TOMAH MAYFLY ASSESSMENT

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INTRODUCTION

Since 1968, the Maine Department of Inland Fisheries and Wildlife (MDIFW) has developed and refined wildlife species assessments to formulate management goals, objectives, and strategic plans. Assessments are based upon available information and the judgments of professional wildlife biologists responsible for individual species or groups of species. This document represents the first planning effort undertaken by MDIFW for the Tomah mayfly (*Siphlonisca aerodromia*), a species listed as threatened in Maine.

Assessments provide the background for species planning initiatives. A "Natural History" section reviews biological characteristics of the species useful to understanding its status. The "Management" section recaps previous actions, strategic plans, relevant rules, and regulatory authority. Historic, current, and projected future conditions for the species are discussed individually for "Habitat," "Population," and "Use and Demand" analyses. The major points of an assessment appear in "Summary and Conclusions."

The Tomah mayfly, first described from specimens collected in New York in the early 1900s and later thought to be extinct, was "rediscovered" by Dr. K. Elizabeth Gibbs at Tomah Stream, Maine, in 1978. This assessment draws heavily on subsequent studies in Maine by Dr. Gibbs and her graduate students in the Department of Entomology, University of Maine. Dr. Gibbs and Marcia Siebenmann prepared a draft Tomah mayfly assessment for MDIFW in 1995; this document was updated in 2000 with information from recent research and survey projects.

NATURAL HISTORY

Description

The Tomah mayfly (*Siphlonisca aerodromia*) was first described by Needham (1909) from adult specimens collected by C.P. Alexander in 1907 from the Sacandaga River, NY. Clemens (1915) later described the nymph, or immature aquatic stage. The species was recently redescribed by Burian and Gibbs (1991) from specimens collected in Maine. Keys to identify this insect can be found in Needham et al. (1935), Edmunds et al. (1976), Merritt and Cummins (1974), and Peckarsky et al. (1990). *Siphlonisca* is a monotypic genus, with *S. aerodromia* being its only species. The Tomah mayfly is a large mayfly; adults (imagos) and nymphs range from 15-19 mm in length. Greatly expanded abdominal segments 5-9, and median tubercles (small bumps) on the mesothoracic and metathoracic sterna (underside of the middle (2nd) and last (3rd) segments of the thorax) are distinguishing features of both adults and nymphs (Figure 1). The species name *aerodromia* is derived from the abdominal flanges which are reminiscent of characteristics of fossil mayflies from the Carboniferous era.

Distribution

The Tomah mayfly was first collected from the Sacandaga River, NY in the area of Northville and the Sacandaga Park, between 1907 and 1925, and possibly from south of Wells, NY after 1925 (Needham 1909, Clemens 1915, Edmunds et al. 1976). Unfortunately, construction of the Sacandaga Reservoir in the 1930s altered the river in the area where the original collections had been made, and the species was apparently

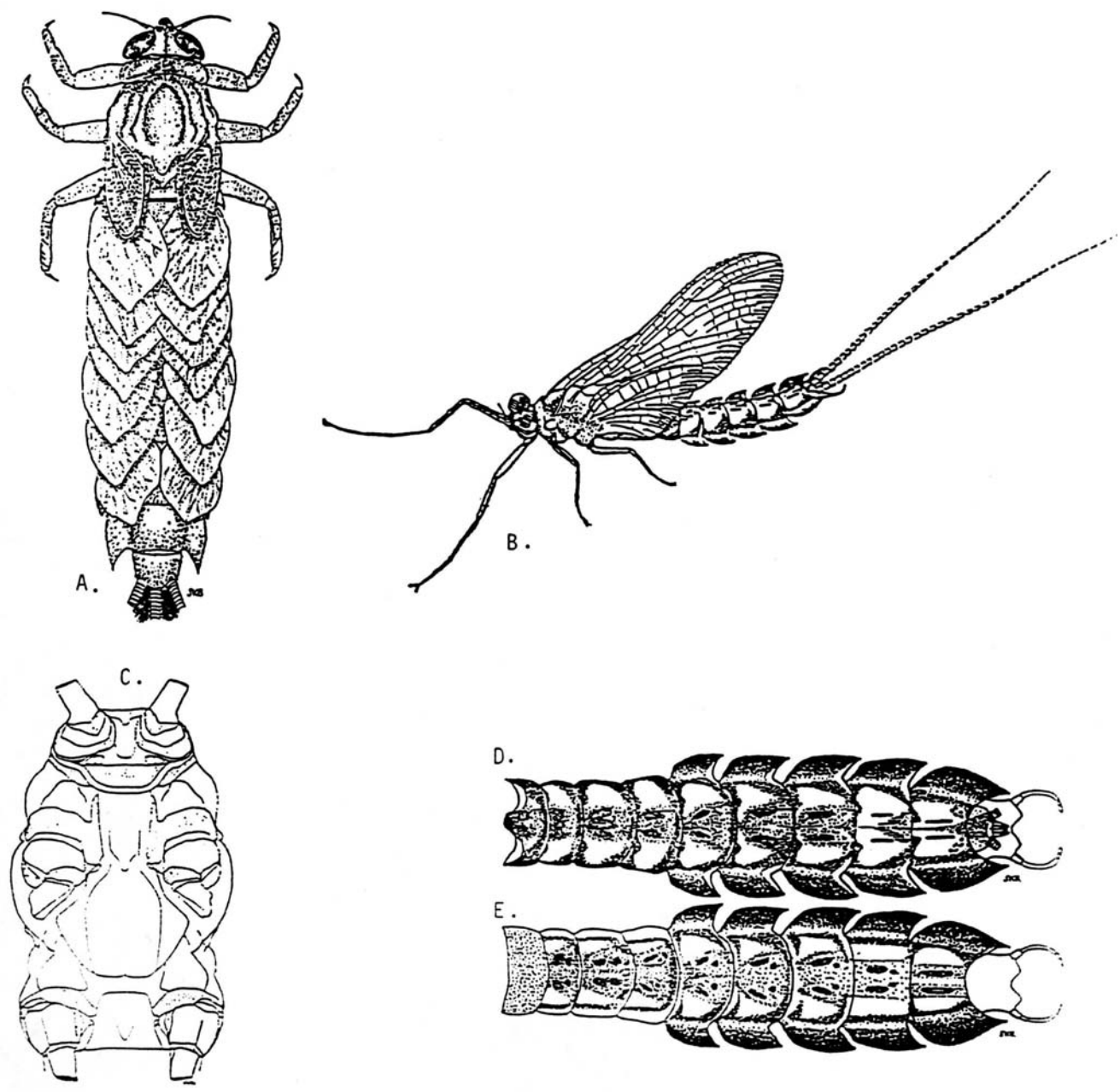

Figure 1. *Siphlonisca* aerdromia: A - mature nymph dorsal view; B - male imago; C - ventral view of thoracic sterna of male imago; D - dorsal view of abdomen of male imago; E - ventral view of abdomen of male imago (from Burian and Gibbs 1988).

extirpated. The Tomah mayfly was not reported again in the U.S. until it was collected from Tomah Stream (Codyville), Maine in 1978 (Gibbs 1980).

Subsequently, in an effort to assemble all the information available on the mayfly's distribution and biology, the published literature was searched and persons associated with aquatic insect studies at universities, museums, and research organizations in New York, New England, and the Eastern Canadian Provinces were contacted requesting records of the species (Gibbs 1991). In addition, extensive searches have been conducted in Maine and the western region of New Brunswick (Gibbs 1989, 1991; Burian and Gibbs 1991; Mack and Gibbs 1991; Gibbs and Siebenmann 1993; Gibbs and Siebenmann unpublished information, Siebenmann and Gibbs 1996, Maritimes and Northeast Pipeline L.L.C. 1998). Amateur mayfly collectors have also searched for this species (Boyle 1980), but the scope and intensity of their efforts is hard to assess.

As a result, the Tomah mayfly has been recorded from 13 sites in Maine in the Mattawamkeag, Passadumkeag, East Machias, St. Croix, Union, Sebasticook, Aroostook, Allagash, and Dead River (Franklin County) drainages (Figure 2; Appendix B). It has also been found at one site in northern New York on the Black River, near Lowville, Lewis County, in 1986, and again (four survey sites) in 1995 (pers. comm. Barbara L. Peckarsky, Cornell University, to Kathryn J. Schneider, New York Natural Heritage Program) (Figure 3). It was not, however, relocated during a 1992 resurvey of the Sacandaga River, including the original collection sites (Figure 3, Appendix A), which showed the river to be much altered by multiple dams (Gibbs and Siebenmann 1993). The only other reported collection sites for the Tomah mayfly are in Canada:

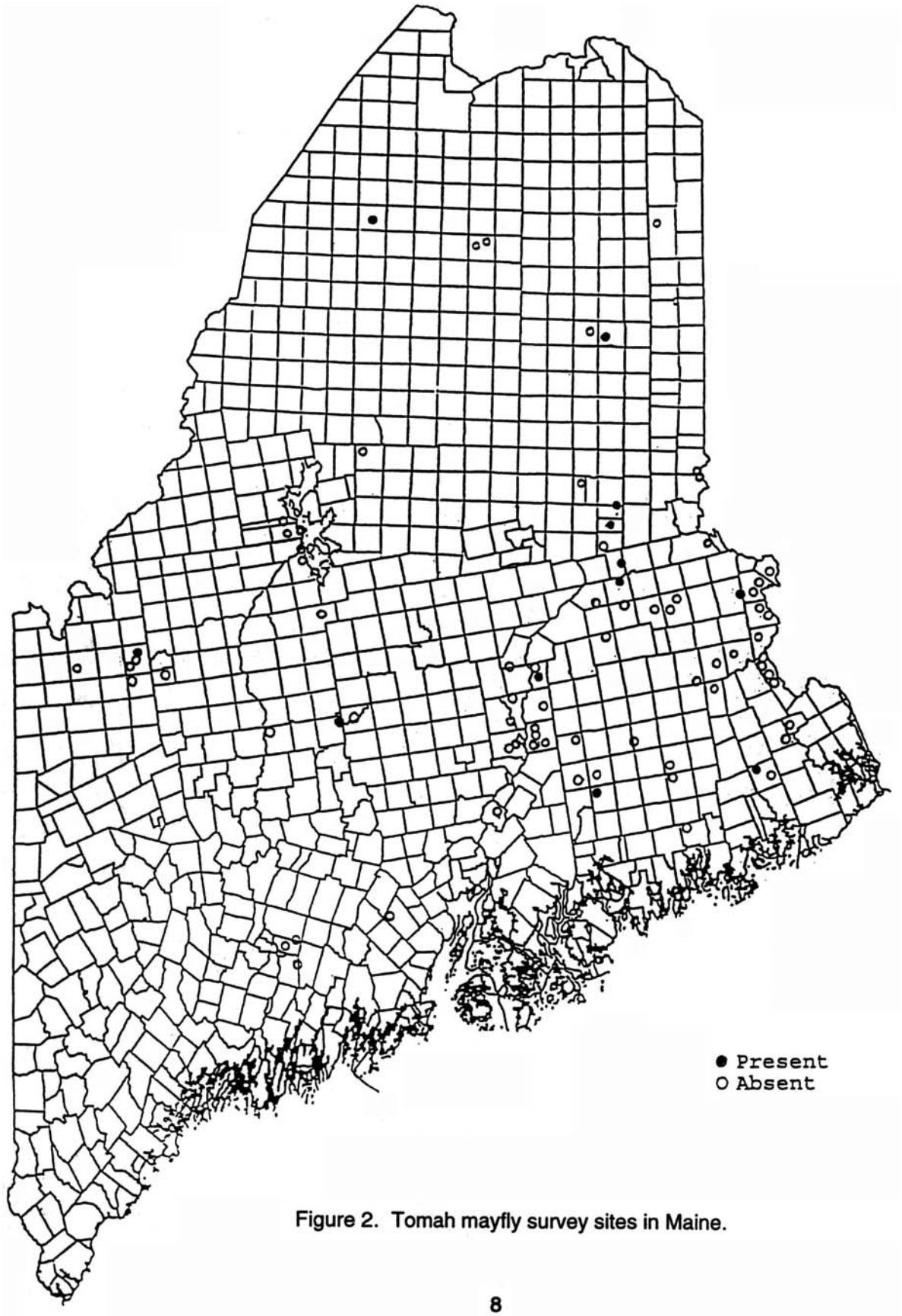

Figure 2. Tomah mayfly survey sites in Maine.

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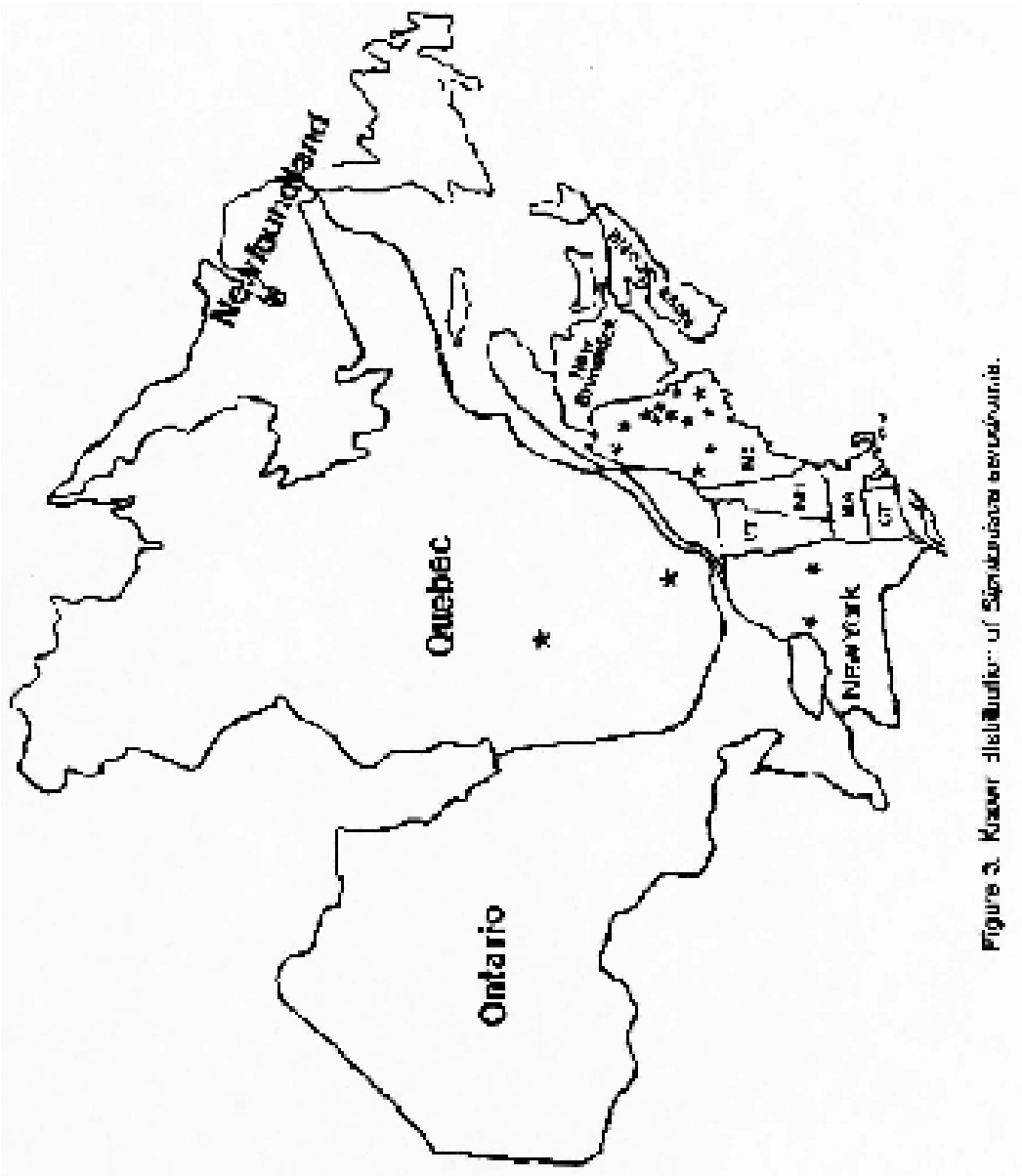

Figure 3. Known distribution of Siphlonisca aerodromia.

Lake Melville, Labrador in 1952 (Fiance 1978), Nominique, Quebec in 1941 (Hutchinson 1989) and the Waswanipi River, Quebec in 1963 (Magnin and Harper 1970) (Figure 3). Attempts to locate the species in New Brunswick and Nova Scotia by Whiting (1992) and in western New Brunswick by Gibbs and Siebenmann (1993) (Appendix C) were unsuccessful.

Life History

Although Needham (1909), Clemens (1915), and Edmunds et al. (1976) give some information on emergence and adult activity of the Tomah mayfly at the Sacandaga River, NY, most of the species' life history data is from studies at Tomah Stream, Maine (Gibbs and Mingo 1986; Gibbs and Siebenmann 1992, 1993, 1994, 1996). Descriptions of the stream habitat for the Tomah mayfly are given for Maine in Gibbs and Mingo (1986), and Gibbs (1989, 1991); and for New York in Needham (1909), Clemens (1915), and Edmunds et al. (1976).

In Maine, the Tomah mayfly inhabits small rivers and streams bordered by extensive areas of seasonally inundated sedge meadow flood plain. This is a dynamic habitat, characterized by a short period of flooding from snow and ice melt during April-May, followed by a receding of water from the flood plain during the summer. In the flood plains of these streams, standing water remains until late May or early June, either as areas connected to the main stream channel or as isolated pools. A rich macroinvertebrate community typically inhabits these habitats (Huryn and Gibbs 1998). Members of this aquatic invertebrate community come either from the flood plain or the river channel. Flood plain fauna (e.g. *Aedes* mosquitoes and *Pisidium* fingernail clams)

complete their entire life cycle within the flood plain, whereas river-flood plain fauna have phases of their life cycle in both the river channel and the flood plain. Several important mayfly species, including the Tomah mayfly, are members of the river-flood plain fauna. It is in these flooded areas that the most nymphal growth and development occurs, and from which the winged subadults emerge. Tomah mayfly nymphs were also found in isolated pools remaining as water receded from the flood plain following spring floods in the Sacandaga River (Needham 1909, Clemens 1915).

Plant communities of flood plains in which the Tomah mayfly is found are dominated by sedges and rushes (Gibbs 1989, 1991). Stem density and genus richness of sedges and rushes were significantly higher in five flood plains where the Tomah mayfly was present than in five flood plains where it was absent (Gibbs 1989). At Tomah Stream, a high percent cover of tussock sedge (*Carex stricta*, *C*. *vesicaria)*, wool-grass (*Scirpus cyperinus*), and soft rush (*Juncus effusus*) characterized sites where the mayfly occurred (Gibbs 1989). In April and May, when water covers the flood plain, dead sedge plants from the previous year's growth remain structurally intact while shoots of the new year's growth appear among them. The resulting three-dimensional plant material provides shelter, substrate, and abundant food for the spring aquatic invertebrate community. In addition, mature nymphs of the Tomah mayfly and other aquatic insects use the upright stems and leaves of the new growth as adult emergence sites.

At Tomah Stream, the species is univoltine — producing one generation per year. Eggs are laid in the stream channel during June, and nymphs hatch the following November or December. The immature mayflies grow slowly beneath the ice, feeding

on fine detritus and algae at near-freezing water temperatures. With increasing water levels following snow melt in March or April, they move out of the stream channel into the adjacent inundated flood plain. Here they become predaceous and feed on other species of mayfly nymphs, mainly *Siphlonurus* spp. but also, to a lesser extent, on *Leptophlebia* spp. and *Ephemerella* spp. In the flood plain, the nymphs grow rapidly, with females more abundant than males. During the last two weeks of May, while still in the flood plain, Tomah mayfly nymphs molt to the final instar, or stage, of larval development. As the nymphs approach emergence (the molt to the adult winged form), the wing pads darken and the nymphs cease to feed. Finally, they crawl out of the water — usually onto an upright plant stem or leaf — and molt to the winged subadult (subimago) or “dun.” This emergence, or “hatch” to anglers, typically begins during the last week of May and lasts about ten days. Emergence occurs throughout the day, but mainly during the late morning and early afternoon (ie. predominantly between 10am and 2pm EDST). The subadult stage then lasts about three days before the final molt to the adult (imago) or “spinner", which can live from 1-9 days. Mating and egg-laying occur in the early evening (ie. between 7:25pm and 8:20pm EDST on June 11, 1992). Mating takes place over the stream, and eggs are deposited on the surface of the water in the stream channel. The fact that up to 92% of eggs from unmated females hatch or show embryonic development, combined with a female-biased sex ratio among nymphs, suggests parthenogenic reproduction (reproduction from the development of unfertilized eggs) may occur in this species. However, recent genetic analysis of the Tomah mayfly from six sites in Maine suggests that parthenogenesis rarely, if ever, occurs in these populations (Gibbs et al. 1998).

Climatic differences between sites at Tomah Stream and the Dead River (>200 km apart) in Maine result in an approximate 20-day later emergence chronology for the Dead River population (Gibbs et al. 1998). Emergence and adult activity also occurred during late May and early June at the Sacandaga River, NY (Edmunds et al. 1976), and in southern Quebec where an adult was collected on June 3, 1941 (Hutchinson 1989). However, the adult recorded from Labrador was collected on July 10 (Fiance 1978), suggesting later emergence in more northern latitudes.

An abundance of other macroinvertebrates occur with the Tomah mayfly in the inundated flood plain (Mingo and Gibbs 1986, Burian and Gibbs 1991, Gibbs 1989, 1991, Gibbs and Siebenmann 1996, Huryn and Harris 1999, 2000). Mayfly species at Tomah Stream include *Siphloplecton basale* (Walker), *Siphlonurus mirus* Eaton, *S*. *alternatus* (Say), *S*. *quebecensis* (Provancher), *Arthroplea bipunctata, Leptophlebia cupida* Say, *L*. *nebulosa* (Walker), *L*. *johnsoni* McDunnough, *Eurylophella temporalis* (McDunnough), *Ephemerella subvaria* McDunnough, *E*. *septentrionalis* McDunnough, and *Baetisca laurentina*. Huryn and Harris (1999, 2000) found 149 species of Trichoptera (caddisflies) at the Tomah Stream study site, equal to one-half of all caddisfly species presently known from Maine! Twelve caddisfly species are known in Maine only from Tomah Stream, and one species, of the microcaddisfly genus *Hydroptila*, is new to science (Harris and Huryn, manuscript in review). Larval Chironomidae (midges), and Coleoptera (beetles) (*Hydroporus* and *Halophorus*) are also present as well as Hemiptera (true bugs) (*Siagara*) and Amphipoda (scuds) (*Hyalella azteca* (Saussure)).

At Tomah mayfly sites, nymphs of the mayfly genus *Siphlonurus* are very abundant relative to other mayfly taxa. Also, abundance of *Siphlonurus* spp. nymphs is higher in flood plains in which the Tomah mayfly is present than in similar flood plain areas where the species is absent (Gibbs 1989, 1991). However, the total biomass of macroinvertebrates, as well as the biomass of various taxa, changes dramatically throughout the period of flood plain inundation (April - June). From 25 April to 3 June 1997 at the Tomah Stream site, total macroinvertebrate biomass increased 16-fold; during this period, the contribution of *Leptophlebia* spp. dropped from 85% to 17%, while the proportion of *Siphlonurus* spp. biomass increased from 6-46%, and *S. aerodromia* increased from 3-12% of the total biomass of macroinvertebrates (Huryn and Gibbs 1998).

Fish present in the inundated flood plain at Tomah Stream in April and May include common shiner (*Notropis cornutus* (Mitchill)), three-spine stickleback (*Gasterosteus aculeatus* Linnaeus), chain pickerel (*Esox niger* Lesueur), and the common white sucker (*Catostomus commersoni* (Lacepede)). These species, as well as brook trout (*Salvelinus fontinalis* (Mitchill)) from the stream channel, are known, from examination of the gut contents, to feed heavily on macroinvertebrates in the flood plain, especially mayflies (Gibbs and Mingo 1986).

There are a variety of terrestrial vertebrates that also prey on macroinvertebrates in the flood plain. Common snipe (*Capella gallinago*), which feed on larvae of mayflies and other aquatic insects (Terres 1980), were commonly observed on the flood plain at Tomah Stream during spring inundation in 1997 (Huryn and Gibbs 1998). Black ducks (*Anas rubripes*) were present along Tomah Stream during April and

May 1997 (Huryn and Gibbs 1998), and >200 black ducks are regularly seen at this site during annual spring eagle surveys (M. McCollough and C. Todd, MDIFW, pers. comm.). Mayflies make up as much as 50% of the diet of female black ducks during egg-laying in Maine, and sedge meadow flood plains likely represent an important source of protein for pre-laying hens (Reinecke 1977). Yellow rails (*Coturnicops noveboracensis*), which feed on flood plain invertebrates (Bookhout and Stenzel 1987) and are very rare in Maine, occurred sympatrically with Tomah mayflies at 2 sites in 1990 (Albright et al. 1991).

MANAGEMENT

Regulatory Authority

Protection of Maine's Invertebrates

The Maine Department of Inland Fisheries and Wildlife is charged to "preserve, protect and enhance the inland fisheries and wildlife resources of the state; to encourage the wise use of these resources; to ensure coordinated planning for the future use and preservation of these resources; and to provide for the effective management of these resources" (12 MRSA, Chpt. 702, Section 7011). "Wildlife" is defined as "any species of the animal kingdom, except fish, which is wild by nature, whether or not bred in captivity, and includes any part, egg or offspring thereof, or the dead body parts thereof" (Section 7001).

Unless listed as endangered or threatened, however, invertebrates are currently provided only minimal protection under Maine law. The laws which govern hunting, trapping, and possession of Maine's wildlife (Sections 7401, 7406) pertain solely to "wild birds" and "wild animals". By definition, "wild animals" includes only mammals (Section 7001) - thus excluding invertebrates from any closed season or general possession coverage. Except for listed species, invertebrates are also excluded from scientific collection permit requirements by the same definition (Section 7242). Permits are required, however, to possess for exhibition purposes (Section 7231), import or introduce into the state (Section 7237), or take or transport within the state for breeding and advertising purposes (Section 7241), because these laws refer to all "wildlife", which includes invertebrates.

Protection of Endangered and Threatened Invertebrates

The Maine Endangered Species Act of 1975 prohibits the take, exportation, hunting, trapping, possession, processing, offering for sale, selling, transporting, feeding, baiting or harassing of any endangered or threatened species of fish and wildlife, including invertebrates (12 MRSA, Section 7756). Because the Tomah mayfly was officially listed as a threatened species in Maine in 1997, it is fully protected from these activities. Prohibitions do not apply to acts that affect the quality and quantity of habitat available to the species. Furthermore, state law, as written, contains inconsistencies regarding deliberate harassment, harassment, and take.

Concern has been raised about "deliberate harassment" (Section 7756, subsection 1, paragraph D) of endangered or threatened invertebrates. "Harass", as defined in Section 7001 (Definitions), means "an intentional or **negligent** (emphasis added) act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns". After reviewing the statute (MRSA 12, Section 7756. Prohibited Acts) in December, 1994, the Attorney General's Office determined that the words "deliberately" and "harasses" shall be interpreted to mean intentionally (with forethought) kills, torments, troubles, or worries a listed species. This prohibition was interpreted to apply to acts that are **deliberately** directed at individuals or groups of individuals of a listed species and result in the death of individuals, alteration or disruption of normal behavior patterns, or adversely impact normal life processes. In an attempt to remedy this shortcoming, Section 7756 was amended in 1999 to read:

> "For the purposes of this section, "to take, take and taking" means the intentional **or negligent** (emphasis added) act or omission that results in the death of any endangered or threatened species."

The prohibition on "harassing" endangered or threatened wildlife is now somewhat less ambiguous with regard to intent, when "harassing" results in the death (i.e. taking) of an individual or group of individuals of a listed species. However, the prohibition of harassment may not be interpreted to include *non-lethal* acts (e.g. torments, troubles, or worries) that predispose to injury one or more individuals of a listed species. A first violation of the intentional harassment prohibition is punishable by a mandatory warning; the second violation is punishable as a Class E crime.

In 1999, the legislature also amended Section 7756 to allow the Commissioner to permit the "incidental" take of any endangered or threatened species. There are three provisions of the Incidental Take Permit (Section 7756, subsection 2, paragraph C):

1) such taking is incidental to, and not the purpose of, carrying out an otherwise lawful activity;

2) the taking will not impair the recovery of any endangered species or threatened species; and

3) the person develops and implements an incidental take plan approved by the Commissioner to take an endangered species or threatened species pursuant to paragraph D;

However, because of the narrow definition of "take" (i.e. act or omission that results in death) adopted by the legislature, prohibited acts that are *non-lethal* in nature may not be permissible under an Incidental Take Permit.

Current law also prohibits collection (scientific, hobby) of endangered or threatened invertebrates. Exemptions for educational or scientific purposes are currently granted through Scientific Collecting Permits on an annual basis (Section

7756). The transplantation, introduction, or reintroduction of an endangered or threatened invertebrate may be enabled pursuant to the Commissioner of MDIFW developing a recovery plan for that species, which is then approved through both a public and legislative hearing process (Section 7754).

In summary, the Maine Endangered Species Act protects the Tomah mayfly from take, export, possession, etc. The Act does not protect the Tomah mayfly from activities that affect the quality and quantity of its habitat. It is unclear whether a court would find unintentional harassment of an endangered or threatened species to be an offense, unless the harassment directly resulted in the deaths of one or more individuals. Similarly, it is unclear whether prohibited acts that have non-lethal effects on an endangered or threatened species are permissible under an Incidental Take Permit. Collection of this species (e.g. for scientific purposes) is currently prohibited without a Scientific Collecting Permit. Transplantation or reintroduction would require an approved recovery plan.

Habitat Protection

Federal, state, and municipal regulations exist for protecting wetlands used by the Tomah mayfly. At present, these are the most important management tools for protecting Tomah mayfly habitat.

Section 404, Clean Water Act

Section 404 of the federal Clean Water Act provides the Army Corps of Engineers (Corps) with regulatory authority to control filling of waters and wetlands.

The 404 Program is administered jointly by the Corps (which has permit authority) and the Environmental Protection Agency (EPA). Guidelines, as defined by EPA, prohibit projects that would adversely affect endangered or threatened species (federally listed), violate water quality standards, or involve toxic discharges. The guidelines also require mitigation of unavoidable impacts.

The Corps has three categories of permits enabling filling of wetlands. In New England, certain projects affecting isolated wetlands less than one acre are permitted by *Nationwide Permit #26* authorization. *General Permits* may be issued by the Corps for certain activities in small geographic areas. Such permits are in effect for five years and may be modified or revoked if adverse environmental impacts increase. *Individual Permits* are required for projects that do not qualify for Nationwide and General permits. These permits are generally needed for larger projects affecting wetlands; they have a 30-day public comment period and provide for input on fish and wildlife values.

In most cases, the EPA, Corps, and other federal review agencies (including the U.S. Fish and Wildlife Service) attempt to reach a consensus decision on project applications. In general, the Corps makes most decisions, but the EPA may veto Corps-issued permits based on a determination of unacceptable adverse effects on wildlife areas and other criterion. This authority may be exercised by EPA to designate areas in advance of discharge or filling. This planning process of Section 404, labeled "Advanced Identification of Disposal Sites," allows EPA and the Corps to work in cooperation with state and local authorities to identify sites unsuitable for filling. In New England, it is expected that Advance Identification will be more actively used as a planning tool for increased wetland protection (Widoff 1988).

Potential exists for closer cooperation and communication between MDIFW and the Corps to intensify wetland protection. Potential also exists to prepare lists of Tomah mayfly sites or habitats that merit protection through Advanced Identification. These wetlands could be added to an EPA list of priority wetlands already developed for Maine (EPA 1987 in Widoff 1988). This list is updated periodically and recommendations for additions may be proposed at any time.

The Maine Endangered Species Act

A 1988 amendment of the Maine Endangered Species Act (12 MRSA, Section 7754) enables the Commissioner of Inland Fisheries and Wildlife to designate areas currently or historically providing physical or biological features essential to the conservation of an endangered or threatened species as "Essential Habitat". Under the Act, state agencies and municipal governments may not permit, license, fund, or carry out projects that would significantly alter an Essential Habitat or violate protection guidelines adopted for the habitat. Essential Wildlife Habitats are implemented as "consultation zones" to flag development projects within endangered and threatened species habitat and allow MDIFW to work with landowners and project applicants to minimize or avoid potential conflicts before a project begins.

Essential Habitat was first designated to protect bald eagle (*Haliaeetus leucocephalus*) nest sites in Maine in 1989. Since then, piping plover (*Charadrius melodus*) and least tern (*Sterna albifrons*) nesting, feeding, and brood-rearing areas, and roseate tern (*Sterna dougallii*) nesting areas have also been protected via Essential

Habitat designation. Essential Wildlife Habitat designation could also be used to protect Tomah mayfly habitat.

The Natural Resource Protection Act of 1988

The Natural Resource Protection Act of 1988 (NRPA) provides for designation of "Significant Wildlife Habitat" for state and federally listed endangered and threatened species and certain other wildlife, and contains provisions for protecting freshwater wetlands. The NRPA prohibits dredging; bulldozing; removing soil, sand, or vegetation; draining; filling; or construction, repair or alterations of permanent structures without a permit in areas designated as Significant Wildlife Habitat. Significant Wildlife Habitat for species on the Maine or federal lists of endangered or threatened species is to be identified and mapped by MDIFW and adopted by the Maine Department of Environmental Protection (DEP) through rulemaking. Habitat protection guidelines and permit review criteria would be developed by MDIFW for these areas and may include acceptable types of development, recommended setbacks or buffers, and recommendations for timing of development activities. These guidelines are also adopted as part of DEP regulations.

Maine's Comprehensive Growth Management Act similarly enables Significant Wildlife Habitats of rare species to be identified and submitted to the Department of Economic and Community Development for use by towns for comprehensive planning purposes. MDIFW reviews town comprehensive plans and all permit applications within Significant Wildlife Habitats. To date, Significant Wildlife Habitat has only been

designated for seabird nesting islands. This habitat protection tool could also be used to protect Tomah mayfly habitat.

The NRPA also contains provisions for protection of some freshwater wetlands, which could also benefit Tomah mayfly habitat. The Act provides that a permit is needed for development activities that may fill or alter wetlands. Generally, wetland impacts of <4,300 ft^2 require no review and are exempt from permitting requirements. Three tiers of review are employed depending on the amount of area altered in the wetland (4,300 ft^2 - 15,000 ft^2 , 15,000 ft^2 - 1 acre, >1 acre). The Maine Department of Environmental Protection reviews freshwater wetlands permits (in many instances in consultation with MDIFW) for activities in organized towns.

Mandatory Shoreland Zoning

Organized towns and municipalities are required by the Mandatory Shoreland Zoning Law to pass ordinances that establish a shoreland zone in all districts within 250 feet of the upland edge of freshwater wetlands >10 acres, and designate resource protection in those areas that are rated “moderate” or “high” value by MDIFW (Jones 1986). Within resource protection districts, agriculture, new buildings, campsites, road construction, and parking facilities are prohibited, and other development activities require permit applications for approval. MDIFW generally does not review town permit applications but occasionally is consulted by municipal officials. Towns are permitted to adopt wetland protection guidelines more stringent than those mandated by the Mandatory Shoreland Zoning Law.

Zoning in Unorganized Townships

In Maine's unorganized townships, development activities in wetlands are regulated by the Land Use Regulation Commission (LURC). LURC wetland protection rules apply to any wetlands (non-forested) delineated on LURC's zoning maps, which essentially are any non-forested wetlands identified on National Wetland Inventory maps. Applicants whose activities will alter >15,000 ft^2 of a mapped wetland, or ≥1 acre (≥43,560 ft^2) of any combination of wetland and upland, are required to delineate all wetlands in the project area; LURC may consider impacts to any newly mapped wetlands in its review of permit applications.

Other state environmental regulations, such as the Site Location of Development Act, may also be applied occasionally to protect endangered species habitat. MDIFW formally reviews and comments on approximately 500 permit applications annually through its regional offices. Hundreds of additional projects are reviewed on an informal and pre-consultation basis. Regional staff consult with the Endangered and Threatened Species Program biologists for permit applications involving listed species. These species and their habitats are granted protection in accordance with pertinent regulations.

Past Goals and Objectives

There are no past goals and objectives for the Tomah mayfly in Maine.

Past Management

The Tomah mayfly in Maine has received little management attention. MDIFW has management authority at one site, Mattagodus Stream in Mattagodus Meadows Wildlife Management Area (Webster Plt.), and holds the flowage rights to Tomah Stream, but no management activities specific to the Tomah mayfly have taken place. The Bureau of Parks and Lands (BPL) owns nearly 300 acres at Tomah Stream and has management authority at Thompson Deadwater (T2 R4 WELS). Since 1990, there have been proposals by BPL to impound Thompson Deadwater and by MDIFW to impound Tomah Stream. Although these projects have not been approved, if built, they could result in substantial losses of Tomah mayfly habitat.

Current Research and Management

Since 1990, MDIFW has received $2,500 to $5,000 annually in federal funding (Section 6 Endangered Species Act) to address research and management of the Tomah mayfly. These funds have been matched by state grants and used primarily to support life history and genetics research, and status surveys conducted by Dr. K. Elizabeth Gibbs and M. Siebenmann, Entomology Department/Applied Ecology and Environmental Studies, University of Maine. Since 1997, they have also supported research by Dr. Alexander Huryn, Department of Biological Sciences, University of Maine, who has led investigations on the structure and productivity of the macroinvertebrate community that inhabits the flood plain of Tomah Stream during spring inundation, and the role the Tomah mayfly plays in this community (Huryn and Gibbs 1998, Huryn, published abstract). During 1999 - 2000, MDIFW included surveys

for the Tomah mayfly in its ecoregional survey of the Downeast coastal region (Weik et al 2000), and will continue with additional surveys in 2001 - 2002 throughout the St. John Uplands and Boundary Plateau ecoregions in northern and northwestern Maine.

HABITAT ASSESSMENT

Past Habitat

Historically, streams like Tomah, with extensive “wet meadows “, were abundant in Maine and elsewhere in the Northeast. Where records exist, these systems are reported to have supported a rich and diverse fauna of wildlife (Widoff 1988), and it seems likely that some of these sites would have supported populations of the mayfly. However, the damming of rivers for mills, water storage, and transporting timber has been a central feature in the history and development of Maine since the earliest days of European settlement. Thousands of dams were built in the state from the colonial period to the present (Hasbrouck 1984). Many have washed away, but there are still approximately 600 dams in Maine, varying greatly in size, age, function, and state of repair. These dams have greatly modified Maine’s river systems, created many lakes on reaches of rivers formerly bordered by wide flood plains, and drastically altered the normal seasonal flow patterns of rivers. Prior to the creation of Flagstaff Lake, a large water storage area for Wyman Dam, the Dead River and smaller Flagstaff Pond were surrounded by extensive sedge meadow flood plains (Widoff 1988), suggesting this area may have originally supported a more extensive mayfly population than the small relic population that now exists in a short reach of Dead River above the lake.

Sedge meadows are still one of the most common wetland types in Maine. The Maine Wetland Inventory indicates over 57,602 acres of fresh meadow exist in the state. Yet, despite extensive surveys, the Tomah mayfly has only been found at a few locations. It is apparent, then, that not all sedge meadows have habitat suitable for the

Tomah mayfly. Watershed area, basin topography, soils, and other hydro-geological features likely influence factors affecting habitat suitability. It may be that only a small portion of seasonally flooded sedge meadows have the right combination of features to support this insect. To date, only 13 of more than 150 sites surveyed with seemingly appropriate habitat have populations of this insect.

Current Habitat

Currently, the Tomah mayfly has been found in Maine at only 13 sites (Figure 2). Most are in unorganized townships, under private industrial forest ownership, and are widely distributed, from the St. Croix River west to the Dead River drainage, and north to the Allagash River drainage. Although other sites may exist, more surveys are needed to make this determination. Given the known present distribution of the Tomah mayfly in Maine, its historic distribution (5 additional sites in New York, Labrador, and Quebec (Figure 3)), and the fact that surveys in Nova Scotia and New Brunswick have been unsuccessful, future survey efforts in northern Maine may offer the best hope for finding additional populations.

Habitat Projection

The future of this species and its habitat likely depends on the ability of state wetland statutes and appropriate wetland management to maintain the natural productivity and ecological integrity of suitable, seasonally-flooded sedge meadows. Most of the sites where the Tomah mayfly occurs are privately owned, primarily by industrial forest products companies. The long-term viability of these sites, and

therefore the Tomah mayfly, also will be dependent upon outreach to landowners and cooperative management agreements to successfully conserve this species for the future.

POPULATION ASSESSMENT

Past Populations

Past populations of the Tomah mayfly are largely unknown in Maine. It is likely some populations were reduced or eliminated when dams flooded appropriate habitat. For example, the species has not been reported from the Sacandaga River, NY, since the river was altered by construction of the Sacandaga Reservoir in the 1930s. Similarly, creation of Flagstaff Lake flooded much of the once-extensive sedge meadow flood plains that surrounded a portion of the Dead River and the smaller Flagstaff Pond (Widoff 1988), suggesting this area may have originally supported a more extensive population of the mayfly than the small relic population that now exists in a short reach of Dead River above the lake. A population reduced or isolated by the effects of river alteration would also be more susceptible to extirpation from stochastic events, such as the aerial application of DDT for spruce budworm control during the 1950s-1960s (see Dimond 1967).

Current Populations

In the past 50 years, the Tomah mayfly has been collected from only three sites in Canada, one site in New York, and 13 sites in Maine. Many of these records consist of only one or a few specimens. Where more intensive surveys have been conducted in Maine, the Tomah mayfly is believed to be abundant at 1 site, common at 7 sites, and rare at 5 sites (Appendix B).

Population Projections

In general, if habitat is protected at each site, it is likely populations will remain secure. Deteriorated water quality, dams or impoundments, and dredging or filling would be expected to reduce or extirpate populations. Translocation of individuals to suitable yet previously unoccupied habitats is a potential method for increasing the numbers and occurrences of the Tomah mayfly, if warranted under an approved recovery plan. However, limiting factors, as well as natural population fluctuations for this insect, are unknown. Whether individuals from a source population could repopulate a nearby extirpated site is unknown, but suspected. Gibbs et al. (1998) found minimal genetic differentiation among populations of the Tomah mayfly located >100 km apart, suggesting that adult flight may be an important mode of dispersal and gene mixing between populations. A population consisting of several "subpopulations" in close proximity, relative to dispersal distances, may persist over time, assuming the extinction rate of subpopulations is matched by the rate at which they are reoccupied.

Limiting Factors

Because most of the Tomah mayfly's life is spent in an aquatic stage, it is essential to protect riverine and associated riparian habitats where the species occurs. The stream channel, sedge meadow flood plain, and adjacent upland forest are all integral to completing the life cycle.

In addition to pollutants (ie. chemical spills, agricultural runoff, etc.) that might threaten water quality and affect all aquatic species, the Tomah mayfly is vulnerable to activities, such as construction of dams, that alter the seasonal discharge patterns of

rivers. Increased flow following snow melt is essential to produce the inundated flood plain where the nymphs are found in April and May. A proposed dam on Tomah Stream (Anonymous 1990) would threaten the most abundant and predictable population known. A similar proposal was recently denied for the Tomah mayfly site at Thompson Deadwater. The possibility of similar dams may threaten other sites where the species occurs. The disappearance of the Tomah mayfly from the Sacandaga River following construction of the Sacandaga Reservoir confirms that dam construction constitutes a serious threat to the species.

The nymphs of the Tomah mayfly appear to be restricted to the sedge-dominated flood plains of seasonally flooded rivers and streams, and adjacent stream channels. Any alteration of vegetation in the flood plain by dredging, filling, or invasion by exotic flora would be detrimental to this mayfly's habitat.

Several native species of fish coexist with the Tomah mayfly in the inundated flood plains and stream channels. At Tomah Stream, the common shiner, three-spine stickleback, chain pickerel, common white sucker, and brook trout are present. These species prey on macroinvertebrates, especially mayflies, in the flood plain. Nymphs of the Tomah mayfly can detect chemicals released from brook trout during feeding, and thereby are able to assess the trouts' past feeding behavior; if predation on Tomah mayfly is indicated by the chemicals released from brook trout, nymphs will reduce movement activity, thereby reducing predation risk (Huyrn and Chivers 1998, 1999). The Tomah mayfly may not be able to coexist with predatory fish species for which it has not evolved such defense mechanisms, and thus introducing new fish species to its habitat may put this insect at risk.

USE AND DEMAND ASSESSMENT

Prior to its listing as a state-threatened species in 1997, the Tomah mayfly — like most rare invertebrate species — had largely gone unnoticed by the general public. Today, even with its threatened species status, the Tomah mayfly is still unknown to most of Maine's citizens due to its extreme rarity and inconspicuous nature.

Public outreach to increase the awareness and appreciation of the Tomah mayfly could increase the use and demand for this rare insect from a larger segment of the public. An estimated 91% of Maine's adult citizens engaged in some nonconsumptive use of wildlife and expended more than $50 million in 1988 (Boyle *et al.* 1990). As the popularity of photography and nature study and appreciation grows, and as awareness of the diversity of Maine's wildlife resources grows, the demand for observational and photographic use of rare species, such as endangered or threatened invertebrates, will increase. As interest in these species intensifies, there will likely be increased public demand for interpretive and educational materials to explain and justify species and habitat protection measures. Moderate increases in recreational activity in wetlands will unlikely influence rare invertebrates. Recreational experience of some boaters and anglers will be heightened simply by knowing the Tomah mayfly coexists in the same wetlands.

Increasing numbers of U.S. citizens desire preservation of the greatest diversity of species possible, at state, national, and global levels (Kellert 1980). These desires are based on increasing public perception of scientific, utilitarian, and cultural values of biological diversity, as well as ethical arguments for preserving plant and animal species

that are endangered by the actions of human society. At the state level, public support for preserving biodiversity in Maine is growing and is reflected in strong state legislation to protect endangered and threatened wildlife and their habitats. Regardless of the appeal and familiarity of an individual species, public demand for the conservation of rare species, especially those listed as endangered or threatened, is unequivocally mandated in the preamble to the Maine Endangered Species Act of 1975:

> "The Legislature finds that various species of fish or wildlife have been and are in danger of being rendered extinct within the State of Maine, and that these species are of aesthetic, ecological, educational, historical, recreational, and scientific value to the people of the State. The Legislature, therefore, declares that it is the policy of the State to conserve, by according such protection as is necessary to maintain and enhance their numbers, all species of fish or wildlife found in the State, as well as the ecosystems upon which they depend."

As such, MDIFW is committed to preserving the diversity of all wildlife in the state and is entrusted with the preservation of Maine's natural heritage for future generations. This responsibility is manifested by an increasing commitment to management and research programs that protect and enhance endangered and threatened species of all taxa. The protection and ecological understanding of inconspicuous species, such as the Tomah mayfly, are vital to proper ecosystem management and to the preservation of Maine's natural heritage. The Tomah mayfly contributes to the biological diversity of our state, and its presence adds to the ecological value of Maine's wetlands.

SUMMARY AND CONCLUSIONS

The Tomah mayfly is one of the rarest species of mayflies in the world, and is the only representative of its genus. It is nearly endemic to Maine and has been found at only 13 sites in the state. Because of its limited global distribution, vulnerability of habitat, and its unique taxonomic status, the Tomah mayfly was a candidate for the federal Endangered Species List and was state-listed as threatened in 1997.

Additional research is needed to assess several aspects of the Tomah mayfly's life history and status. The hydrological and biological characteristics of sedge meadows supporting this insect are only beginning to be understood and are in need of additional study. Similarly, studies are needed to develop methods of assessing populations and documenting their fluctuations. Recent studies suggest that Tomah mayfly sites may support unusually high diversity of aquatic invertebrates, including other rare species. Additional survey effort is needed in Maine to fully assess all sites having suitable habitat. Additional surveys are needed in eastern Canada to assess the status and distribution of this insect, particularly in Quebec and Labrador. Although life history has been well documented, it is uncertain what, if any, factors may be limiting the abundance and distribution of this insect.

Until population and distribution studies are completed, the conservation status of this mayfly will be uncertain. In the interim, efforts to secure conservation of existing habitat may be the best strategy to secure known populations. Additional recovery actions may be needed as indicated by future studies.

LITERATURE CITED

Albright, J.J., K.E. Gibbs, J.P. Gibbs, and S.M. Melvin. 1991. Ecology and conservation of rare wildlife in seasonally-flooded sedge wetlands in Maine. 1991 Northeast Fish and Wildlife Conference, Abstracts - Wildlife Session.

Anonymous. 1990. Tomah flowage lease enables 30-year management. News, Maine Department of Inland Fisheries and Wildlife, Public Information Division. February 20.

Bookhout, T.A., and J.R. Stenzel. 1987. Habitat and movements of breeding yellow rails. Wilson Bull. 99:441-447.

Boyle, R.H. 1980. Yep, another nymphmaniac. Sports Illus. 52, Aug. 18:30-32.

Boyle, K.J., S.D. Reiling, M. Tiesl, and M.L. Phillips. 1990. A study of the economic impact of game and non-game species on Maine's economy. Staff Paper No. 423, Dept. of Agriculture and Resource Economics, University of Maine. 119 pp.

Burian, S.K., and K.E. Gibbs. 1988. A redescription of *Siphlonisca aerodromia* Needham (Ephemeroptera: Siphlonuridae). Aquatic Insects 10:237-248.

Burian, S.K., and K.E. Gibbs. 1991. Mayflies of Maine: an annotated faunal list. Maine Agricultural Experiment Station, Tech. Bull. 142. 109 pp.

Clemens, W.A. 1915. Mayflies of the *Siphlonurus* group. Can. Ent. 47:245-260.

Dimond, J.B. 1967. Pesticides and stream insects. I. Effect of experimental application of malathion; II. Recovery of insect populations in DDT-sprayed streams. Bull. No. 23, Maine Forest Service, 21 p.

Edmunds, G.F., Jr., S.L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. University of Minnesota Press, Minneapolis, MN. 330 pp.

Fiance, S.B. 1978. A new locality for *Siphlonisca aerodromia* (Ephemeroptera: Siphlonuridae). Ent. News 89:208.

Gibbs, H.L., K.E. Gibbs, and L. Collins. 1998. Genetic differentiation among populations of the rare mayfly *Siphlonisca aerodromia* Needham. Unpublished report to the Endangered and Nongame Wildlife Program, Maine Department of Inland Fisheries and Wildlife, Bangor, ME. 28 pp.

Gibbs, J.P., W.G. Shriver, and S.M. Melvin. 1991. Spring and summer records of the yellow rail in Maine. J. Field Ornithol. 62:509-516.

Gibbs, K.E. 1989. Distribution and habitat requirements of the mayfly *Siphlonisca aerodromia*. Unpublished report to The Nature Conservancy 20 pp.

Gibbs, K.E. 1991. 1990 studies of *Siphlonisca aerodromia*: distribution of *Siphlonisca* in relation to abundance of prey and flood plain vegetation at Tomah Stream; new collection records for *Siphlonisca* in Maine; search for *Siphlonisca* collection records in eastern Canada. Unpublished Report of the Maine Department of Inland Fisheries and Wildlife, Endangered and Nongame Wildlife Program, Bangor, ME. 22 pp.

Gibbs, K.E. 1994. Life history, status and conservation of the mayfly *Siphlonisca aerodromia* Needham. Maine Naturalist 1:121-130.

Gibbs, K.E., and T.M. Mingo. 1986. The life history, nymphal growth rates, and feeding habits of *Siphlonisca aerodromia* Needham (Ephemeroptera: Siphlonuridae) in Maine. Can. J. Zool. 64:427-430.

Gibbs, K.E. and M. Siebenmann. 1992. Late nymphal and adult biology of *Siphlonisca aerodromia*. Unpublished Report to the Endangered and Nongame Wildlife Fund, Endangered and Threatened Species Group, Maine Department of Inland Fisheries and Wildlife, Bangor, ME. 23 pp.

Gibbs, K.E., and M. Siebenmann. 1993. 1992 studies on rare aquatic insects in Maine. Unpublished report to the Endangered and Nongame Wildlife Fund, Endangered and Threatened Species Group, Maine Department of Inland Fisheries and Wildlife, Bangor, ME. 32 pp.

Gibbs, K.E., and M. Siebenmann. 1994. 1993 studies on rare aquatic insects in Maine. Final report to the Endangered and Nongame Wildlife Fund, Endangered and Threatened Species Group, Maine Department of Inland Fisheries and Wildlife, Bangor, ME. 31 pp.

Gibbs, K.E., and M. Siebenmann. 1996. Life history attributes of the rare mayfly *Siphonisca aerodromia* Needham (Ephemeroptera: Siphlonuridae). Journal of the North American Benthological Society 15:95-105.

Harris, S.C., and A.D. Huryn. In review. A new species of *Hydroptila* from eastern Maine. Entomological News.

Hasbrouck, S. 1984. Maine rivers and streams. Resource Highlights, August, The Land and Water Resources Center, University of Maine, Orono, Maine. 12 pp.

Huryn, A.D. River-flood plain interaction determines production dynamics of mayflies in a riparian sedge-meadow in Maine. North American Benthological Society, Keystone, Colorado. May 2000. Abstract: Bulletin of the North American Benthological Society 17:110.

Huryn, A.D., and D.P. Chivers. 1998. Behavioral response of Siphlonisca aerodromia to chemicals released by predators, prey and injured conspecifics. Unpublished report of the Department of Biological Sciences, University of Maine. 22 pp.

Huryn, A.D. and D.P. Chivers. 1999. Contrasting behavioral responses by detritivorous and predatory mayflies to chemicals released by injured conspecifics and their predators. Journal of Chemical Ecology 25:2729-2740.

Huryn, A.D., and K.E. Gibbs. 1998. Macroinvertebrates of riparian sedge meadows in Maine: a community structured by river-flood plain interaction. Pp. 363-382, *In* D.P. Batzer, R.B. Rader, and S.A. Wissinger (Eds.). Invertebrates in freshwater wetlands of North America: ecology and management. John Wiley & Sons, Inc.

Huryn, A.D., and S.C. Harris. 1999. Caddisflies associated with the habitat of *Siphlonisca aerodromia* at Tomah Stream (Washington Co., Maine). Unpublished report of the Department of Biological Sciences, University of Maine. 22 pp.

Huryn, A.D. and S.C. Harris. 2000. High species richness of caddisflies (Trichoptera) from a riparian wetland in Maine. Northeastern Naturalist 7:189-204.

Hutchinson, R. 1989. Premiere mention de *Siphlonisca aerodromia* Needham (Ephemeroptera: Siphlonuridae) au Quebec et repartition en Amerique du Nord. Faberies 14:25-27.

Kellert, S.R. 1980. Public attitudes towards critical wildlife and natural habitat issues. U.S. Govt. Printing Office, Wash., D.C.

Mack, R.G., Jr., and K.E. Gibbs. 1991. The mayflies of Acadia National Park, Maine, U.S.A.: 277-287. In: J. Alba-Tercedor and A. Sanchez-Ortega Eds., Overview and Strategies of Ephemeroptera and Plecoptera. Sandhill Crane Press, Gainsville, Florida. 588 pp.

Magnin, E. et P.P. Harper. 1970. La nouriture des esturgeons *Acipenser fulvescens* de la riviere Nottaway, tributaire de la baie James. Naturaliste Can. 97s:73-85.

Maritimes & Northeast Pipeline, L.L.C. 1998. Phase II facilities Tomah mayfly survey findings report, pages 1-20. *In* Phase II facilities rare, threatened, and endangered species mitigation report.

Merritt, R.W., K.W. Cummins, and V.H. Resh. 1984. An introduction to the aquatic insects of North America. 2nd ed. Kendall/Hunt Publ. Co., Dubuque, Iowa. 722 pp.

Needham, J.G. 1909. Studies of aquatic insects: a peculiar mayfly from Sacandaga Park. N.Y State Mus. Bul. 134:71-75.

Needham, J.G., J.R. Traver, and Y.C. Hsu. 1935. The biology of mayflies. Comstock Publishing Co., Ithaca, NY. 759 pp.

Peckarsky, B.L., P.R. Fraissinet, M.A. Penton, and D.J. Conklin, Jr. 1990. Freshwater macroinvertebrates of north eastern North America. Cornell University Press, Ithaca, NY. 442 pp.

Reinecke, K.J. 1977. The importance of freshwater invertebrates and female energy reserves for black ducks breeding in Maine. Unpublished Ph.D. dissertation, University of Maine, Orono.

Siebenmann, M., and K.E. Gibbs. 1996. 1995 and 1996 studies on *Siphlonisca aerodromia*. Unpublished report to the Endangered and Nongame Wildlife Fund, Endangered and Threatened Species Group, Maine Department of Inland Fisheries and Wildlife, Bangor, ME. 25 pp.

Teisl, M.F., and K.J. Boyle. 1998. The economic impacts of hunting, inland fishing, and wildlife-associated recreation in Maine. Staff Paper No. 479, Department of Resource Economics and Policy, University of Maine. 7 pp.

Terres, J.K. 1980. Audubon Society encyclopedia of North American birds. Alfred A. Knopf, New York.

Ward, J.V. 1992. Aquatic insect ecology: Biology and habitat. John Wiley & Sons, Inc., NY. 438 pp.

Weik, A.P., S. Dooling, S. Moore, and C. West. 2000. Tomah Mayfly. Pp. 6-13 in A Survey of Rare, Threatened and Endangered Fauna in Maine: east coastal and eastern interior regions (1999). (A.P. Weik, P. deMaynadier, and T. Hodgman eds.). Report of the Maine Department of Inland Fisheries and Wildlife, Bangor, Maine. 116 pp.

Whiting, E.R. 1992. New records of mayflies (Ephemeroptera) from Nova Scotia and New Brunswick, Canada. Ent. News 108:185-192.

Widoff, L. 1988. Maine Wetlands Conservation Plan. Maine State Planning Office, Augusta, ME. 91 pp.

APPENDIX A. TOMAH MAYFLY SITES SURVEYED IN NEW YORK

RIVER SYSTEM	WATER NAME	MAP#	TOWNSHIP	COUNTY	DATE SURVEYED	ABU	COM	RAR	ABS
Sacandaga R	Sacandaga R								
	River Road (Site 1)	79	Hope	Hamilton	5/12/92				X
	River Road (Site 2)	79	Hope	Hamilton	5/12/92				X
	Rte 30 Campground	79	Wells	Hamilton	5/12/92				X
	Russell Rd (old main rd)	79	Wells	Hamilton	5/12/92				X
	Sacandaga River (East Branch)	79	Wells	Hamilton	5/12/92				X
	Sacandaga River (West Branch)								
	Area of Jimmy Creek	79	Wells	Hamilton	5/12/92				X
	Shaker Place	79	Arietta	Hamilton	5/12/92				X
	East of Rte 10 just below Shaker Place	79	Arietta	Hamilton	5/12/92				X
	4.4 mi south of Shaker Pl	79	Arietta	Hamilton	5/12/92				X
	At bridge above Arietta	79	Arietta	Hamilton	5/12/92				X
Black R	Black R	84	Lowville/Watson	Lewis	1986			X[a]	
	(4 sample locations, same site)				5/04/95		X[a]		

ABU = Abundant = frequently more than 5 nymphs in a pan; COM = Common = frequently 1 or 2 nymphs in a pan; RAR = only 1 or 2 nymphs seen during the entire search; ABS = Absent.
[a] = Present, but abundance not ascertained; considered one site.

APPENDIX B. TOMAH MAYFLY SITES SURVEYED IN MAINE

RIVER SYSTEM	WATER NAME	MAP#	TOWNSHIP	COUNTY	DATE SURVEYED	ABU	COM	RAR	ABS
Dennys R	Dead Stream	36	Cooper	Washington	5/19/90				X
	Dennys River								
	Bet. Meddybemps/Dead Stream	36	Meddybemps/Cooper	Washington	5/19/90				X
Kennebec R									
Dead R.	Dead River								
sub-drainage	North Branch								
	Upper (@ bridge, N side)[a]	29	Eustis	Franklin	1986			*[a]	
	Upper (@ bridge, S side)[a]	29	Eustis	Franklin	5/14/94		X[a]		
	Upper (@ bridge, S side)[a]	29	Eustis	Franklin	5/30/94		X[a]		
	Lower[a]	29	Eustis	Franklin	5/14/94		X[a]		
	Boat ramp (E of Rte 27)	29	Eustis	Franklin	5/14/94				X
	South Branch	29	Eustis	Franklin	5/25/90				X
	South Branch								
	Upstream of canoe trip	29	Coplin Plt	Franklin	5/18/90				X
	Fall Brook	30	Solon	Somerset	5/12/90				X
	Kennebago River	28	Stetsontown Twp	Franklin	5/25/90				X
	Sebasticook River								
	Mainstream Pond	31	Cambridge/Harmony	Somerset	5/22/90		X[b]		
	Mainstream Pond	31	Cambridge/Harmony	Somerset	5/15/93			X[b]	
	Sebasticook River	31	Cambridge/Ripley	Somerset	5/13/90				X
	Stratton Brook	29	Wyman Twp	Franklin	5/25/90				X
Kennebec R.	Kennebec River								
sub-drainage	East Outlet(E. side of Rte 6/15)	41	Sapling Twp/ Big Squaw Twp	Somerset/ Piscataquis	5/2/95				X
	Moosehead Lake at Wilson Camps	41	Big Squaw Twp	Piscataquis	5/2/95				X
	West Outlet (@bridge W. side of Rte 6/15)	40-41	Taunton & Raynham Academy Grant	Somerset	5/2/95				X
	Long Pond, west outlet, off gravel rd W. of Rte 6/15	40	Taunton & Raynham Academy Grant	Somerset	5/2/95				X

APPENDIX B (CONTINUED). TOMAH MAYFLY SITES SURVEYED IN MAINE.

RIVER SYSTEM	WATER NAME	MAP#	TOWNSHIP	COUNTY	DATE SURVEYED	ABU	COM	RAR	ABS
Kennebec R. sub-drainage	Moose River (N. side, shoreline side of road @ Maynard's Camps)	40	Rockwood Strip T1 R1	Somerset	5/2/95				X
	W. Branch Eastern River (mainline of natural gas pipeline, milepost 153.48R)	13	Whitefield	Lincoln	5/12/98				X
	Tributory to Togus Stream (Northern Alternate of natural gas pipeline, milepost 153.95)	13	Chelsea	Kennebec	5/12/98				X
	Tributory to Togus Stream (Northern Alternate of natural gas pipeline, milepost 154.50)	13	Chelsea	Kennebec	5/12/98				X
	Stickney Brook (Northern Alternate of natural gas pipeline, milepost 157.60)	13	Chelsea	Kennebec	5/12/98				X
St. George R	St. George River (mainline of natural gas pipeline, milepost 178.68)	14	Searsmont	Waldo	5/12/98				X
Machias R (East)	Northern Inlet	26	T18 ED BPP	Washington	5/26/90				X
	Rocky Lake Stream	26	T18 ED BPP	Washington	5/26/90			X	
	Huntley Brook (mainline of natural gas pipeline, milepost 283.65R)	36	NO 21 TWP	Washington	5/12/98				X
Penobscot R Mattawamkeag R Sub-drainage	Baskahegan Stream through Big Bog	45	Kossuth Twp	Washington	5/02/89				X
	Middle Deadwater	45	Kossuth Twp	Washington	5/02/89				X
	Tolman Deadwater	45	Carroll	Penobscot	5/03/89				X
	Dwinal Flowage/Gott Brook	44	Winn/Lee	Penobscot	5/21/89				X
	Dwinal Flowage	44	Winn/Lee	Penobscot	5/20/92				X
	Mattagodus Stream								

APPENDIX B (CONTINUED). TOMAH MAYFLY SITES SURVEYED IN MAINE.

RIVER SYSTEM	WATER NAME	MAP#	TOWNSHIP	COUNTY	DATE SURVEYED	ABU	COM	RAR	ABS
Penobscot R	N & S of Route 170 bridge	44	Webster Plt	Penobscot	4/29/89		X		
Mattawamkeag R	N & S of Route 170 bridge	44	Webster Plt	Penobscot	5/14/93				X
Sub-drainage	Parallel to Route 169/170	44	Springfield	Penobscot	4/29/89				X
	Mattawamkeag River	44	Kingman Twp/Drew Plt	Penobscot	5/05/89				
	Molunkus Stream	44	Macwahoc Plt	Aroostook	5/25/89				X
	Molunkus Stream	52	Benedicta	Aroostook	5/15/95				X
	Reed Deadwater/Macwahoc Str.	44	N.Yarmouth Acad Grt	Aroostook	1979			*[c]	
	Reed Deadwater/Macwahoc Str.	44	N.Yarmouth Acad Grt	Aroostook	5/01/89			X[c]	
	Reed Deadwater/Macwahoc Str.	44	N.Yarmouth Acad Grt	Aroostook	5/14/93		X[c]		
	Thompson Deadwater/ Wytopitlock Stream	52	T2 R4 WELS/Upper Molunkus	Aroostook	5/02/90		X		
Penobscot R									
Passadumkeag R	Ayers Brook[d]	33	Passadumkeag	Penobscot	'79, 5/25/96			*,X[d]	
Sub-drainage	Ayers Brook Behind Sunny Slope Cemetery	33	Passadumkeag	Penobscot	5/20/92				X
	Birch Stream	33	Arglye/Alton	Penobscot	4/30/89				X
	Cold Stream	33	Passadumkeag	Penobscot	4/26/89				X
	Hemlock Stream	33	Argyle	Penobscot	4/30/89				X
	Passadumkeag R[d]								
	E & W bridge Goulds Ridge Rd	33	Passadumkeag	Penobscot	4/26/89		X[d]		
	resurvey for natural gas pipeline				5/13/98		X[d]		
	Passadumkeag R[d] Above bridge Goulds Ridge Rd	33	Passadumkeag	Penobscot	5/27/93		X[d]		
	Passadumkeag (E. Branch)	34	T3 R1 NBPP	Penobscot	5/07/89				X
	Pollard Brook	33	Howland/Edinburg	Penobscot	4/30/89				X
Penobscot R	Olamon Stream	33	Greenbush	Penobscot	5/20/90				X
(West Branch)	Pine Stream Flowage	49	T3 R13 WELS	Piscataquis	6/01/90				X
	Pine Stream (@bridge on Golden Rd, 10.8 mi from Greenville Rd)	49	T3 R13 WELS	Piscataquis	5/29/95				X
	Sunkhaze Stream	33	Milford	Penobscot	5/20/90				X
	Sunkhaze Stream (just above	33	Milford	Penobscot	5/9/95				X

APPENDIX B (CONTINUED). TOMAH MAYFLY SITES SURVEYED IN MAINE.

RIVER SYSTEM	WATER NAME	MAP#	TOWNSHIP	COUNTY	DATE SURVEYED	ABU	COM	RAR	ABS
Penobscot R	Dudley Br. on right)								
(West Branch)	Sunkhaze Stream (shoreline on rt just above powerline & NWR marker)	33	Milford	Penboscot	5/9/95				X
	Baker Brook (@County Rd	33	Milford	Penboscot	5/9/95				X
	crossing Dudley Brook	33	Milford	Penboscot	5/9/95				X
	E. Branch Piscataquis River (E side of river 2 mi N of gravel road off Upper Shirley Rd - 4.8 mi from landfill entrance)	41	Shirley	Piscataquis	5/29/95				X
	W. Branch Penobscot River (W of Lobster Stream along Poulin Rd)	49	Northeast Carry Twp	Piscataquis	5/29/95				X
	Pushaw Stream	33	Old Town	Penobscot	5/29/89				X
	Pushaw Stream (E. side of I-95)	33	Old Town	Penobscot	5/21/95				X
	Sedgeunkedunk Stream (Millinocket lateral of natural gas pipeline milepost 2.63R)	23	Orrington	Hancock	5/12-13/98				X
	Otter Stream (Millinocket lateral of natural gas pipeline milepost 19.49)	33	Milford	Penobscot	5/12-13/98				X
Pleasant R	Mopang Stream								
	Route 9 bridge	25	T30 MD BPP	Washington	5/08/90				X
	South of Route 9	25	T24 MD BPP	Washington	5/08/90				X
	Pleasant River/Great Heath	25	Columbia	Washington	4/26/90				X
Saint Croix	Dog Brook								
	Tomah Sites 11 & 12	46	Codyville Plt	Washington	1990				X
	Little Tomah Stream[e]								
	Tomah Site #7	46	Codyville Plt	Washington	1990		X[e]		
	Tomah Site #8	46	Codyville Plt	Washington	1990			X[e]	
	Just above where old road ends on Little Tomah	46	Codyville Plt	Washington	5/11/94		X[e]		

APPENDIX B (CONTINUED). TOMAH MAYFLY SITES SURVEYED IN MAINE.

RIVER SYSTEM	WATER NAME	MAP#	TOWNSHIP	COUNTY	DATE SURVEYED	ABU	COM	RAR	ABS
Saint Croix	Just above where old road ends on Little Tomah	46	Codyville Plt	Washington	5/30/94		X[e]		
	Musquash Stream/Lambs Deadwater	35	Grand Lake StreamPlt	Washington	5/09/90				X
	Saint Croix								
	Behind sand pit	46	Vanceboro	Washington	5/19/94				X
	Little Falls picnic area	46	Lambert Lake Twp	Washington	5/19/94				X
	Georgia-Pac. boat landing	36	Baileyville	Washington	5/20/94				X
	.7 mi above jnct of dirt road beyond boat landing	36	Baileyville	Washington	5/20/94				X
	Gauging sta. below Grand F.	36	Baileyville	Washington	5/20/94				X
	Grand Falls Road - .6 mi from jnct w/Lamb Farm Rd	36	Baileyville	Washington	5/20/94				X
	Loon Bay Picnic Area	46	Dyer Twp	Washington	5/20/94				X
	1.8 mi north of Bingo Rd	46	Dyer Twp	Washington	5/20/94				X
	5.4 mi north Bingo Rd jnct	46	Lambert Lake Twp	Washington	5/20/94				X
	Salmon Stream	46	Vanceboro	Washington	5/19/94				X
	Tomah Stream								
	Research Site[e]	46	Codyville Plt	Washington	1978-89[f]	*[e]	*[e]	*[e]	
	Research Site[e]	46	Codyville Plt	Washington	4/25/89	X[e]			
	Research Site[e]	46	Codyville Plt	Washington	1991	X[e]			
	Research Site[e]	46	Codyville Plt	Washington	1992	X[e]			
	Research Site[c]	46	Codyville Plt	Washington	5/13/93	X[e]			
	Research Site[c]	46	Codyville Plt	Washington	5/30/94	X[e]			
	Site #1[e]	46	Codyville Plt	Washington	1990		X[e]		
	Site #2[e]	46	Codyville Plt	Washington	1990		X[e]		
	Site #3[e]	46	Codyville Plt	Washington	1990	X[e]			
	Site #4[e]	46	Lambert Lake Plt	Washington	1990		X[e]		
	Site #5[e]	46	Codyville Plt	Washington	1990		X[e]		
	Site #6 (Todd Farm)[e]	46	Codyville Plt	Washington	1990		X[e]		
	Site #9	46	Codyville Plt	Washington	1990				X
	Site #10[e]	46	Codyville Plt	Washington	1990			X[e]	
	Site #13	46	Waite	Washington	1990				X

APPENDIX B (CONTINUED). TOMAH MAYFLY SITES SURVEYED IN MAINE.

RIVER SYSTEM	WATER NAME	MAP#	TOWNSHIP	COUNTY	DATE SURVEYED	ABU	COM	RAR	ABS
Saint Croix	Site #14	46	Waite	Washington	1990				X
	Site #15	46	Waite	Washington	1990				X
	Site #16[e]	36	Waite	Washington	1990			X[e]	
	Site #17[e]	36	Waite	Washington	1990		Not Sampled		
	Site #18	36	Indian Twp	Washington	1990				X
	Site #19[e]	36	Indian Twp	Washington	1990			X[e]	
	Site #20	36	Indian Twp	Washington	1990				X
	Todd Farm[e]	46	Codyville Plt	Washington	5/19/93			X[e]	
	Dead Brook	53	Orient	Aroostook	5/23/96		Not Sampled		
	Grand Lake Brook (between Farm Cove on W Grand Lake and Little River Lake)	35	T6ND BPP/T43MD BPP	Washington	5/31/96				X
	Grand Lake Stream (below Gould Landing area)	35	T27 ED	Washington	5/18/95				X
	Greenland Brook	45	Danforth	Washington	5/31/96				X
	Greenleaf Brook	53	Amity and Orient	Aroostook	5/23/96				X
	Huntley Brook	36	Indian Twp	Washington					
	E side of bridge on Rte 1				5/18/95				X
	W side of Rte 1 above bridge				5/18/95				X
	Kennebec Brook (11.3 mi from Rte 1 on Bingo Rd)	36	Fowler Twp	Washington	5/18/95				X
	Monument Brook	53	Orient and Amity	Aroostook	5/23/96				X
Narraguagus R	Allen Brook (mainline of natural gas pipeline milepost 258.03A	34	T35 MD	Hancock	5/13-14/98				X
Union R	Union River (West Branch)	24	Amherst	Hancock	5/08/89				X
	Dead Stream (Stud Mill Rd Alt of natural gas pipeline milepost 250.95)	34	T32 MD	Hancock	5/13/98				X
	Union River (East Branch)								
	Middle Branch	24	Aurora	Hancock	5/08/89				X
	Middle Branch (above and below	24	Osborn	Hancock	5/13-14/98		X		

APPENDIX B (CONTINUED). TOMAH MAYFLY SITES SURVEYED IN MAINE.

RIVER SYSTEM	WATER NAME	MAP#	TOWNSHIP	COUNTY	DATE SURVEYED	ABU	COM	RAR	ABS
Union R	mainline of natural gas pipeline, milepost 241.50)								
St. John R	Aroostook River (off Rte 164, .8 mi N of jct w/ Rte 1)	65	Presque Isle	Aroostook	5/16/95				X
	Boody Brook (E of Rte 11, E side of where 3A Road crosses brook)	58	T8 R5 WELS	Aroostook	5/21/95				X
	Caribou Brook (at bridge crossing on American Realty Rd)	62	T11 R9 WELS	Aroostook	5/22/95				X
	Chemquasabamticook Stream (just above McNally's Hunting Camps)	61	T12 R13 WELS	Aroostook	5/25/95			X	
	Dead Brook (200 m upstream from bridge on American Realty Rd)	63	T11 R9 WELS	Aroostook	5/22/95				X
	Little Madawaska River (where gravel rd crosses stream NW of Tangle Ridge Rd	64	Westmanland	Aroostook	5/16/95	Not Sampled			
	St. Croix Stream (3A Rd 5.6 mi E of Rte 11, N side of 3A Rd after crossing stream at boat landing	58	St. Croix Twp	Aroostook	5/21/95			X	

ABU = Abundant = frequently more than 5 nymphs in a pan; COM = Common = frequently 1 or 2 nymphs in a pan; RAR = only 1 or 2 nymphs seen during the entire search; ABS = Absent.

[a] **= Present, but abundance not ascertained; considered one site.**

APPENDIX C. TOMAH MAYFLY SITES SURVEYED IN NEW BRUNSWICK, CANADA

WATER NAME	LOCATION	COUNTY	DATE SURVEYED	ABU	COM	RAR	ABS
Mohannus Stream	At bridge off Burnt Hill Rd	Charlotte	5/27/92				X
Meadow Brook	North of line bet. St. David Parish & Dufferin Parish (Pagan Cove inlet)	Charlotte	5/27/92				X
Palfrey Stream	Rte 630 to washed out bridge	York	5/28/92				X
Dead Creek	Just south of Forest Resource Office on Rte 122	York	5/28/92				X
	Off Harten Settlement Rd Bridge on Dead Creek	York	5/28/92				X

ABU = Abundant = frequently more than 5 nymphs in a pan; COM = Common = frequently 1 or 2 nymphs in a pan; RAR = only 1 or 2 nymphs seen during the entire search; ABS = Absent.