population size has not been estimated. The Eastern Upper Peninsula population (Mackinac County, MI) consists of three subpopulations and previous surveys indicate a population size that likely exceeds 1,500 adults, but recent estimates are not available. The Northwest Lower Peninsula Population (Charlevoix County, MI) consist of a single site), but a population estimate is not available. The Northeast Lower Peninsula Population (Alcona, Alpena and Presque Isle Counties, MI) consist of three subpopulations, but

population estimates are not available. The Western Lower Peninsula population (Oceana and Mason Counties, MI) consists of one subpopulation without an estimate of population size. Overall, the Northern Recovery Unit likely meets criteria 1 for reclassification as the Northern Wisconsin and Eastern Upper Peninsula populations meet or exceed the number of subpopulations and likely the population size.

Southern Recovery Unit

In the Southern Recovery Unit we were able to determine population distribution based on distance between sites, landscape features and genetic data. We estimate that the Southern Recovery Unit consists of ten populations: Spring Creek Complex (IL) Population, Winnebago County (IL) and Rock County (WI) Population, Lower DesPlaines River Valley (IL) Population, Ozaukee County (WI) Population, Lower Wisconsin River (WI) Population, Ripley County (MO) Population, Dent, Iron and North Reynolds Counties (MO) Population, South Reynolds County (MO) Population (MO), Centerville (MO) Population, and the Phelps County (MO) Population (Table 1). Within the 10 populations there are 15 subpopulations that are unevenly distributed across populations. The Spring Creek Complex Population (Cook County, IL) has one subpopulation, and the population size has not been quantified. The Winnebago County, IL and Rock County, WI Population has two subpopulations and population size has not been quantified in either. The Lower DesPlaines River Valley (LDRV) Population (Cook, DuPage and Will Counties, IL) has three subpopulations with population estimates conducted by Soluk and Mierzwa (2012). LDRV Subpopulation One was estimated between 154 and 212 adults and LDRV Subpopulation Two was estimated at 10 adults. The size of Subpopulation 3 has not been estimated due to insufficient data. The Ozaukee County, WI Population consists of one site and the population size has not been estimated. The Lower Wisconsin River (Iowa and Richland Counties, WI) Population consists of two subpopulations and the population size has not been estimated for either. There are five populations in Missouri consisting of seven subpopulations: Centerville, Dent, Iron, Phelps, North Reynolds, South Reynolds and Ripley Subpopulations. The Dent, Iron and North Reynolds Populations consists of 3 subpopulations. Based on mark recapture studies at three of the 11 sites in the Reynolds County Subpopulation it was estimated to contain 1,300 adult Hine's emerald dragonflies (Walker and Smentowski 2014 and Walker et al, 2020).

Note: Population distribution and subpopulation distribution were determined in the recovery plan based on available conservation theory. The population distribution described above applies that theory and is based on genetic data where available, distance between locations with records, and landscape features.

Criterion 2. Within each subpopulation, there are at least two breeding habitat areas, each fed by separate seeps and/or springs. In other words, within each of the two recovery units there are two populations with three subpopulations that contain two breeding habitat areas or $2 \times 2 \times 3 \times 2 = 24$ total breeding areas across the species range.

Thirty-two subpopulations potentially exist across the range of the Hine's emerald dragonfly. Thirteen of these subpopulations contain more than one breeding area. However, breeding areas are not distributed according to the criteria in the recovery plan (see Table 1 in the Appendix). Of the 17 potential subpopulations in the Northern Recovery Unit, four of them: The Ridges (WI),

Mackinac County (MI) One, Mackinac County (MI) Two, and Alpena County (MI)) have two or more breeding areas. Of the 15 subpopulations in the Southern Recovery Unit, nine of them contain two or more breeding areas. The Cedarburg Bog, a single site that makes up the Ozaukee County Population in southeast Wisconsin consists of two breeding areas. Breeding has been confirmed in the Southwest Wisconsin Population, at two separate locations. All three of the subpopulations in the Lower DesPlaines River Valley population have two or more breeding areas. The population in Northern Cook County, Illinois has two breeding areas. There are three subpopulations in Missouri (Dent, North Reynolds, and Ripley) that have two or more breeding areas. It should be noted that there are locations across the species range where adult Hine's emerald dragonfly have been verified and potential breeding habitat has not been sampled, hence it is extremely likely additional breeding habitat exists within populations where it has not yet been confirmed to date. Therefore, sampling of potential larval habitat is a high recovery priority across the species range.

Determination: Criterion 2 has not been completely met but may be realized with sampling of potential larval habitat, especially within some populations where reproduction occurs but breeding habitat has not been verified.

Criterion 3. For each population, the habitat supporting at least two subpopulations should be legally or formally protected and managed for Hine's emerald dragonfly, using long-term protection mechanisms such as watershed protection, deed restrictions, land acquisition, or nature preserve dedication. In addition, mechanisms protecting the up gradient groundwater should also be in place.

Habitat Protection and Management:

Within the six populations in the Northern Recovery Unit, we recognize 17 subpopulations. The habitat of five of those subpopulations are entirely managed and protected by Federal or State agencies, while others have a mixture of ownership and are not completely protected and managed (see Table 1 in the Appendix).

Within the six populations in the Southern Recovery Unit, we recognize 15 subpopulations. The habitat in seven of those subpopulations are entirely managed and protected by Federal, State or County agencies, while others have a mixture of ownership and are not completely protected and managed (see Table 1 in the Appendix). However, this can be misleading when interpreting the species status because the size and number of sites within subpopulations varies across the Southern Recovery Unit.

Almost all recognized habitat within the three subpopulations in the Lower DesPlaines River Valley Population (Illinois) is now protected in perpetuity and most of it is managed by County and State agencies (Table 1). Habitat occurs on private property owned by Heidelberg Materials property in Will County, but it has been protected in perpetuity and is being managed under a habitat conservation plan (Hanson Materials 2021).

The habitat within the Ozaukee County, Wisconsin Population is protected and managed by the Wisconsin Department of Natural Resources and the University of Wisconsin (Table 1; W. Smith, Wisconsin Department of Natural Resources, pers. comm. 2012).

The entire Hine's emerald dragonfly habitat area that has been identified within the Southwest Wisconsin Population is managed and protected by the Wisconsin Department of Natural Resources (Table 1; W. Smith, pers. comm. 2012).

In Missouri, the habitat in two of the seven subpopulations is completely protected and managed by either the U.S Forest Service or Missouri Department of Conservation (Table 1). The Forest Plan for the Mark Twain National Forest identifies several actions supporting management of Hine's emerald dragonfly habitat (USFS 2005). Management actions identified and implemented as resources are available, include control of non-native and/or undesirable (e.g., woody) plant species, restoration of local hydrology, and methods to minimize unauthorized vehicle and heavy equipment access near fens with known or suspected Hine's emerald dragonfly populations.

Groundwatershed Protection:

In the Northern Recovery Unit, groundwater recharge areas have been delineated for 13 sites. Within the Northern Wisconsin Population 12 groundwater recharge areas were delineated by Cobb and Bradbury (2008). An additional groundwater recharge area has been mapped for Cedarburg Bog (Ozaukee County) by the Wisconsin Department of Natural Resources and Wisconsin Geological and Natural History Survey (Joanne Kline, WDNR, pers. comm., 2013). Groundwater modeling was completed by Sampath et al (2015) that informed fen hydrology in the upper peninsula of Michigan and the relation to water levels in Lake Huron.

In the Southern Recovery Unit, groundwater recharge areas have been delineated at one site in Ozaukee County, Wisconsin (Cobb and Bradbury 2008), seven sites in Illinois (Locke et al, 2005; Graef 2008; STS 2009; AECOM 2011), and two sites in Missouri (Beeman and Aley 2012).

The regulatory mechanisms that protect the groundwatershed for Hine's emerald dragonfly habitat include sections 7 and 9 of the Endangered Species Act of 1973 (ESA) and the Illinois Natural Areas Preservation Act. Section 7(a)(2) of the ESA requires Federal agencies to consult with the U.S. Fish and Wildlife Service prior to authorizing, funding or carrying out activities that may affect listed species or designated critical habitat. Section 9 of the ESA prohibits any person subject to the jurisdiction of the United States from taking listed wildlife species. The term "take" is defined to include harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting. Regulations implementing the ESA (50 CFR 17.3) further define "harm" to include significant habitat modification or degradation that results in killing or injury of listed wildlife species by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. Illinois sites dedicated as Illinois Nature Preserves are afforded the maximum legal protection against future changes in land use, which can include changes to groundwater that discharges into dedicated nature preserves.

Determination: Criterion 3 has not been completely met. Various protection mechanisms and levels are available across the range of the Hine's emerald dragonfly based on the jurisdiction and authorities of local, County, State and Federal governments. There are also opportunities for conservation easements that can be held by non-government organizations. In addition, many of the sites that the Hine's emerald dragonfly has been verified where already protected for various

reasons before the species was listed as federally endangered. It is likely that the protection mechanisms are the reason viable habitat still exists or is not threatened. However, protection of habitat in perpetuity has also been achieved for sites after the species was listed. Efforts to protect additional habitat is ongoing. Likewise, groundwater protection mechanisms vary across the species range. While we have made progress with our partners to delineate more groundwater recharge areas and work with agencies to protect them, there are sites that need the groundwater recharge areas delineated so that protections can be pursued.

Criterion 4. A monitoring plan must be established for each population within five years to estimate population size on an annual basis for the purpose of determining whether recovery criteria have been achieved.

No monitoring plans have been created; therefore Criterion 4 has not been completely met.

The recovery plan criteria are still appropriate based on our current level of understanding of the species and its distribution.

Updated Information Relevant to the Current Species' Status

Biology and Habitat:

Range and distribution:

While there is not any new information indicating a significant change in population size, there have been seven new locations, or sites, confirmed since the last 5-year review in 2019. Three of the recently confirmed populations have verified breeding habitat that have geological characteristics that are different from typical Hine's emerald dragonfly habitat. For example, breeding habitat had previously only been confirmed in sites with dolomitic or limestone bedrock at or near the surface (approximately within 6 feet); whereas the soil depth to bedrock is 60-120 feet in the three populations confirmed in the last ten years. This new information suggests that the species is not as habitat limited as previously understood. However, this information does not change our understanding of the species' needs or how the species is influenced by threats or stressors. The following is an update on Hine's emerald dragonfly populations by state since the last 5-year review completed in 2019.

Illinois: In 2020, the presence of adult Hine's emerald dragonflies were confirmed at the Rockton Bog Nature Preserve site in Winnebago County. This is only the second record for the species in the county (Gibbons 2020 and 2023).

In 2023, the Hine's emerald dragonfly was confirmed at a new location on private property in Channahon, Will County, Illinois. In addition to several incidental adults being observed at the site, a presence-absence larval survey was conducted and confirmed breeding is occurring at the site. This is a significant discovery as it expands the small and highly threatened Lower DesPlaines River Valley population. The U.S Fish and Wildlife Service is currently exploring opportunities to protect the site.

Michigan: Two new records exist in Michigan that are also recognized as a population not previously known and are being recognized as the Middle West Lower Peninsula Michigan Population. It is considered a separate population for recovery purposes based on the distance from other known records.

Missouri: No new records reported since last review.

Wisconsin: In 2020, the presence of the Hine's emerald dragonfly was confirmed at an additional site on private property in Rock County, Wisconsin. The observation of adult dragonflies represented the first confirmed sighting of the species in the county. In 2021, adult Hine's emerald dragonflies were confirmed at two more privately owned sites near the original observation in Rock County, but on separate properties (Gibbons 2020, 2021, 2023).

Population Demographics:

As noted above, data is either out of date or does not exist.

Genetics:

In 2021, Dr. Anthony Cognato, Michigan State University collected two female Hine's emerald dragonflies in Oceana County, Michigan, a location over 60 miles from the nearest known populations. Identification of these individuals was confirmed using phylogenetic analyses of mitochondrial haplotypes. This analysis revealed that each individual represented a different haplotype. Neither haplotype had been previously represented in Michigan, northern Wisconsin, or the Ontario populations, and one was new to the species (Craves et al. 2022). These findings suggest that the Hine's emerald dragonfly in west-central Michigan may be a genetic link between the Southern and Northern Recovery Units.

Taxonomic and nomenclature:

The Hine's emerald dragonfly has a commensal association with a crayfish that was referred to previously as *Cambarus diogenes* (devil crayfish). Larval Hine's emerald dragonfly utilize the burrows of the crayfish as refuge when the habitat dries and for overwintering. Glon et al (2023) used anchored hybrid enrichment data, a new source of additional molecular markers for estimating phylogenetic relationships, to redescribe the crayfish associated with the Hine's emerald dragonfly as *Lacunicambarus nebrascensis* (Great Plains mudbug). *Lacunicambarus nebrascensis* is the only species of *Lacunicambarus* across most of its range and its range overlaps with that of the Hine's emerald dragonfly.

Threats Analysis (threats, conservation measures, and regulatory mechanisms):

Threats:

The greatest threat to the Hine's emerald dragonfly continues to be the destruction and modification of its habitat. The recovery plan (U.S. Fish and Wildlife Service 2001) and previous status reviews (U.S. Fish and Wildlife Service 2013) completed for Hine's emerald dragonfly cover many of these threats in detail. Below is a description of threats to the species that the U.S. Fish and Wildlife Service and our partners have identified since the recovery plan was issued in 2001. See Table 2 (appendix) for a list of known threats.

Present or threatened destruction, modification or curtailment of its habitat or range:

Invasive Vegetation

Invasive vegetation can potentially impact Hine's emerald dragonfly behavior and habitat. The encroachment of cattails (*Typha* spp.) and woody vegetation has the potential to affect adult flight behavior and movement which can limit breeding success and fragment populations. Other invasive plant species can impact habitat features that help fulfill life history requirements. For example, a necessary component of larval habitat is groundwater. Encroachment of woody invasive species in upland areas has the potential to allow greater runoff of precipitation and loss of subsurface water through evapotranspiration. Herbaceous invasive species can also impact necessary breeding habitat features. For example, common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*) displace crayfish, and hence their burrows that serve as refugia for Hine's emerald dragonfly larvae.

Fragmentation

Since the recovery plan was written, new information has been gained on barriers to adult Hine's emerald dragonfly movement. These barriers to movement can affect dispersal and flight behavior that may lead to isolated populations and increase the vulnerability of Hine's emerald dragonfly populations to the effects demographic and genetic stochasticity. The long-term viability of any species is based on a combination of population size and genetic diversity that are essential to counteract stochastic or catastrophic events.

Fragmentation or barriers to movement can lead to reduced population sizes and/or a loss in genetic diversity. Barriers to movement that may lead to fragmentation include closed canopy forest and bridges. Observations of adult Hine's emerald dragonfly flight behavior around the Interstate 355 bridge that extends over the DesPlaines River Valley in Illinois indicate a decrease in observed adult activity beneath the bridge since the completion of the bridge deck (Soluk et al. 2011, p. 14). Observers noted adults avoiding the area underneath the bridge. In general, dragonflies were often observed flying towards the bridge, quickly increasing flight height to deck level, and then crossing at or near traffic height. Of the eleven possible Hine's emerald dragonflies observed Soluk et al, three flew directly over the bridge, and none flew under it. The remaining individuals did not attempt to cross the bridge. At this time, it is unclear as to what causes the various flight behaviors observed or what other bridges may serve as barriers to movement. Methods to mitigate this impact are being assessed. Preliminary studies were initiated in 2012 to observe specific aspects of Hine's emerald dragonfly flight behavior around barriers and to assess the potential to discourage road crossing with various mitigative measures (e.g., planted vegetation, netting, etc.) (D. Soluk, pers. comm., 2012).

Invasive Animals

Feral hogs, armadillos, and beavers could potentially destroy Hine's emerald dragonfly habitat in Missouri, as well as in northern parts of the species range. Feral hogs are known to rut while foraging for tubers, insects, and other organisms. This rutting behavior can cause significant impacts to fens and other wetland communities. Currently, feral hogs do not pose a threat to Hine's emerald dragonfly habitat outside of Missouri, but feral hogs are known to occur in southern Illinois and western Wisconsin.

Likewise, the nine-banded armadillo (*Dasypus novemcinctus*) foraging behavior has the potential to destroy habitat. Armadillos dig-up insect larvae for food and will forage in underground burrows during cold periods. The armadillo's range expansion is expected to continue (Taulman and Robins 1996). Armadillos have been consistently moving northward and eastward from the Rio Grande since the latter part of the 19th century. There are different hypotheses as to why the armadillo has expanded its range including changes in land use practices, removal of natural predators, and climate change. Threats from the armadillo to Hine's emerald dragonfly and its habitat will need to be monitored.

Beaver dams can cause flooding of wetland communities supporting the Hine's emerald dragonfly. Beavers had posed a potential threat at Lockport Prairie in Illinois, but this threat has been reduced with the installation of a beaver drain tube in the beaver dam to manage inundation of Hine's emerald dragonfly habitat. The Missouri Department of Conservation continues to manage threats from feral hogs and beavers through their state-wide recovery plan for the species. However, it is not known if such control measures will be sufficient to eliminate the adverse impacts that continue to threaten sites in Missouri.

Livestock

High density of livestock or prolonged periods of grazing have the potential to alter the floristic quality of fens. Overgrazing can reduce or remove sensitive native plant species and can promote the establishment of species such as poison hemlock (*Conium maculatum*), multiflora rose (*Rosa muliflora*), and meadow fescue (*Festuca pratensis*). Large livestock also has the potential to trample habitat features like crayfish burrows that serve as refugia for larvae. Grazing is viewed as a threat at several sites in Missouri.

All-Terrain Vehicles

As discussed in previous reviews (U.S. Fish and Wildlife Service), all-terrain vehicles (ATV) have caused impacts to wetland vegetation and rivulets in Hine's emerald dragonfly breeding habitat. A year after Hine's emerald dragonfly larvae were found at Blue Flag Fen in Missouri, extensive damage from an ATV trail and associated rutting had altered the hydrology of the fen, resulting in surface water at the site to become reduced and confined.

Overutilization for commercial, recreational, scientific, or educational purposes:

Overutilization is not believed to be a factor in the continued existence of the Hine's emerald dragonfly. Federal protection under section 9 of the ESA prohibits unauthorized collection of individuals of the species. In addition, ESA section 10 recovery permits issued to researchers when conducting activities that may adversely affect the Hine's emerald dragonfly include conditions to avoid and minimize harm to the dragonfly.

Disease or predation

Disease and predation are not believed to be a factor affecting the continued existence of the Hine's emerald dragonfly.

Inadequacy of existing regulatory mechanisms

Ground water protection methods are varied and limited across the species range based on jurisdiction. For example, in Illinois habitat with nature preserve dedication under the Illinois

Natural Areas Protection Act provide additional legal protection of the groundwater associated with the habitat. As stated above, delineation of groundwater recharge areas enables the U.S. Fish and Wildlife Service and our partners to work toward maintaining noncontaminated groundwater infiltration.

The Hine's emerald dragonfly is listed as federally endangered species and is therefore afforded protection in all states under the ESA. In addition, the Hine's emerald dragonfly is State listed as endangered in the four states (Illinois, Michigan, Missouri, and Wisconsin) that are within its current range, thereby affording the species additional State level protections.

Other natural or manmade factors affecting its continued existence.

Environmental Contaminants

The recovery plan discusses the potential threat of habitat altering chemicals. Research has been initiated and is ongoing on the potential impacts of herbicides used as a management tool to control invasive vegetation. Research results have shown effects in growth, feeding and behavior of larvae from exposure to various concentrations of herbicides (Soluk et al. 2011, p. 14). The University of South Dakota conducted laboratory toxicity studies to assess the effect of Fusilade®, a grass specific herbicide, on the Hine's emerald dragonfly (Soluk et al. 2011). The research found that Hine's emerald dragonfly larvae appear somewhat resilient to environmentally high concentration of Fusilade® and there is some potential for sub-lethal impacts that require more analyses (Soluk et al. 2011).

Two oil pipeline leaks occurred outside of Hine's emerald dragonfly habitat in 2010. In September 2010, an oil pipeline break occurred outside of Romeoville Prairie Nature Preserve in Romeoville, Illinois. Based on the analysis that was conducted following the Romeoville leak, no oil was detected in the habitat or the groundwater. In December 2010, another pipeline accident released oil into Hine's emerald dragonfly habitat at the Long Run parcel on private land in Lockport, Illinois. Clean up efforts were completed and the site was reclaimed to the extent practical. However, the Hine's larval habitat at the site was permanently destroyed and a restoration plan has been completed to mitigate for the associated impacts from the pipeline leak (United States Fish and Wildlife Service, United States Department of the Interior and Natural Resource Trustees for the State of Illinois 2023).

Climate Change

Climate change will be a particular challenge for biodiversity because the interaction of additional stressors associated with climate change and current stressors (e.g., invasive species, hydrologic changes, etc.) may push species beyond their ability to survive. The synergistic implications of climate change and habitat fragmentation is the most threatening facet of climate change for biodiversity. In addition, local extinction and range shifts are also being documented for some species including dragonflies. Recent changes in climate have expanded, contracted, or shifted the climate niches of many species; the result is often a change in the species' geographic range. In a study of all 37 species of resident odonates (dragonflies and damselflies) in the United Kingdom, all but two species increased in range size, and all but three species shifted northwards at their range margin in the last 40 years (Hickling et al. 2005, p. 504).

While there is uncertainty about the exact nature and severity of climate change related impacts anticipated within the Hine's emerald dragonfly's range, several scientific studies project that there will be increased duration and intensity of heat waves in summer, higher levels of humidity and evaporation; changing patterns of precipitation with fewer rain events of greater intensity; increased frequency and more severe dry spells; and more flooding from heavy rains.

Climatic changes may impact the Hine's emerald dragonfly and its habitat in a variety of direct and indirect ways including changes in hydrology; loss of suitable habitat; loss of inter-specific relationships with crayfish; and increased threats from invasive species. As a result, these changes have the potential to have demographic impacts on the species. For example, data on population sizes in Illinois reveal that declines in the population correlate with short-term droughts (Soluk and Mierzwa 2012, pp. 22-25). In years when droughts occur, there is very low recruitment which leads to a small cohort. While the population eventually recovers slightly, it appears to not return to its pre-drought size.

Summary of Threats

Destruction and modification of habitat continues to be the greatest threat to the Hine's emerald dragonfly. Many of the threats to habitat vary across the range of the species (Appendix Table 2) but also vary in magnitude and ability to be mitigated. Direct loss of habitat is the most severe threat but occurs infrequently due to laws protecting wetlands and measures taken to preserve habitat. Other threats to hydrology or from fragmentation and contamination can also have a permanent impact on habitat and even entire populations of the species but our ability to manage or prevent these threats is limited. Invasive plant species is the most widespread of the threats; however, the magnitude of this threat and our ability to manage it depends on the invasive species and the degree that it has encroached upon Hine's emerald dragonfly habitat. Management of impacts from invasive plants and animals will be an ongoing effort.

Conservation Measures:

Captive Rearing and Augmentation of the Hine's Emerald Dragonfly

Captive rearing of the Hine's emerald dragonfly continues to expand and increase achievements toward augmenting the Lower DesPlaines River Valley population. Morris (2023) evaluated the role of density and detrital community in growth and survivorship of hatchling Hine's emerald dragonflies. Microbenthic community samples were collected in productive Hine's emerald dragonfly habitat and contrasted with samples collected from microcosms. Experiments were designed to evaluate optimal density and growth in laboratory microcosms by comparing rates of survivorship of larvae housed under varying conditions. Results indicate that microbenthic communities from natural habitat were more abundant than laboratory microcosms. Density and components of the microbenthic community, such as Amphipoda and edible prey types, negatively and positively impact survivorship and growth of larvae in microcosms. "Though it is possible to yield high survivorship in small microcosms, when calculating cost considering the number of people and hours required to care for these microcosms, medium microcosms greatly increase efficiency for captive rearing, as well as surpass survivorship and growth observed in the lab previously" (Morris 2023). These results provide useful insight to help inform and direct the Hine's emerald dragonfly captive rearing program to maximize survivorship.

Captive Rearing and Experimental Release of the Great Plains Mudbug (crayfish)

In efforts to restore larval habitat for the Hine's emerald dragonfly, the U.S. Fish and Wildlife Service and our partners are working together to rear the Great Plains mud bug (*Lacunicambarus nebrascensis*) and to augment and reintroduce the species into Hine's emerald dragonfly larval habitat. As discussed above, burrows for the crayfish are essential for Hine's emerald dragonfly larvae to serve as refuge when their habitat dries and for overwintering. The U.S. Fish and Wildlife Service and our partners at the Forest Preserve District of DuPage County, initiated a captive rearing program for the crayfish. This work is also supported by our partners at the University of South Dakota, Lincoln Park Zoo, and Brookfield Zoo. Comprehensive knowledge of species movement and home range is necessary to formulate effective augmentation plans. For freshwater burrowing crayfish, this type of information is generally lacking. Tesar (2022) conducted studies to acquire detailed information that is essential for augmentation of the crayfish. They tested the use of mobile and stationary passive integrated transponder telemetry technology to track the movements of the crayfish in Hine's emerald dragonfly habitat. The results indicated that the crayfish could be tracked above and below ground and that the use of both stationary and mobile tracking equipment was necessary to recapture the crayfish within different microhabitats. They also implemented trial release methods for the introduction of the crayfish with starter holes to induce burrowing and no holes. Introduction treatment did not significantly impact the number of crayfish that relocated from their introduction point, and 64% of released Great Plains mudbug crayfish burrowed within 3m of their introduction point. This indicated that a successful release into Hine's emerald dragonfly habitat was possible (Tesar 2022).

Environmental DNA Sampling Methods: Quantitative Polymerase Chain Reaction (qPCR) and Loop-mediated Isothermal Amplification (LAMP)

The use of environmental DNA sampling, DNA extracted directly from the environment to successfully detect the presence of rare species or those of conservation concern has increased in the last few years (Francis-Thomsen et al. 2011). Environmental DNA is especially promising for reducing the time and personnel costs associated with surveying for the Hine's emerald dragonfly within complex landscapes. The relatively simple sample collection methods used in eDNA monitoring will also work well with potential Hine's emerald dragonfly habitat because of the low flows and volumes in most systems where the larvae are present. Furthermore, the ability to collect samples from areas downstream of larval streamlet habitat may ameliorate issues of access to larval habitat that can limit surveying in some cases.

Working under a Service funded Science Support Partnership Grant, researchers at the U.S. Geological Survey and University of South Dakota mapped the complete mitochondrial genome of the endangered Hine's emerald dragonfly and developed two eDNA markers each for the Hine's emerald dragonfly and the Great Plains mudbug (Jackson et al. 2018). These markers have successfully detected eDNA from both species in lab and field samples using qPCR. Results from lab experiments with these markers suggest optimum sampling temperatures and duration of eDNA persistence in the environment. We have used the Hine's emerald dragonfly markers to identify unknown larvae from Michigan as Hine's emerald dragonfly. They also determined that the markers can be used to identify Hine's emerald dragonfly exuviae. Identification of small larvae and exuviae will be useful in the recovery of the species.

An essential step in developing a protocol is to evaluate the dynamics of eDNA concentration under controlled and field conditions. Schmidt and the Soluk Lab at the University of South Dakota examined the persistence and accumulation of eDNA from captive Hine's emerald dragonfly larvae in experimental mesocosms at temperatures (5.0°C and 16.0°C) that reflect seasonal variation in their natural habitat, and they evaluated the usefulness of eDNA protocols for studying the distribution and abundance of the Hine's emerald dragonfly and the crayfish by assessing patterns of eDNA distribution in the field over several months. In mesocosms, the dragonfly's eDNA persisted longer at 5.0°C but accumulated more readily at 16.0°C. In the field, they determined that life-history events (e.g., egg hatching and emergence) affected seasonal variations in eDNA more significantly and consistently than temperature for both species.

Research continues toward the development of LAMP eDNA sampling protocols. USGS has developed LAMP portable detector assays to detect Hine's emerald dragonfly. The next steps will be to test the methods sensitivity to various conditions in the laboratory and finally in a direct comparison with existing Hine's emerald dragonfly qPCR assays on parallel samples from field sites known to contain the species.

Species Distribution Model

The Illinois Natural History Survey (2023) completed a U.S. rangewide species distribution model for the Hine's emerald dragonfly to identify potential areas of species occurrence to identify potential areas where the species may occur and surveys can be directed. With new locations being recorded in Illinois, Michigan, and Wisconsin since the last review, the SDM along with new survey techniques will provide tools to assess the potential to further expand the distribution of the species.

Education and Training

Efforts to train more people to conduct adult and larval surveys were implemented. Dr. Paul McKenzie, retired U.S. Fish and Wildlife Service Endangered Species Biologist led workshops in Missouri that has attracted interested biologists from across the species range. The workshops have focused on how to search for, net, and identify adult Hine's emerald dragonflies (McKenzie 2023 and 2024). In 2024, the Service worked with Dr. Daniel Soluk at the University of South Dakota to coordinate a workshop for 20 research-oriented biologists to be trained on identification and adult and larval survey techniques for the Hine's emerald dragonfly (report pending).

Habitat Conservation Plan

Hanson Material Service completed a habitat conservation plan and received an incidental take permit under section 10 of the Endangered Species Act for multiple state and federally endangered species, Hine's emerald dragonfly, Blanding's turtle, spotted turtle, leafy prairie clover and the Lakeside daisy (Hanson Material Service 2021). This permit authorizes the take in the form of 49.6 acres of adult Hine's emerald dragonfly habitat. The loss of 29.1-acres of Blanding's turtle and spotted turtle habitat are expected to result in the incidental take of no more than 12 Blanding's turtle individuals and two spotted turtle individuals. In return, mitigation under the plan includes the permanent protection of over 500 acres of habitat, restoring, enhancing, and maintaining approximately 321 acres of habitat, hydrological protection

mechanisms and monitoring associated with groundwater, vegetation, and the Hine's emerald dragonfly will be ongoing throughout the life of the permit (30 years).

3.0 Recommendations for future activities

Reclassification is possible based on the actions that have been implemented and greater understanding of the species distribution within recovery units. Presence/absence surveys and surveys to estimate population sizes need to be expanded and more surveyors professionally trained to identify new populations. Additionally, there is a need for increased efficiency to process permits, utilize the rangewide distribution model, implement and expand eDNA research. Though partnerships are extensive across the range, there is a need to expand cooperation and partnerships with State agencies and non-government organizations to provide support toward this effort utilizing expertise, staff, and funding opportunities.

Protection of habitat and associated recharge areas continue to be a high priority to achieve reclassification or delisting. Priority should be given to sites which have been discovered on private land. Conservation is occurring on some of the privately owned sites due to conservation agreements with the Service (Section 10 and Partners program) and our State, County and non-government organization partners.

1. Continue to implement Hine's emerald dragonfly captive rearing and augmentation in the Lower DesPlaines River Valley population.
2. Implement the rangewide distribution model to identify and survey potential larval habitat for species presence.
3. Protect habitat in new locations.
4. Implement eDNA survey protocols with partners across the species historic range.
5. Monitor and estimate the size of Hine's emerald dragonfly populations.
6. Coordinate efforts with partners to restore and manage larval and adult (including recharge areas) habitat in existing, historic, and new sites as they are verified.
7. Assist in groundwater and habitat protection, enhancement, and management efforts.

4.0 Synthesis

The recovery criteria for the Hine's emerald dragonfly were designed to address the viability of the species through the conservation principles of resiliency (e.g., 500 adults per subpopulation, number of breeding areas per subpopulation, protection of habitat, etc.) and redundancy (e.g., North and South Recovery Units with two populations consisting of three subpopulations). The recovery criteria for population distribution and size have not been met nor have those that address habitat features and protection.

Currently, every population of the Hine's emerald dragonfly is under stress from threats that are directly and indirectly impacting the species and its habitat (Table 2).

The populations in the Southern Recovery Unit may be experiencing a greater magnitude of threats with the Illinois population being the most vulnerable to extirpation. While the populations in the Southern Recovery Unit are believed to be smaller, there is greater genetic diversity within the Southern populations which makes them extremely important to the survival and recovery of the species. The vulnerability of populations in the Southern Recovery Unit, and the species as a whole, to effects from demographic and genetic stochasticity may be increasing due to the severity of the threats to the small populations. Demographic stochasticity can cause small populations to vary widely in size. A drastic reduction in population size can exacerbate the effects of genetic stochasticity or can lead to the further decline of a population to extirpation. As a population loses individuals, it may lose genetic variation, which may reduce the species' fitness or ability to cope with environmental change. So, while the Southern populations may currently contain genetic diversity that may be necessary for the species to survive and adapt in a changing environment, the potential for the Southern populations to become extirpated is compounded by several direct and indirect threats and by small population sizes, which compromises the viability of the species rangewide.

Based on the current population status and distribution, and the continuing threats to the species and its habitat, the Hine's emerald dragonfly continues to be in danger of extinction throughout all or a significant portion of its range, and therefore, continues to meet the definition of an endangered species.

U.S. FISH AND WILDLIFE SERVICE
STATUS REVIEW of Hine's Emerald Dragonfly
(*Somatochlora hineana*)

Current Classification:

Status Recommendation resulting from Status Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist (Indicate reasons for delisting per 50 CFR 424.11):
 - The species is extinct.
 - The species does not meet the definition of an endangered or threatened species.
 - The listed entity does not meet the statutory definition of a species.
- No change needed.

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date _____

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APPENDIX

Table 1. Distribution and Status of Hine’s Emerald Dragonfly Based on Recovery Criteria

Unit	Pop.	Subpopulation¹	Adult Subpop. Size	Site² * = site found since issuance of recovery plan	Adult # per site	Number of Breeding Areas³	Legally Protected and Managed⁴	GW Area Delineated - Protected	Mntrng. Plan
Northern Recovery Unit	Northern Wisconsin Population	Mink River Estuary, Door County, WI	TBD	Mink River	TBD	Yes, 1 verified	Partially protected	Delineated partially protected	No
		The Ridges, Door County, WI	TBD	Three Springs Creek	TBD	Yes, 1 verified	Partially protected	Delineated partially protected	No
			TBD	North Bay Marsh	TBD	Yes, 1 verified	Partially protected	Delineated partially protected	No
			TBD	Mud Lake North Complex (Lime Kiln, Pioneer, and Grove Roads)	TBD	Yes, 6 verified	Partially protected	Delineated partially protected	No
			TBD	Mystery Creek (Mud Lake South)	TBD	Not confirmed	Partially protected	Delineated partially protected	No
			TBD	Piel Creek	TBD	Yes, 1 verified	Partially protected	Delineated partially protected	No
			TBD	Baileys Harbor	TBD	Not confirmed	Partially protected	Delineated partially protected	No
			TBD	Ridges Sanctuary	TBD	Yes, 3 verified	Partially protected	Delineated partially protected	No
			TBD	Toft Point	TBD	Not confirmed	Unknown	No	No

Unit	Pop.	Subpopulation¹	Adult Subpop. Size	Site² * = site found since issuance of recovery plan	Adult # per site	Number of Breeding Areas³	Legally Protected and Managed⁴	GW Area Delineated - Protected	Mntrng. Plan	
		Arbter Lake, Door County, WI	TBD	Arbter Lake	TBD	Not confirmed	Partially protected	Delineated partially protected	No	
		Washington Island, Door County, WI	TBD	Big Marsh	TBD	Yes, 1 verified	Partially protected	Delineated partially protected	No	
		Black Ash Swamp, Door and Kewaunee Counties, WI	TBD	Black Ash Swamp	TBD	Yes, unknown	Not protected	No	No	
		Gardner Marsh, WI	TBD	Gardner Marsh	TBD	Yes, unknown	Partially protected	Delineated partially protected	No	
		Ephraim Swamp, Door County	TBD	Ephraim Swamp	TBD	Yes, unknown	Partially protected	No	No	
		Kellner Fen, Door County, WI	TBD	Kellner Fen	TBD	Yes, 1 verified	Partially protected	Delineated partially protected	No	
	Eastern Upper Peninsula Population	Mackinac County One, MI		TBD	I-75 West	TBD	Not confirmed	Partially protected	No	No
				TBD	Brevort Lake Road	TBD	Yes, 1 verified	Fully protected	No	No
				TBD	Castle Rock Road*	TBD	Not confirmed	Fully protected	No	No
				TBD	Summerby Swamp and wetland complex	267	Yes, 1 verified	Fully protected	No	No
				TBD	Round Lake*	TBD	Yes, 1 verified	Fully protected	No	No

Unit	Pop.	Subpopulation¹	Adult Subpop. Size	Site² * = site found since issuance of recovery plan	Adult # per site	Number of Breeding Areas³	Legally Protected and Managed⁴	GW Area Delineated - Protected	Mntrng. Plan	
			TBD	Hay Lake*	TBD	Yes, 1 verified	Fully protected	No	No	
			TBD	Huebner	TBD	Yes, 1 verified	Fully protected	No	No	
		Mackinac County Two, Michigan	TBD	I-75 East	TBD	Yes, 1 verified	Partially protected	No	No	
			TBD	Acklund Road	TBD	Yes, 1 verified	Fully Protected	No	No	
			TBD	Foley Creek	TBD	Yes, 1 verified	Partially protected	No	No	
			TBD	Martineau Creek	TBD	Yes, 1 verified	Partially protected	No	No	
			TBD	Inglesbee Swamp	TBD	Not confirmed	Partially protected	No	No	
			TBD	Horseshoe Bay	TBD	Not confirmed	Fully Protected	No	No	
			TBD	Bois Blanc Island	TBD	Yes, 1 verified	Partially Protected	No	No	
		Western Upper Peninsula	Menominee County	TBD	Hayward Lake*	TBD	Not confirmed	Fully Protected	No	No
		NE Lower Peninsula Population	Presque Isle County, MI	TBD	Thompson's Harbor State Park*	TBD	Yes, 1 verified	Fully Protected	No	No
			Alpena County, MI	TBD	North Point Rd. Fen	TBD	Yes, 1 verified	Partially protected	No	No
				TBD	Misery Bay	TBD	Yes, 1 verified	Not protected	No	No

Unit	Pop.	Subpopulation¹	Adult Subpop. Size	Site² * = site found since issuance of recovery plan	Adult # per site	Number of Breeding Areas³	Legally Protected and Managed⁴	GW Area Delineated - Protected	Mntrng. Plan
		Alcona County, MI	TBD	Negwegon State Park - North*	TBD	Not confirmed	Fully Protected	No	No
				Negwegon State Park - South*	TBD	Not confirmed	Fully Protected	No	No
	NW Lower Peninsula Population	Charlevoix County, MI	TBD	Garden Island (Beaver Island Archipelago)*	TBD	Not confirmed	Fully Protected	No	No
	Middle Western Michigan Population	Oceana and Mason Counties, MI	TBD	Oceana County 1*	TBD	Not confirmed	Not Protected	No	No
			TBD	Mason County 1*	TBD	Not confirmed	Not Protected	No	No
Southern Recovery Unit	Northwest Cook County, IL Population	Spring Creek Complex	TBD	Spring Lake Nature Preserve*	TBD	Not confirmed	Fully Protected	Delineated but not protected	No
				Route 62 Marsh*	TBD	Yes, 1 verified (teneral)	Fully Protected	No	No
				Galloping Hill Fen*	TBD	Yes, 1 verified	Fully Protected	No	No
	Winnebago County, IL and Rock County, WI Population	Winnebago Co., IL	TBD	Lost Floral Fen on Raccoon Creek*	TBD	Not confirmed	Partially Protected	No	No
				Rockton Bog State Natural Area*	TBD	Not confirmed	Fully Protected	No	No
		Rock Co., WI	TBD	Cleophas Reserve*	TBD	Not confirmed	Partially Protected	No	No
				Gabower-Reilly East*	TBD	Not confirmed	Partially Protected	No	No

Unit	Pop.	Subpopulation¹	Adult Subpop. Size	Site² * = site found since issuance of recovery plan	Adult # per site	Number of Breeding Areas³	Legally Protected and Managed⁴	GW Area Delineated - Protected	Mntrng. Plan
				Brigg's Wetland*	TBD	Not confirmed	Partially Protected	No	No
	Lower DesPlaines River Valley Population	Lower DesPlaines River Valley Subpopulation 1	154 - 212	Lockport Prairie NP	79/134	Yes, 5 verified	Fully Protected	Delineated but not protected	No
River South				66/69	Yes, 4 verified	Fully Protected	Delineated but not protected	No	
Romeoville Prairie NP				TBD	Not confirmed	Fully Protected	Delineated but not protected	No	
Long Run Seep NP and				3	Yes, 2 verified	Fully Protected	Delineated but not protected	No	
Long Run/ComEd Parcel				TBD	Yes, 2 verified	Fully Protected	Delineated but not protected	No	
Theodore Marsh*				TBD	Not confirmed	Fully Protected	No	No	
Young's Road*				TBD	Yes, 1 verified	Not Protected	No	No	
		Lower DesPlaines River Valley Subpopulation 2	10	Keepataw FP	10	Yes, 5 verified	Fully Protected	No	No
Black Partridge FP				TBD	Not confirmed	Fully Protected	No	No	
Argonne Labs*				TBD	Yes, 2 verified	Fully Protected	No	No	

Unit	Pop.	Subpopulation¹	Adult Subpop. Size	Site² * = site found since issuance of recovery plan	Adult # per site	Number of Breeding Areas³	Legally Protected and Managed⁴	GW Area Delineated - Protected	Mntrng. Plan
				Waterfall Glen FP	TBD	Yes, 1 verified (no larvae found since 2009)	Fully Protected	No	No
		Lower DesPlaines River Valley Subpopulation 3	TBD	Cherry Hill Woods FP*	TBD	Not confirmed	Fully Protected	No	No
	TBD		McMahon Fen NP	TBD	Yes, 2 verified	Fully Protected	Delineated but not protected	No	
	TBD		Palos Fen NP*	TBD	Not confirmed	Fully Protected	No	No	
	Ozaukee County, WI Population	Ozaukee County	TBD	Cedarburg Bog	TBD	Yes, 2 verified	Partially protected	Delineated but not protected	No
	Lower Wisconsin River Population	Iowa County	TBD	Lower Wisconsin State Riverway – Kendall Lake and Avoca Wildlife Area*	TBD	Yes, 1 verified	Fully Protected	No	No
		Iowa and Richland Counties	TBD	Lower Wisconsin State Riverway - Knapp Creek*	TBD	Yes, 1 verified	Fully Protected	No	No
		Ripley County	TBD	Cottonmouth Fen*	TBD	Not confirmed	Not protected	No	No

Unit	Pop.	Subpopulation¹	Adult Subpop. Size	Site² * = site found since issuance of recovery plan	Adult # per site	Number of Breeding Areas³	Legally Protected and Managed⁴	GW Area Delineated - Protected	Mntrng. Plan
	Ripley County Population		TBD	Emerald Fen*	TBD	Yes, 1 verified	Not protected	No	No
			TBD	Glass Lizard Fen*	TBD	Yes, 1 verified	Fully Protected	No	No
			TBD	Montgomery Fen*	TBD	Yes, 2 verified	Fully Protected	No	No
			TBD	Overcup Fen*	TBD	Not confirmed	Fully Protected	No	No
	Dent, Iron and North Reynolds Population	Dent County	TBD	Bates Hollow*	TBD	Yes, 1 verified	Partially protected	Dent County	TBD
			TBD	Fortune Hollow*	TBD	Yes, 1 verified	Fully Protected	No	TBD
		Iron County	TBD	Barton Fen*	TBD	Yes, 1 verified	Fully Protected	Delineated but not protected	No
		North Reynolds County	TBD	Bee Fork East*	TBD	Not confirmed	Fully Protected	No	No
			TBD	Bee Fork Center*	TBD	Yes, 1 verified	Fully Protected	No	No
			TBD	Bee Fork West*	TBD	Yes, 1 verified	Fully Protected	No	No
			TBD	Grasshopper Hollow	TBD	Yes, 4 verified	Fully Protected	No	No
			TBD	Johnson Shut-in State Park – proper*	176	Yes, 1 verified	Fully Protected	No	No
		TBD	Johnson Shut-in Walker Tract*	TBD	Yes, 1 verified	Fully Protected	No	No	

Unit	Pop.	Subpopulation ¹	Adult Subpop. Size	Site ² * = site found since issuance of recovery plan	Adult # per site	Number of Breeding Areas ³	Legally Protected and Managed ⁴	GW Area Delineated - Protected	Mntrng. Plan
			TBD	Kay Branch*	1,024	Yes, 5 verified	Not protected	No	No
			TBD	Wisdom/Lanham Fen*	TBD	Yes, 1 verified	Not protected	No	No
	South Reynolds County Population	South Reynolds County	TBD	Deckard Hollow*	TBD	Not confirmed	Not protected	No	No
			TBD	Ruble Meadow	TBD	Yes, 1 verified	Not protected	No	No
	Centerville Population	Centerville	TBD	Centerville Slough*	99	Yes, 1 verified	Not protected	No	No
	Phelps County Population	Phelps County	TBD	Kaintuck Hollow*	TBD	Yes, 1 verified	Fully Protected	No	No

1) Subpopulations are a theoretical depiction of the potential population structure within each population based on proximity of individual sites and number of breeding areas identified.

2) Sites where Hine's emerald dragonfly adults and larvae have been documented are included.

3) A site is considered a breeding site when at least one of the following criteria are met: a) the presence of a Hine's emerald dragonfly exuvia; b) the observation of a teneral Hine's emerald dragonfly; c) the presence and verification (e.g., species expert, final instar male larva, or genetic analysis of larva is positive) of Hine's emerald dragonfly larvae; d) observation of a female Hine's emerald dragonfly ovipositing; or e) the presence of multiple territorial male Hine's emerald dragonflies.

4) Legally protected and managed – long-term protection mechanisms such as watershed protection, deed restrictions, land acquisition, or nature preserve dedication.

Acronyms used: TBD= To be determined; NP = Nature Preserve; FP = Forest Preserve; Mntrng. = Monitoring

Table 2. Threats to Hine’s Emerald Dragonfly and Its’s Habitat Across the Species Current Range

Site	Direct loss of habitat	Fragmentation	Hydrological	Contaminants	Vehicle mortality	Invasive animals	Invasive plants	Livestock	ATV’s
Wisconsin									
Mink River Estuary			X	X			X		
Three Springs Creek			X	X		X	X		
North Bay Marsh			X	X	X		X		X
Mud Lake North Complex (Lime Kiln, Pioneer, and Grove roads)			X	X	X	X	X		
Mystery Creek (Mud Lake South)			X	X	X		X		
Piel Creek			X	X	X		X		X
Baileys Harbor			X	X	X		X		
Ridges Sanctuary			X	X	X		X		
Toft Point			X	X			X		
Arbter Lake			X	X			X		
Big Marsh			X	X	X		X		
Black Ash Swamp			X	X			X		
Gardner Marsh			X	X	X		X		
Ephraim Swamp			X	X			X		
Kellner Fen			X	X			X		
Cedarburg Bog			X	X	X		X		
Lower Wisconsin State Riverway – Kendall Lake/Avoca Wildlife Area			X				X		
Lower Wisconsin State Riverway - Knapp Creek Wetland			X				X		

Site	Direct loss of habitat	Fragmentation	Hydrological	Contaminants	Vehicle mortality	Invasive animals	Invasive plants	Livestock	ATV's
Cleophas Reserve*	Unknown								
Gabower-Reilly East*	Unknown								
Brigg's Wetland*	Unknown								
Michigan									
I-75 West		X	X	X	X		X		
Brevort Lake Road		X			X		X		X
Castle Rock Road		X	X		X		X		
Summerby Swamp			X	X	X		X		
Round Lake							X		X
Hay Lake			X				X		
Huebner		X					X		
I-75 East			X	X	X		X		
Acklund Road		X					X		
Foley Creek		X	X		X		X		
Martineau Creek		X	X				X		
Inglesbee Swamp		X	X		X		X		
Horseshoe Bay		X					X		
Bois Blanc Island			X	X	X				
Thompson's Harbor State Park			X						
North Point Rd. Fen			X						
Misery Bay	Unknown								
Negwegon State Park - North		X					X		
Negwegon State Park - South		X					X		
Hayward Lake	Unknown								

Site	Direct loss of habitat	Fragmentation	Hydrological	Contaminants	Vehicle mortality	Invasive animals	Invasive plants	Livestock	ATV's
Garden Island									Unknown
Oceana County #1									Unknown
Mason County #1									Unknown
Illinois									
Spring Lake Nature Preserve		X	X		X		X		
Route 62 Marsh		X	X		X		X		
Galloping Hill Fen		X	X		X		X		
Lost Floral Fen on Raccoon Creek		X					X		
Rockton Bog State Natural Area*		X							
Lockport Prairie		X	X		X		X		X
River South and Middle Parcel	X	X	X		X		X		X
Romeoville Prairie		x	X		X		X		X
Long Run Seep		X	X		X		X		
Long Run/ComEd	X	X	X	X	X		X		
Theodore Marsh		X	X		X		X		
Young's Road	X	X	X		X		X		
Keepataw			X		X		X		X
Black Partridge		X	X		X		X		X
Waterfall Glen		X	X		X		X		
Argonne Labs		X	X						
Cherry Hill Woods		X			X		X		
McMahon Fen		X	X		X		X		X
Palos Fen		X			X		X		
Missouri									
Bates Hollow			X			X			
Fortune Hollow			X			X			X

Site	Direct loss of habitat	Fragmentation	Hydrological	Contaminants	Vehicle mortality	Invasive animals	Invasive plants	Livestock	ATV's
Barton Fen			X	X	X	X	X		
Kaintuck Hollow			X			X		X	X
Bee Fork East			X			X		X	
Bee Fork Center			X	X		X		X	
Bee Fork West			X	X		X			
Centerville Slough			X	X	X	X			
Deckard Hollow		X	X			X			
Grasshopper Hollow			X	X		X			
Johnson Shut-in State Park – proper	X		X			X	X		
Johnson Shut-in Walker Tract			X			X	X		
Kay Branch			X			X	X	X	X
Ruble Meadow			X			X	X	X	
WisdomFen			X		X	X	X	X	
Cottonmouth Fen		X	X			X	X		
Emerald Fen			X			X	X		
Glass Lizard Fen		X	X			X	X		
Montgomery Fen			X			X		X	
Overcup Fen		X	X			X	X		

Direct loss of habitat – ground disturbance, filling wetlands, quarrying.

Fragmentation – barriers to movement or loss of corridors for movement.

Hydrological – impacts to the quantity and quality to surface and subsurface hydrology.

Contaminants – habitat altering chemicals and other substances that may cause direct or indirect take.

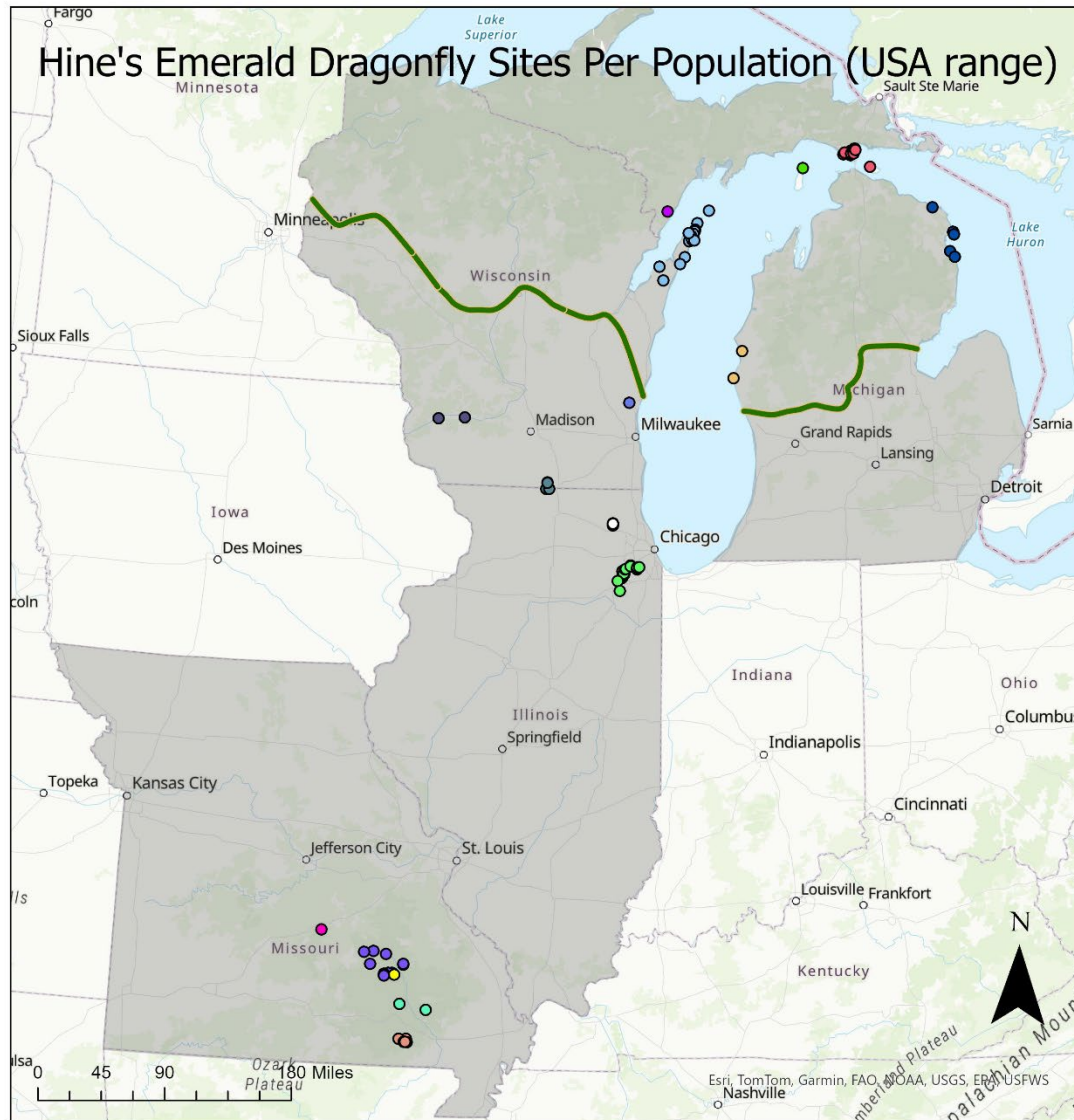
Vehicle mortality – mortality due to direct and indirect impacts with cars, trucks and trains

Invasive animals – feral hogs, armadillos, beavers, and other animals that can cause destruction of habitat.

Invasive plants – vegetation that impacts habitat features (e.g., common reed) and/or encroaches on habitat (woody vegetation).

Livestock and haying – crushing crayfish burrows and loss of vegetation in adult and larval habitat from livestock, equestrian use and haying.

ATV's – impacts to wetland vegetation and rivulets from all-terrain vehicles.



Legend

- | | | | |
|---|--|---|--|
| ● Centerville Population | ● Lower Wisconsin River Population | Northwest Cook County, IL Population | ● Western Upper Peninsula |
| ● Dent, Iron and North Reynolds Population | ● Middle Western Michigan Population | ● Ozaukee County, WI Population | ● Winnebago County, IL and Rock County, WI Population |
| ● Eastern Upper Peninsula Population | ● NE Lower Peninsula Population | ● Phelps County Population | Recovery Unit Boundary |
| ● Lower DesPlaines River Valley Population | ● NW Lower Peninsula Population | ● Ripley County Population | |
| | ● Northern Wisconsin Population | ● South Reynolds County Population | |