

FLORISTIC DYNAMICS OF A SMALL ISLAND COMPLEX IN LAKE WINNIPESAUKEE, NEW HAMPSHIRE

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ABSTRACT

Three Mile Island, New Hampshire (U.S.A.), located on the northwest arm of Lake Winnepesaukee in central New Hampshire, is approximately 17.4 ha in size. The flora of this island has been studied intermittently by various botanists and naturalists since 1900. Surveys and collections of the vascular plant flora were undertaken by the authors between 1978 and 1985. A single synthetic list of the island's vascular flora was produced, including plants listed by all previous observers. A total of 363 species is here reported, including *Cypripedium arietinum*, a rare species listed by the state of New Hampshire. General characteristics of plant taxa lost and gained reflect the land use patterns of Three Mile Island, a continuum of small changes occupying eight decades.

Key Words: Vascular plant flora, vegetation dynamics, *Cypripedium arietinum*, Three Mile Island, Lake Winnepesaukee, New Hampshire

GEOLOGICAL AND HUMAN HISTORY

The flora of Three Mile Island, Lake Winnepesaukee, New Hampshire (U.S.A.) has been studied intermittently by various botanists and naturalists since the island was purchased by the Appalachian Mountain Club in 1900 (Lawrence, 1901; Kelsey, 1902, 1903; Pease, 1911; Wilde, 1921; Hartmann, 1941; Sackett and Maciejowski, 1977; Maciejowski et al., 1981). The most extensive compilation of vascular plant species on the island (Pease, 1911) included notations and collections made by A. S. Pease (August, 1903), J. H. Emerton (May, 1906), and R. A. Ware (July, 1906). The present study is a flora of the vascular plants occurring on Three Mile Island from 1978 to 1985 and a comparison of this flora with that noted by Kelsey (1902), Pease (1911), and Hartmann (1941), with observations on vegetational changes that have occurred on the island since the turn of the century.

Three Mile Island is located on the northwest arm of Lake Winnepesaukee in central New Hampshire (Figure 1); it is approximately 17.4 ha in size. The island is managed by the Appalachian Mountain Club as a family camp, open primarily during July and August. Two small islands known as Hawk's Nest and Blueberry Islands (Figure 1) are also affiliated with the camp.

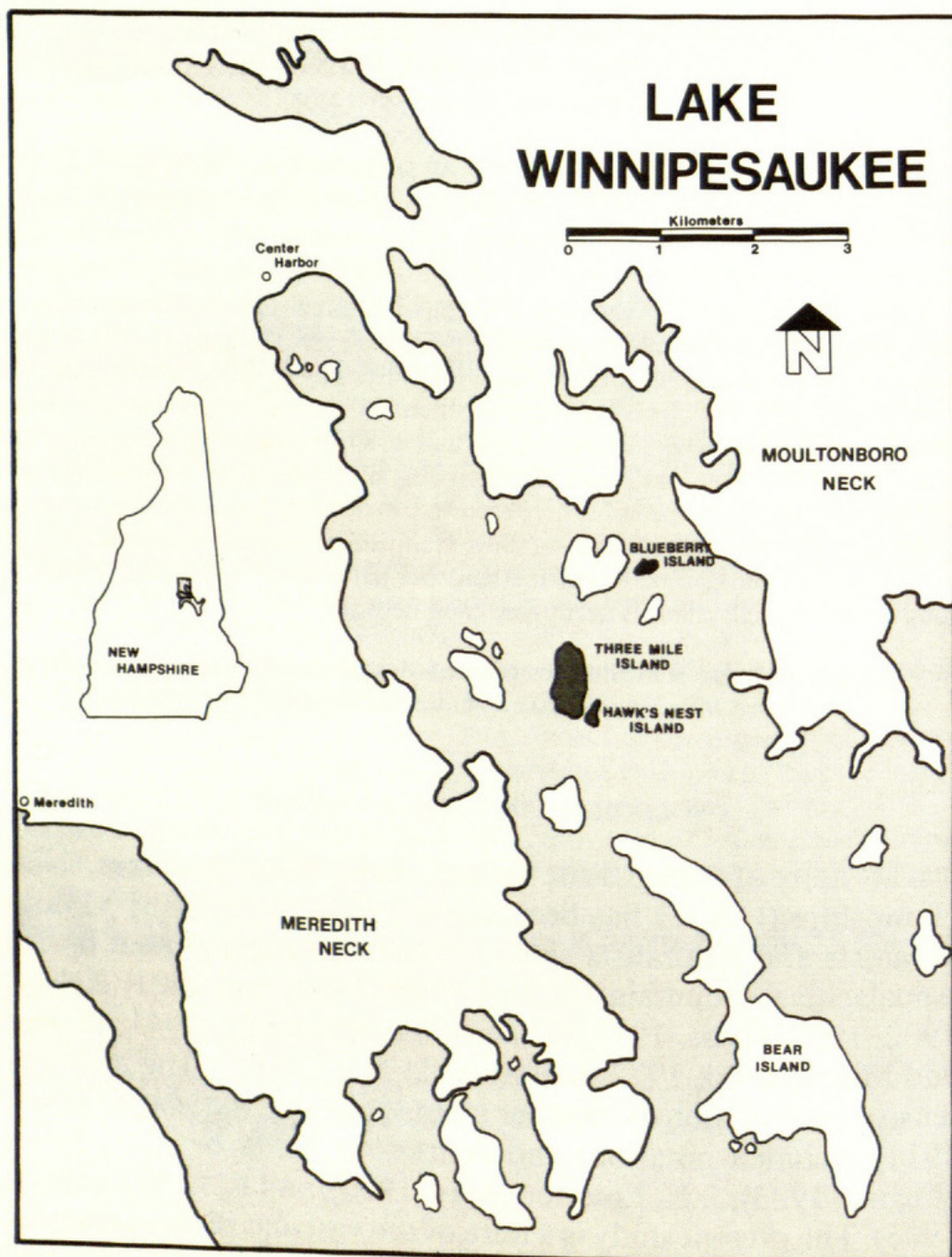


Figure 1. Map of the study area and location of the study sites (shown in gray shading) in New Hampshire, U.S.A.

The geology of the islands in Lake Winnepesaukee in the reach between Moultonboro Neck and Meredith Neck (Figure 1) is quite uniform. Bear, Pine, Black Cat, Three, Five, and Six Mile Islands are all comprised of outcrops of the Winnepesaukee Quartz Diorite, a medium-grained, gray quartz diorite (N.H. Highway Dept., 1940; Quinn, 1941). In places it is found in contact or in gradational sections with granite and diorite. The bedrock core of

Three Mile Island is covered with a surface mantle of broken blocks of bedrock from the local area produced by the intense frost-prying action which influenced this area immediately following the last glaciation. The mantle also contains unevenly distributed pockets of glacial till, comprised largely of silt, sand, and small stones. These pockets give way towards the island's shores to similar pockets of beach sand and washed lake-bottom deposits (pers. comm. from B. K. Fowler, 1975, to J. L. Trickey, member, Three Mile Island Camp Committee, in regard to geology of Three Mile Island). Maximum relief is only 16 m above mean lake level.

VEGETATION

Records from the 1890's indicate the islands were then largely covered with a second-growth forest of poplars and birches, with an abundant evergreen understory of pines, hemlocks, and spruces (Rogovin, 1983). At the turn of the century the island's character was described as "picturesquely rocky," supporting a heavy stand of mixed timber with a richly diversified undergrowth of herbs and shrubs (Atkins, 1972). Today the island forests are dominated by *Fagus grandifolia*, *Quercus rubra*, and *Pinus strobus* (Maciejowski et al., 1981). Other prominent species include *Acer rubrum*, *Betula papyrifera*, and *Tsuga canadensis*. Present tree composition is characteristic of Braun's (1950) Hemlock-White Pine-Northern Hardwood forest. The understory is dominated by *Aralia nudicaulis* and *Gymnocarpium dryopteris*; the most prominent shrubs are *Vaccinium angustifolium* and *Gaylussacia baccata* (Maciejowski et al., 1981).

In 1903 an herbarium collection was started at Three Mile Island to document all vascular plants on the islands; since then, protection of the natural character of the island has been a continuing concern to both campers and management. Cutting for firewood is restricted to forest in the center of Three Mile Island, and coordination of activities on the islands adheres to a land use management plan (Sackett and Maciejowski, 1977; Maciejowski et al., 1981; Holland et al., 1983).

In May, 1901, H. P. Kelsey introduced 481 plants representing 60 predominantly woody species to Three Mile Island; of these, probably nine (Table 1) were indigenous (Pease, 1911). Kelsey (1902) also included in his list such southern and Alleghenian

Table 1. Total species reported, new taxa, and persistence from previous collections of plant species at Three Mile Island, New Hampshire, USA.

Collector	Number of Species			
	Total Species Reported	New to TMI	Persistence of Non-Indigenous Species Introduced by Kelsey in 1901	Persistence of Indigenous Species Reported by Pease (1911)
Kelsey (1902)*	60	—	—	—
Pease (1911)	265	—	51	—
Hartmann (1941)**	193	31	9	153
MMH/BAS (this study)	243	66	10	157

* Nine species planted by Kelsey were indigenous to the islands.

** Ten species first observed on the islands by Hartmann persist today.

species as: *Liriodendron tulipifera*, *Magnolia acuminata*, *M. tripetala*, *M. fraseri*, *M. virginiana*, and *Halesia carolina* (*Mohrodendron carolinum* of Kelsey, 1902), all transplanted far to the north of their natural ranges.

E. G. Hartmann visited Three Mile Island during one week in early August, 1941 to note the changes that had occurred in the flora of the island in the thirty-year period since Pease's (1911) list was published. Hartmann (1941) was particularly interested "to see how many of the Allegheny Mountain plants were still to be found on the island." Although Hartmann did not undertake a thorough collection, 193 taxa of vascular plants were observed, and 31 of these species were not included in the 1911 list (Table 1). Of the indigenous plants listed by Pease, 67% were found, whereas only 28% of Kelsey's introduced species were seen. Hartmann (1941) suggested that there had been considerable mortality among the southern plants during their 40 years in a northern environment. Although Hartmann's notes are quite useful, there is no opportunity for a detailed comparison between her collection and ours since hers was not a comprehensive study, and no specimens are available from her 1941 visit.

FLORA OF THREE MILE ISLAND

Surveys and collections of the vascular plant flora were undertaken by the authors between 1978 and 1985; collections were

made July 22–29, 1978; July 26–28, 1979; May 31–June 1, 1980; September 26–28, 1980; July 25–31, 1981; May 28–31, 1982; June 18–21, 1982; July 24–31, 1982; June 3–5, 1983; June 18–21, 1984; and August 17–18, 1985. Nomenclature follows Fernald (1950) for most of our collections; Tryon (1978) is our reference for the ferns. However, in an effort to produce a single synthetic list for the island, we have also included plants listed by Pease (1911) and by Hartmann (1941) even if we did not re-locate these species.

With the exception of the ferns, the name in the left column of our list is taken from Fernald (1950), the name [in brackets] is the name from Pease (1911), and the letters in the right column are symbols indicating sources of information (*see* Key below). Pease's (1911) nomenclature followed the 7th edition of Gray's Manual (Robinson and Fernald, 1908). Thus, the list below is a compilation of all plants noted on Three Mile Island during the twentieth century.

We were able to check many of our specimens against Pease's collection (now at NEBC) or against Ware's collection (partly at SCHN, partly at George Mason University, and partly at NEBC) or against Emerton's and anonymous collections (at George Mason University). The value of such early plant collections appropriately stored and maintained can never be over-estimated; in fact, a study such as this might well have ended with more questions than answers had not the original specimens been available for scrutiny. For example, the *Viburnum dentatum* L. recorded by R. Ware has now been split into *V. recognitum* Fern. for northern Arrow-wood and *V. dentatum* L. for southern Arrow-wood (Fernald, 1950); Ware's specimen confirmed that Three Mile Island supported the northern species in 1906.

KEY

- A. Specimens of anonymous collectors with incomplete data (all pre-1911). In the A.M.C. herbarium (now at George Mason University).
- E. Plants collected by J. H. Emerton in May, 1906. In the A.M.C. herbarium (now at George Mason University).
- H. Plants noted (but not collected) by E. G. Hartmann in 1941.
- K. Plants introduced by H. P. Kelsey in May, 1901.

- M. Plants collected by M. M. Holland, 1978–85. At George Mason University herbarium.
- P. Plants collected by A. S. Pease, August 24–25, 1903. In herbarium of A. S. Pease (now mostly at NEBC).
- S. Plants recorded (but not collected) in B. A. Sorrie Field Notebook (1985).
- T. Plants recorded (but not collected) in Three Mile Island Natural History Notebook (1964–85), but not including M. and S. above.
- W. Plants collected by R. A. Ware, July 9–16, 1906. In A.M.C. herbarium (now at George Mason University).
- # Plants included in a MS. list (but not necessarily collected) made by A. S. Pease in August, 1903.
- /–/– Not found before 1964.
- * Not found since 1909.

ANNOTATED CHECKLIST

EQUISETACEAE

Equisetum pratense Ehrh. –/–/– M.

LYCOPODIACEAE

Lycopodium clavatum L. W. M.

L. complanatum L. var. *flabelliforme* Fern. W. M.

L. obscurum L. W. M.

OPHIOGLOSSACEAE

Botrychium dissectum Spreng. [*B. obliquum* Muhl.] A. *

B. simplex E. Hitchc. –/–/– T.

OSMUNDACEAE

Osmunda cinnamomea L. W. M.

O. claytoniana L. H. M.

O. regalis L. # M.

POLYPODIACEAE

Athyrium filix-femina (L.) Roth [*Asplenium filix-femina* (L.) Bernh.] W. M.

Dennstaedtia punctilobula (Michx.) Moore [*Dicksonia punctilobula* (Michx.) Gray] W. M.

Dryopteris clintoniana (D. C. Eaton) Dowell [*Aspidium cristatum* (L.) Sw. var. *clintonianum* D. C. Eaton] P. *

D. cristata (L.) Gray var. *cristata* –/–/– M.

- D. intermedia* (Willd.) Gray [*Aspidium spinulosum* (O. F. Muell.) Sw. var. *intermedium* (Muhl.) D. C. Eaton] W. M.
D. marginalis (L.) Gray [*Aspidium marginale* (L.) Sw.] W. M.
Gymnocarpium dryopteris (L.) Newm. [*Phegopteris dryopteris* (L.) Fee] W. M.
Onoclea sensibilis L. A. M.
Polypodium virginianum L. [*P. vulgare* L.] W. M.
Polystichum acrostichoides (Michx.) Schott # M.
Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw. [*Pteris aquilina* L.] W. M.
Thelypteris noveboracensis (L.) Nieuwl. [*Dryopteris noveboracensis* (L.) Gray] H. M.
T. palustris Schott [*Aspidium thelypteris* (L.) Sw.] W. M.
T. phegopteris (L.) Slosson [*Phegopteris polypodioides* Fee] A. *
Woodsia ilvensis (L.) R. Br. recorded by "Miss Adams" in Pease (1911) *

TAXACEAE

- Taxus canadensis* Marsh. W. *

PINACEAE

- Abies balsamea* (L.) Mill. # *
A. fraseri (Pursh) Poir. K. *
Chamaecyparis thyoides (L.) BSP. K. M.
Juniperus communis L. var. *depressa* Pursh A. M.
J. virginiana L. K. *
Larix laricina (DuRoi) K. Koch H.
Picea mariana (Mill.) BSP. W. *
P. pungens Engelm. H.
P. rubens Sarg. -/-/- M.
Pinus pungens Lamb. K. H.
P. resinosa Ait. W. M.
P. strobus L. W. K. M.
Tsuga canadensis (L.) Carr. W. K. M.
T. caroliniana Engelm. K. *

SPARGANIACEAE

- Sparganium fluctuans* (Morong) Robins. H.

ZOSTERACEAE

- Potamogeton gramineus* L. [*P. heterophyllus* Schreb.] # *

- P. spirillus* Tuckerm. [*P. dimorphus* Raf.] P. *
P. amplifolius Tuckerm. -/-/- M. S.

ALISMATACEAE

- Sagittaria rigida* Pursh H.

GRAMINEAE

- Agropyron repens* (L.) Beauv. -/-/- M.
A. trachycaulum (Link) Malte var. *glaucum* (Pease & Moore)
 Malte [*A. caninum* (L.) Beauv. var. *tenerum* (Vasey) Pease
 & Moore] P. A. *
Agrostis alba L. # M.
A. scabra Willd. # M.
Anthoxanthum odoratum L. -/-/- M.
Dactylis glomerata L. -/-/- M.
Danthonia compressa Aust. -/-/- S.
D. spicata (L.) Beauv. W. M.
Deschampsia flexuosa (L.) Trin. -/-/- M.
Festuca elatior L. -/-/- M.
Muhlenbergia glomerata (Willd.) Trin. P. M.
Oryzopsis asperifolia Michx. E. M.
O. pungens (Torr.) Hitchc. E. M.
Panicum boreale Nash -/-/- M.
P. columbianum Scribn. H.
P. lanuginosum Ell. var. *fasciculatum* (Torr.) Fern. -/-/- M.
P. latifolium L. W. *
P. linearifolium Scribn. W. *
Phalaris arundinacea L. -/-/- M.
Phleum pratense L. W. M.
Poa compressa L. # M.
P. pratensis L. H. M.
Trisetum spicatum (L.) Richter var. *molle* (Michx.) Beal
 -/-/- M.

CYPERACEAE

- Carex arctata* Boott -/-/- M.
C. argyrantha Tuckerm. [*C. foenea* Willd. var. *perplexa* Bai-
 ley] P. M.
C. brunnescens (Pers.) Poir. P. *
C. communis Bailey E. M.
C. debilis Michx. var. *rudgei* Bailey -/-/- M.
C. intumescens Rudge -/-/- M.

- C. laxiflora* Lam. W. *
C. lupulina Muhl. W. P. M.
C. projecta Mackenz. -/-/- M.
C. scoparia Schkuhr # M.
C. trisperma Dew. # M.
Eleocharis tenuis (Willd.) Schultes # *
Scirpus atrovirens Willd. H.
S. rubrotinctus Fern. -/-/- M.

LEMNACEAE

- Lemna minor* L. -/-/- M.

ERIOCAULACEAE

- Eriocaulon septangulare* With. recorded by "M. A. Coe" in
Pease (1911) M.

COMMELINACEAE

- Commelina communis* L. -/-/- M.

JUNCACEAE

- Juncus greenei* Oakes & Tuckerm. -/-/- M.
J. pelocarpus Meyer P. *
J. tenuis Willd. W. M.
Luzula multiflora (Retz.) Lejeune -/-/- M.

LILIACEAE

- Clintonia borealis* (Ait.) Raf. A. *
Helonias bullata L. K. *
Hemerocallis flava L. -/-/- M.
Lilium grayi S. Wats. K. *
L. philadelphicum L. W. M.
L. superbum L. K. *
Maianthemum canadense Desf. W. M.
Medeola virginiana L. W. M.
Polygonatum pubescens (Willd.) Pursh [*P. biflorum* (Walt.)
Ell.] # M.
Smilacina racemosa (L.) Desf. A. M.
Streptopus amplexifolius (L.) DC. var. *americanus* Schultes
-/-/- M.
Trillium erectum L. -/-/- M.
Uvularia sessilifolia L. [*Oakesia sessilifolia* (L.) Wats.] # *

IRIDACEAE

- Iris versicolor* L. W. M.

Sisyrinchium montanum Greene var. *crebrum* Fern. [*S. angustifolium* Mill.] W. M.

ORCHIDACEAE

Cypripedium acaule Ait. E. S. T.

C. arietinum R. Br. P. E. S.

Goodyera pubescens (Willd.) R. Br. -/-/- M.

G. tessellata Lodd. [*Epipactis tessellata* A. A. Eat.] A. S.

Habenaria hookeri Torr. P. W. *

H. psycodes (L.) Spreng. H.

Malaxis unifolia Michx. [*Microstylis unifolia* (Michx.) BSP.]
A. *

Spiranthes cernua (L.) Richard # *

S. gracilis (Bigel.) Beck A. T.

SALICACEAE

Populus deltoides Marsh. -/-/- M.

P. grandidentata Michx. A. M.

P. tremuloides Michx. E. M.

Salix alba L. H.

S. bebbiana Sarg. [*S. rostrata* Richards] A. M.

S. glaucophylloides Fern. [*S. glaucophylla* Bebb. var. *angustifolia* Bebb.] H.

MYRICACEAE

Comptonia peregrina (L.) Coult. [*Myrica asplenifolia* L.] W.
E. M.

Myrica gale L. W. M.

M. pennsylvanica Loisel. [*M. carolinensis* Mill.] W. *

CORYLACEAE

Alnus rugosa (Du Roi) Spreng. [*A. incana* (L.) Moench] A. K.
M.

A. crispa (Ait.) Pursh [*A. viridis* DC.] K. *

A. serrulata (Ait.) Willd. W. *

Betula lenta L. # K. *

B. lutea Michx. f. W. K. M.

B. papyrifera Marsh. -/-/- M.

B. populifolia Marsh. W. E. M.

Carpinus caroliniana Walt. K. M.

Ostrya virginiana (Mill.) K. Koch # M.

FAGACEAE

Fagus grandifolia Ehrh. # M.

Quercus alba L. recorded by "W. H. Ropes" in Pease (1911)
M.

Q. rubra L. W. M.

ULMACEAE

Ulmus americana L. # *

POLYGONACEAE

Polygonum cilinode Michx. W. K. M.

P. persicaria L. H.

Rumex acetosella L. # S. T.

R. obtusifolius L. H.

CHENOPODIACEAE

Chenopodium album L. -/-/- M.

CARYOPHYLLACEAE

Cerastium vulgatum L. H. M.

Lychnis alba Mill. -/-/- M.

Stellaria media (L.) Cyrillo -/-/- M.

NYMPHAEACEAE

Nymphaea odorata Ait. [*Castalia odorata* (Ait.) Woodville &
Wood] # *

RANUNCULACEAE

Anemone virginiana L. E. M.

Cimicifuga americana Michx. K. *

Clematis virginiana L. K. *

Coptis groenlandica (Oeder) Fern. [*C. trifolia* (L.) Salisb.]
A. *

Ranunculus acris L. recorded by "M. A. Coe" in Pease
(1911) M.

Thalictrum polygamum Muhl. # M.

Xanthorhiza simplicissima Marsh. [*Zanthorhiza apiifolia*
L'Her.] K. H.

BERBERIDACEAE

Berberis canadensis Mill. K. *

MAGNOLIACEAE

Liriodendron tulipifera L. K. S.

Magnolia acuminata L. K. *

M. fraseri Walt. K. *

M. tripetala L. K. *

M. virginiana L. K. *

CALYCANTHACEAE

Calycanthus floridus L. K. *

PAPAVERACEAE [FUMARIACEAE]

Corydalis sempervirens (L.) Pers. W. M.

CRUCIFERAE

Brassica rapa L. [*B. campestris* L.] E. *

SAXIFRAGACEAE

Hydrangea arborescens L. H.

Itea virginica L. K. *

Ribes glandulosum Grauer [*R. prostratum* L'Her.] A. *

HAMAMELIDACEAE

Hamamelis virginiana L. W. M.

PLATANACEAE

Platanus occidentalis L. K. *

ROSACEAE

Amelanchier canadensis (L.) Medic. W. E. [W. specimen looks like hybrid]

A. laevis Wieg. -/-/- M.

A. stolonifera Wieg. [*A. spicata* (Lam.) K. Koch] W. E. M.

Fragaria vesca L. var. *americana* Porter # M.

Potentilla canadensis L. -/-/- M.

P. norvegica L. [*P. monspeliensis* L.] W. M.

P. recta L. -/-/- S. T.

Prunus pensylvanica L. f. E. M.

P. serotina Ehrh. # M.

Pyrus melanocarpa (Michx.) Willd. A. M.

Rosa blanda Ait. recorded by "M. A. Coe" in Pease (1911) M.

R. palustris Marsh. [*R. carolina* L.] H. M. T.

R. setigera Michx. K. *

Rubus allegheniensis Porter A. M.

R. hispidus L. recorded by "M. A. Coe" in Pease (1911) M.

R. idaeus L. var. *aculeatissimus* [C. A. Mey.] Regel & Tiling A.

R. idaeus L. var. *strigosus* (Michx.) Maxim. M.

- R. laciniatus* Willd. K. *
R. odoratus L. A. S. T.
Spiraea latifolia Borkh. W. M.
S. tomentosa L. # M.

LEGUMINOSAE

- Apios americana* Medic. [*A. tuberosa* Moench] # *
Desmodium perplexum Schub. [*D. dillenii* Darl.] recorded by
“M. A. Coe” in Pease (1911) E. H. M.
Robinia hispida L. K. H. M.
Trifolium agrarium L. W. M.
T. hybridum var. *elegans* (Savi) Boiss. H. M.
T. pratense L. A. M.
T. repens L. W. M.
Vicia cracca L. -/-/- M.

OXALIDACEAE

- Oxalis europaea* Jord. -/-/- M.

ANACARDIACEAE

- Rhus radicans* L. [*R. toxicodendron* L.] W. M.
R. typhina L. W. M.

AQUIFOLIACEAE

- Ilex glabra* (L.) Gray K. M.
I. montana T. & G. [*I. monticola* Gray] K. *
I. verticillata (L.) Gray A. M.
Nemopanthus mucronata (L.) Trel. E. M.

ACERACEAE

- Acer pensylvanicum* L. A. M.
A. rubrum L. A. M.
A. saccharum Marsh. # M.

BALSAMINACEAE

- Impatiens capensis* Meerb. [*I. biflora* Walt.] A. M.

VITACEAE

- Parthenocissus inserta* (Kerner) K. Fritsch [*Psedera vitacea*
(Knerr) Greene (?)] # M.
P. sp. K. *
Vitis aestivalis Michx. var. *argentifolia* (Munson) Fern. A. M.

TILIACEAE

- Tilia americana* L. # M.

GUTTIFERAE

- Hypericum canadense* L. -/-/- M.
H. frondosum Michx. [*H. aureum* Bart.] K. *
H. densiflorum Pursh K. *
H. majus (Gray) Britt. H.
H. perforatum L. recorded by "M. A. Coe" in Pease (1911)
M.
H. spathulatum (Spach) Steud. [*H. prolificum* L.] K. *
H. virginicum L. A. *

VIOLACEAE

- Viola incognita* Brainerd var. *forbesii* Brainerd W. H. M.
V. pallens (Banks) Brainerd # *
V. renifolia Gray A. *
V. septentrionalis Greene A. M.

NYSSACEAE

- Nyssa sylvatica* Marsh. # M.

ONAGRACEAE

- Epilobium angustifolium* L. A. *
E. coloratum Biehler H.
E. glandulosum Lehm. var. *adenocaulon* (Haussk.) Fern. [*E. adenocaulon* Haussk.] H.
E. strictum Muhl. [*E. densum* Raf.] # *
Oenothera biennis L. # *

ARALIACEAE

- Aralia hispida* Vent. # M.
A. nudicaulis L. A. M.
A. racemosa L. A. M.

UMBELLIFERAE

- Sanicula marilandica* L. H.
Sium suave Walt. [*S. cicutaeifolium* Schrank] P. M.

CORNACEAE

- Cornus alternifolia* L. f. K. *
C. canadensis L. W. M.
C. rugosa Lam. [*C. circinata* L'Her.] A. *
C. stolonifera Michx. K. *

CLETHRACEAE

- Clethra acuminata* Michx. K. *
C. alnifolia L. K. *

PYROLACEAE

- Chimaphila maculata* (L.) Pursh -/-/- M.
C. umbellata (L.) Bart. var. *cisatlantica* Blake A. M.
Moneses uniflora (L.) Gray -/-/- M.
Monotropa hypopithys L. # *
M. uniflora L. W. M.
Pyrola elliptica Nutt. W. T.
P. rotundifolia L. var. *americana* (Sweet) Fern. [*P. americana* Sweet] H. T.
P. secunda L. W. *
P. virens Schweigger [*P. chlorantha* Sw.] W. M.

ERICACEAE

- Arctostaphylos uva-ursi* (L.) Spreng. A. T.
Chamaedaphne calyculata (L.) Moench var. *angustifolia* (Ait.) Rehd. E. M.
Gaultheria procumbens L. W. M.
Gaylussacia baccata (Wang.) K. Koch A. M.
G. baccata (Wang.) K. Koch forma *glaucocarpa* (Robinson) Mackenzie # *
Kalmia angustifolia L. W. M.
K. latifolia L. K. *
Leiophyllum buxifolium (Berg.) Ell. K. *
Leucothoe editorum Fern. & Schub. [*L. catesbaei* (Walt.) Gray] K. H.
Lyonia ligustrina (L.) DC. # M.
Oxydendrum arboreum (L.) DC. K. *
Rhododendron arborescens (Pursh) Torr. K. H.
R. calendulaceum (Michx.) Torr. K. H. M.
R. canadense (L.) Torr. W. E. K. M.
R. catawbiense Michx. K. H.
R. maximum L. K. M.
R. roseum (Loisel.) Rehd. [*R. canescens*, in part, of ed. 7] M.
R. vaseyi Gray K. *
R. viscosum (L.) Torr. K. M.
Vaccinium angustifolium Ait. [*V. pensylvanicum* Lam.] A. M.
V. atrococcum (Gray) Heller -/-/- M.
V. corymbosum L. # M.
V. vacillans Torr. [*V. vacillans* Kalm.] # *

DIAPENSIACEAE

- Galax aphylla* L. K. *
Shortia galacifolia T. & G. K. * [not in Fernald, 1950]

PRIMULACEAE

Lysimachia terrestris (L.) BSP. # M.

Trientalis borealis Raf. [*T. americana* (Pers.) Pursh] A. M. T.

STYRACACEAE

Halesia carolina L. K. M.

OLEACEAE

Fraxinus americana L. # M.

GENTIANACEAE

Gentiana andrewsii Griseb. anonymously reported in Pease (1911) *

Nymphoides cordata (Ell.) Fern. [*N. lacunosum* (Vent.) Fern. # *

APOCYNACEAE

Apocynum androsaemifolium L. W. M.

Vinca minor L. -/-/- M.

ASCLEPIADACEAE

Asclepias exaltata L. [*A. phytolaccoides* Pursh] # S.

A. syriaca L. -/-/- M.

BORAGINACEAE

Myosotis scorpioides L. -/-/- M.

LABIATAE

Lycopus americanus Muhl. -/-/- M.

L. uniflorus Michx. # M.

Mentha arvensis L. var. *villosa* (Benth.) S. R. Stewart [*M. arvensis* L. var. *canadensis* (L.) Briq.] # M.

Prunella vulgaris L. # M.

Pycnanthemum tenuifolium Schrad. [*P. flexuosum* (Walt.) BSP.] H.

Scutellaria epilobiifolia A. Hamilton [*S. galericulata* L.] anonymously reported in Pease (1911) M.

S. lateriflora L. H. M.

SCROPHULARIACEAE

Gratiola aurea Muhl. # M.

Melampyrum lineare Desr. W. M.

Verbascum thapsus L. # M.

Veronica officinalis L. H. M.

V. scutellata L. -/-/- M.

V. serpyllifolia L. -/-/- M.

BIGNONIACEAE

Catalpa bignonioides Walt. K. *

OROBANCHACEAE

Epifagus virginiana (L.) Bart. # M.

Orobanche uniflora L. A. *

PLANTAGINACEAE

Plantago major L. # M.

RUBIACEAE

Cephalanthus occidentalis L. W. K. M.

Galium tinctorium L. W. *

G. triflorum Michx. # *

Mitchella repens L. W. M.

CAPRIFOLIACEAE

Diervilla lonicera Mill. A. M.

D. sessilifolia Buckl. K. H. M.

Lonicera canadensis Bartr. A. M.

L. japonica Thunb. var. *halliana* Nicholson K. *

Sambucus canadensis L. -/-/- M.

S. pubens Michx. -/-/- M.

Viburnum acerifolium L. W. M.

V. alnifolium Marsh. A. *

V. cassinoides L. A. M.

V. lentago L. -/-/- M.

V. recognitum Fern. [*V. dentatum* L.] W. M.

CAMPANULACEAE [LOBELIACEAE]

Lobelia cardinalis L. H.

L. dortmanna L. reported by "M. A. Coe" in Pease (1911) *

L. inflata L. -/-/- M.

COMPOSITAE

Achillea millefolium L. A. M.

Anaphalis margaritacea (L.) C. B. Clarke reported by "M. A. Coe" in Pease (1911) M.

Antennaria canadensis Greene W. *

A. fallax Greene P. *

A. neglecta Greene # M.

- A. neodioica* Greene # M.
A. plantaginifolia (L.) Hook. E. S.
Aster acuminatus Michx. # M.
A. divaricatus L. # M.
A. dumosus L. # *
A. macrophyllus L. P. E. M.
A. nemoralis Ait. -/-/- M.
A. novi-belgii L. # M.
A. puniceus L. # M.
A. umbellatus Mill. # M.
A. undulatus L. P. M.
Bidens connata Muhl. (?) #
B. frondosa L. H. M.
Chrysanthemum leucanthemum L. -/-/- M.
Cirsium vulgare (Savi) Tenore -/-/- M.
Erechtites hieracifolia (L.) Raf. H.
Erigeron canadensis L. -/-/- M.
E. strigosus Muhl. [*E. ramosus* (Walt.) BSP.] # M.
Eupatorium perfoliatum L. # *
E. purpureum L. # *
Gnaphalium macounii Greene [*G. decurrens* Ives] # *
G. obtusifolium L. -/-/- M.
G. uliginosum L. -/-/- M.
Hieracium aurantiacum L. -/-/- M.
H. paniculatum L. reported by "M. A. Coe" in Pease (1911) *
H. pilosella L. -/-/- M.
H. pratense Tausch -/-/- M.
H. scabrum Michx. reported by "M. A. Coe" in Pease (1911) S.
Lactuca canadensis L. # M.
Prenanthes trifoliolata (Cass.) Fern. reported by "M. A. Coe" in Pease (1911) M.
Rudbeckia serotina Nutt. -/-/- M.
Solidago altissima L. -/-/- M.
S. arguta Ait. P. # M.
S. bicolor L. A. M.
S. caesia L. # M.
S. canadensis L. A.*
S. graminifolia (L.) Salisb. # *
S. juncea Ait. A. M.

- S. nemoralis* Ait. A. M.
S. rugosa Ait. # M.
S. tenuifolia Pursh -/-/- M.
Taraxacum officinale Weber # M.

DISCUSSION

Continuity and Change During Eight Decades

A total of 363 species of vascular plants, representing 199 genera and 73 families, has been reported and/or collected on Three Mile Island. Of the species introduced by Kelsey, only the following persist: *Chamaecyparis thyoides*, *Carpinus caroliniana*, *Liriodendron tulipifera*, *Robinia hispida*, *Ilex glabra*, *Rhododendron calendulaceum*, *Rhododendron maximum*, *Rhododendron viscosum*, *Halesia carolina*, and *Diervilla sessilifolia*. Most of Kelsey's introductions have disappeared presumably due to intolerance to cold or other climatic/environmental factors.

Since 80% of Kelsey's introductions did not survive, it is instructive to compare geographic ranges of the surviving exotics to the ranges of those not persisting. Of the 10 surviving exotics, 40% naturally reach the latitude of TMI in New England, 20% almost reach the latitude of TMI in New England, 20% range north to Pennsylvania and West Virginia, and 20% range north to Virginia. Thus, 60% of the surviving exotics have been able to survive at TMI in spite of the fact that they are north of their normal ranges. Of the 41 non-surviving exotics, 12% naturally reach the latitude of TMI in New England, 15% almost reach the latitude of TMI in New England, 44% range north to Pennsylvania and West Virginia, 19% range north to Virginia; one is a Rocky Mountain species, two are Old World species, and one (the unidentified *Parthenocissus*) cannot be assigned a range. Of the non-survivors, only 12% might have been expected to survive at the latitude of TMI. Survivorship of Kelsey's introductions was not totally predictable: five northern species that might have been expected to persist did not survive, while six southern species did survive. We might speculate that the microhabitats surrounding each introduction might have been critical in providing the protection necessary to assure survival, but since no location maps of Kelsey's introductions are available, the role of microhabitat must remain speculation.

Table 2. Comparison of native versus adventive species reported at Three Mile Island, New Hampshire, USA, from 1901 to 1985. "Native" is used here to mean indigenous to Three Mile Island, while "adventive" refers to plants from elsewhere in New Hampshire, the United States, and/or Eurasia that have apparently reached the island through human activities.

Habitat	Number of Species		
	Persistent [Common to Pease (1911) and to this study]	Lost [Reported only by Pease (1911)]	Influx [Reported only by this study]
Native woodland	91	34	30
Native open area	68	22	21
Native aquatic	11	8	6
Adventive	14	1	24
Kelsey introductions	10	41	0

As can be seen from Table 1, we recorded many species new to Three Mile Island. Some species collected only in 1978–85 include: *Chenopodium album*, *Lychnis alba*, *Cerastium vulgatum*, *Stellaria media*, *Moneses uniflora*, *Vinca minor* and *Scutellaria epilobiifolia*. In all, 66 species recorded in this study were not included in the 1911 list. An additional 10 species first recorded on Three Mile Island by Hartmann (1941) persist today.

Table 1 compares both species totals and persistence of species on Three Mile Island. General characteristics of plants lost and gained as a group reflect the land use of Three Mile Island, which has been a continuum of small changes spread out over eight decades. Continual influx (and loss) of native woodland species as well as of adventive species account for the two largest changes (Table 2). While the number of adventive ("weedy") species has increased, the number of species indigenous to the islands has remained remarkably constant (Table 2). We suggest that the increase in "weedy" species may be attributed to heavier human traffic (over 1000 people in 1985). "Weedy" adventives are restricted to areas of greatest human use (such as at the main dock and near the central dining facilities). The apparent balance between the number of species reported by Pease (1911) and by this study for "native woodland," "native open area," and "native aquatic" (Table 2) suggests that the numbers of invasions and extinctions have been roughly equal during the last 75 years. In general, we propose that the same niches are available today as

were present 80 years ago, although they may be occupied by different species today.

The Simpson index of resemblance (Simpson, 1965) was used to compare the early taxonomic composition of the total flora of Three Mile Island (Pease, 1911) to the present 1978–85 collection. An index of resemblance was not calculated with the Hartmann list since her collection was limited to a single week (Hartmann, 1941). This index ($100c/nl$, in which “c” is the number of taxonomic units common to the two floras and “nl” the total number of units in the smaller of the two) seems particularly useful in comparing floras of approximately equal numbers occurring in a single area. The Simpson index of resemblance between the two collections is 0.66. This value falls midway between the lowest (59.2) and highest (72.0) values reported (Lauermann and Burk, 1976) for Penikese Island, part of the Elizabeth Islands chain southwest of Woods Hole, Massachusetts, and suggests that Three Mile Island has experienced a level of disturbance comparable to Penikese.

Conservation

Botanically the most exciting find during this project was the re-discovery of *Cypripedium arietinum* on August 18, 1985. Earlier that year, Brackley (1985) reported that there was only a single known New Hampshire station for this species. The initial discovery of specimens of Ram’s-Head Ladyslipper at Three Mile Island was apparently made during the first botanical exploration of the island on August 17, 1900 (Wilde, 1921). The species flourished well enough during the early twentieth century that 50 blossoms were counted on a botanical trip to the island in 1909 (Richards, 1910). However, by 1985 the population had greatly dwindled in size.

The few individuals left in this colony are growing in close proximity to a popular trail. When the location of the Ram’s-Head Ladyslipper was mentioned to concerned campers and island managers, there was general agreement that the location should be protected as best as possible. The Land Use Plan adopted by the Three Mile Island Camp Committee in 1973 has undoubtedly been instrumental in protecting this and other rare species (Maciejowski et al., 1981; Holland et al., 1983), and it is expected that this management plan will continue to provide the

adequate flexibility combined with sufficient rigor needed to promote wise stewardship of the island's natural resources.

The land use plan is ecological in nature and was derived from a compartment model of the basic kinds of environment required by humans (adapted from Odum, 1969). Land areas on islands owned by the Appalachian Mountain Club were classified (Holland et al., 1983) into four major categories of environment utilized by humans:

1. Protective—contain unusual vegetation or natural formations and are generally undeveloped. Under the plan, these areas are most restricted from future development.

2. Compromise—consists of land areas containing a small density of buildings and located along areas of shoreline. While no new building is encouraged, replacement building, trail maintenance, and cutting of vegetation to maintain vistas and to protect buildings are allowed.

3. Productive—designed for forestry and wildlife habitat, improvement cuttings, and managed for the harvest of firewood.

4. Urban—consists of existing built-up areas and areas of heavy use. Although these areas have been used intensively over the years, it is recommended that future construction be approved by an outside review board within the Appalachian Mountain Club.

In adopting these land use recommendations, the Camp Committee stipulated that any new plans for construction within the Urban or Compromise areas must be submitted with a simple environmental impact statement outlining the cost of the proposed project in terms of alteration of the natural state of the area in question. The land use plan was primarily drafted as a guide for the committee to use when planning for future improvements such as cabins, or recreational facilities. However, the plan also helped to resolve a land use conflict which existed at the time the plan was developed. While most people affiliated with Three Mile wanted to preserve the natural state of the island to the fullest possible extent, a conflict arose when proposals were made to increase total number of campers during the island's ten-week season to offset the higher costs of operation. Although the number of campers did not increase, the land use plan provided alternatives for orderly development while maintaining maximum protection of the island's natural state (Sackett and Maciejowski, 1977).

Since its inception in 1972, the land use plan has proven to be a workable framework for maintaining the natural character of Three Mile Island. The designers of the land use plan envisioned a flexible structure, which would allow for minor amendments and additions when necessary. In October of 1985, after the re-discovery of the Ram's-Head Lady Slipper, the Camp Committee agreed to designate the site of the Ram's-Head Lady Slipper a "Protective" area, and thus to continue its commitment to preserve the natural biota of Three Mile Island.

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