3.4.4 Changes in vegetation, 1796 to 2000 A.D.

Changes in wetland plant community type will be assessed in relation to changes in the environmental stresses within the marsh basin between 1796 and 2000 A.D. The change in wetland plant community type will be analyzed using percent cover as a measure of change. Changes in flood stress, salt stress, and fire disturbance were discussed in previous sections of the ecological synthesis. The change in wetland plant community type will be linked to changes in the environmental stress regime using plant species tolerance limits established for each stress. The ecological condition of Mentor Marsh in 1796 is presented first, to establish antecedent condition.

3.4.4.1 Vegetation in 1796 A.D.

In 1796, the eastern and central portions of the marsh basin were dominated by swamp forest with small areas of alder (shrub scrub) and open marsh recorded for the northeast basin. The western basin was a large open marsh. The Grand River and the stream that drained the eastern basin of the marsh formed separate confluences with Lake Erie, but were still hydrologically connected through the relict meander bend during times of high flow.

During the first survey expedition into the Western Reserve, Seth Pease and John Milton Holley ran a survey line that crossed the eastern basin of Mentor Marsh providing our most complete description of the vegetation within Mentor Marsh in presettlement times. Field notes recorded by Pease and Holley on August 27, 1796, describe the vegetation of
the eastern basin as dominated by swamp forest. A detailed analysis of Pease and Holley’s survey line, as it is reconstructed from their survey notes, is provided below.

*Pease and Holley’s survey line*

A transcript of Seth Pease’s survey line, as he extracted it from John Milton Holley’s field notes, (Pease, 1796: Fairport Harbor, 2002) follows:

Minutes of a line ran between the 8th and 9th ranges beginning at the 40 mile post on the last line (ran on a magnetic course N.)

Extracted from the field notes of Milton Holley – August 26th (1796) set a stake at the place of beginning and mkd E. side 40 M. 8 R. S. side T.S. No. 9, - W. side 9R.N. side T.S. No. 10.

**FIRST MILE**- To a dry run course N.W. @ 15 ch; to a dry run course W. at 40 ch.; to a dry run W. at 55 ch.; to a dry run N.W. @63.50 gentle rises & descents of pretty good land timbered with Chestnut, B & W Oak, Beech, Bass, Maple, Hickory, Butternut and W. Wood, set a post and mkd. S. side 1 mi., E. side, 8 R., W. side 9 R. & 80 ch.

**SECOND MILE**- To a run course N.W. @ 16.50, to a creek 25 lks wide course S.W. @ 45 ch. Land level, soil good, timber as before & mkd S. side 2 mi., E. side 8 R., W. side 9 R @ 80 chs.

**THIRD MILE**- To a dry run course N.W. @ 39 ch. To a creek 15 lks wide course N.W. @ 55 gentle rises & descents of pretty good land timber Beech, Maple, Ash, Elm, Cypress, Hickory set a post & mkd. 3 M. & 80 ch.

**FOURTH MILE**- To low swampy land @ 18 ch.; to dry land @ 27 ch.; to a run course N.E. & 66 ch. To run; S.W. @ 72 ch. Land pretty good, timber Maple, Beech, B & W Oak, Chestnut, Hickory, Cypress & W.Wood; set a post & mkd. 4 M. & 80 ch.

**FIFTH MILE**- To a creek 15 lks wide course N.W. @ 75.50 first part of the mile is flat and swampy, the latter flatter covered with S. Maple under growth spice bush, soil good, set a post and mkd. E. side 8 R. 40 M. S.E. side Tn. No. 10; West side 9 R Tn. No. 10; N.E. side Tn. No. 11; South side 5 M. a yellow birch 9 In. over bears N. 53⁰E. 10 lks. a soft Maple 8 In. over bears N. 1⁰E 20 lks. A yellow Birch 9 In. over bears S.84⁰ W 35 lks. all mkd. 1796. Encamped for the night.
SIXTH MILE- Aug. 27- to a Creek course N.E. @ 26.50 crossed it 6 times @ 33.50 to same N.W. 55.50 crossed it 6 times @ 67 chs. To the same N.W. @ 78 ch. Land pretty good, Timber H. & S. Maple, Beech, Ash, Elm, Hickory, Chestnut, Oak, Butternut, Bass and Iron wood set a post and mkd. 6 M. @ 80.

SEVENTH MILE- To low swampy land @ 25 ch. Land to the swamp is good timber in the swamp, Birch, Pine, B. Ash and Elm ends with S. Maple and thick Alders set a post and mkd. 7 M @ 80 ch.

EIGHTH MILE- To flat land timbered with S. Maple @ 28 ch to an open marsh @ 52 ch.; to a creek of still black looking water 50 lk wide and 3 feet deep @ 56.50 to timbered land @ 58 chs. to the bank of Lake Erie @ 62.50, set a post and mkd. S. side 7 Mi. 62 chs. and 50 lks. E. side Tn. No. 11, 8 R.; W. side 9 R, Tn. No. 10 from which a Butternut tree 8 in. over bears N. 28° W dist 15 lks, a W. wood 10 in. over bears S. 21° W 54 lks mkd. S. side of Butternut tree 1796 52 M. 62 ch. 50 lks. from S. line; W. side 9 R.; E. side 8 R. The mouth of the creek is entirely stooped with sand.

The surveyors’ notes for the first through the sixth miles show quite a bit of variation in vegetative community type within the Mentor Marsh watershed along the Blackbrook tributary. From what we know of this area today, this variation is expected because the surveyors were crossing riparian areas (Blackbrook); old beach ridges (where soil drainage would be sufficient to support the more xeric tree species such as chestnut); areas with poorer drainage (supporting the more mesic species such as beech and sugar maple); and very poorly drained areas (supporting swamp forest). But, most significant to the ecological synthesis of Mentor Marsh, are Pease and Holley’s notes for the seventh and eighth miles. A reconstruction depicting the vegetation as it is described in the survey notes for the seventh and eighth miles is shown in Figure 3.41.

The seventh mile begins on the uplands that overlook the extreme southeast corner of the Marsh. This location is just east of where Blackbrook was rerouted to enter the marsh in
Figure 3.41: Reconstruction of Pease and Holley’s survey line showing vegetation within the eastern basin in 1796.
1988 (Figure 3.42). The woods overlooking the marsh (on the bank; upper right in the photograph) were described as “good timber” by Pease and Holley, which it is today. The extreme southeast corner of the marsh basin was described as a low swampy land with birch, (yellow birch, *Betula alleghaniensis* Britton); pine; blue ash (probably *Fraxinus nigra* Marshall; Bissell pers. comm., 2003); and elm, (American elm, *Ulmus americana* L.).

As shown in the photograph, this area is now heavily dominated by *Phragmites australis*. Further north and within the marsh basin itself, just south of present day Shipman Pond, Pease and Holley described the vegetation as dominated by “S. Maple” (Figure 3.41), indicating soft maple. Sugar maple (*Acer saccharum* Marsh.) and black maple (*Acer nigrum* Michaux f.) were denoted in the surveyors’ notes as “H. maple.” Red maple (*Acer rubrum* L.) and silver maple (*Acer saccharinum* L.) were denoted in the surveyors’ notes as “S. maple.” Therefore, the use of the term soft maple refers to the occurrence of red maple (*Acer rubrum*) and silver maple (*Acer saccharinum*). At the end of the seventh mile, the survey line crossed an area currently inundated by the southern portion of Shipman Pond. The seventh mile is described to end with “S. maple and thick Alders.” The alders were probably speckled alder (*Alnus rugosa* (Duroi) Sprengel) because speckled alder is repeatedly identified in the marsh basin, including the eastern basin, in later vegetative surveys. Voss (1985) tells us that speckled alder is a shrub characteristic of “older zones of bogs, along lakes and streams, in extensive mucky swamps, and in all sorts of wetlands” and “is found in the northern half of Ohio.”
Figure 3.42: Photograph taken in 2001 looking across the southern portion of the eastern basin.
The eighth mile was described as “S. Maple” at a distance of 28 chains from the 7th mile marker. Again, Pease and Holley’s notes indicate this area of the marsh basin was dominated by red maple (Acer rubrum) and silver maple (Acer saccharinum), two trees species associated with the swamp forest in later years as well. This is followed by an “open marsh” at 52 chains from the 7th mile marker. The open marsh would have supported plants adapted to higher flood stress than the swamp forest tree species and the speckled alder previously encountered, but we are not told if the open marsh supported floating-leaved vegetation, swamp grass, or some other type of “open marsh” vegetation. A short distance of 4 and half chains, approximately 92 yards, beyond the open marsh was “a creek of still black looking water.” From this we know that, in 1796, there was a stream occupying the relict river channel formed by the Grand River within the marsh basin where Shipman Pond is located today. It is important to note that this was not a pond but a stream that lay within the old channel of the Grand River. This is an important point in interpreting ecological change because the drainage provided by this stream became blocked by beach accretion in subsequent years causing an increase in flood stress within the marsh basin. It is also important to note the stream’s flow direction is to the north-northeast (i.e., Pease and Holley refer to the mouth of the creek on the shore of Lake Erie) indicating that a flow reversal had already occurred by 1796 subsequent to the establishment of a new point of confluence between the Grand River and Lake. The flow is “still” indicating a low flow condition. This is not surprising because this observation was made in late August, which can be a dry time of year. And, this was a year with historically low Lake Erie water levels, perhaps the lowest observed since that time (Section 3.4.1.1). Pease also described the stream as “black looking” indicating it was
discolored by decaying vegetation. This seems reasonable because the stream flowed through an extensive area of swamp forest and the observation was made during seasonal low flow conditions.

Pease and Holley provide a measurement of the width and depth of the stream within the marsh. It was recorded as “50 lk wide” (33 ft or 11 yards wide) and “3 feet deep” at 56.50 chains (7 tenths of a mile) from the 7th mile marker. The stream was significantly larger than the incoming Blackbrook tributary as recorded in the fifth mile, which was only 15 links (approximately 10 feet) wide. This may indicate the stream that drained the eastern basin of the marsh carried more flow than that contributed by Blackbrook alone. It seems likely that this additional flow was baseflow from groundwater interception especially considering the former riverine condition of the marsh basin. But, regardless of its source, for low flow conditions, this was a substantial creek within the marsh basin located where Shipman Pond is today. It is interesting to note the similarity in stream channel size and location between the stream Pease and Holley measured and the stream that was reestablished between 1937 and 1940 and again in 1997 as discussed in Section 3.4.1.2. The stream appears to be part of the natural flow regime for Mentor Marsh, reestablishing itself under favorable climatic conditions.

At a distance 33 yards north of where the stream crossed the survey line (or 58 chains beyond the 7th mile marker) was “timbered land” and then at 132 yards north of where the stream crossed the survey line was the bank of Lake Erie. Recalling that the surveyors were not following the stream to Lake Erie but were following magnetic north to the
Lake, we find that the stream that flowed within the marsh basin was located to the west of the survey line until it crossed the survey line just 132 yards from the Lake shore then turned to flow to the northeast and then emptied into Lake Erie a short distance away (also see Skinner’s map, 1806, Figure 3.11). This is a significant piece of historic observation regarding the hydrologic connectivity between Lake Erie and the marsh. It tells us that the stream that flowed through the eastern portion of the marsh basin, drained directly into Lake Erie at that time, and indicates that the marsh could receive water from Lake Erie during seiche events. Pease also noted, “The mouth of the creek is entirely stooped (sic) with sand.” This establishes the presence of sand bars across this point of confluence with the Lake and indicates the effect the sand bar would have had on the flow regime at these locations and the areas that they influenced (i.e., increased retention time). Specifically, the sand bars had the potential to retain water within the marsh basin during low flow conditions temporarily increasing flood stress in these areas. This is supported by later observations as depicted in Blunt (1874) and will be discussed later.

The tree that Pease and Holley chose to mark the end of the survey line on the shore of Lake Erie was a butternut (*Juglans cinerea* L.). According to Voss (1985), butternut is a tree species commonly associated with “stream banks and swamp forest” and is also found in “upland beech-maple, oak-hickory, and mixed hardwood stands.” Butternut’s wetland indicator status for the northeast region is FACU+ (Reed, 1988). Pease and Holley marked the south side of the butternut tree “1796.”
It is worth noting the similarity between Seth Peases’ field notes and the Skinner map made 10 years later in 1806 (Figure 3.11). Although the Skinner map was made to depict the property owned by the early settlers, it also confirms what was reconstructed from Pease and Holley’s field notes. The western boundary line of the properties shown on the Skinner map was laid out to coincide with the survey line as established by Pease and Holley in 1796. The map shows the Blackbrook tributary crossing back and forth over the survey line within the watershed of Mentor Marsh before it enters the marsh basin. Pease mentioned crossing the creek 12 times in only one mile in his notes for the sixth mile (the mile surveyed previous to entering the marsh). We can imagine that Pease and Holley found it very frustrating that Blackbrook’s course happened to coincide with their survey line meandering back and forth across it so that they were forced to cross the creek 12 times to keep true to their heading. Also the map shows that within the marsh basin, the stream that drains the eastern portion of the marsh did lie to the west of the survey line until it crossed the survey line only 132 yards from the shoreline. At this location Pease and Holley’s survey line crossed the stream and so they measured and recorded its width and depth. Similar to Pease and Holley’s survey notes, the Skinner map shows the stream emptied directly into Lake Erie thus forming a separate confluence from that of the Grand River with Lake Erie (Figure 3.11).

*Presettlement condition of the western basin*

The only information we have for the western basin for 1796 is a very brief description given by Holley (1796) as he sailed past the Grand River’s old confluence (just to the west of present day Mentor Harbor) on his return voyage at the end of the 1796
expedition on October 20, 1796. He tells us that in the western basin, at the point of old confluence:

“a creek comes in, which forms a large marsh lying a mile along shore, and on the average one hundred rods wide.”

The creek that comes into the marsh basin just prior to its western confluence with Lake Erie is Marsh Creek. Marsh Creek enters the marsh about one mile east of the old point of confluence (Figure 1.2; Figure 1.3).

Holley’s description tells us that where the Marsh Creek tributary entered the marsh basin an open marsh formed. He estimated the dimensions of the open marsh to be about one mile in length and approximately 550 yards (1 rod) in width. This agrees closely with what is observed by Col. Blunt’s survey crew in 1874. There is no evidence to indicate that any changes were made in the basin morphology within the western basin between 1796 and 1876. But, this will be examined more closely in the next section.

_Presettlement condition of the central basin_

What are the hydrologic and vegetative conditions of the central portion of the marsh basin in 1796? I have not been able to discover a detailed description of the central portion of the marsh basin made in 1796. Holley’s description of the length of the open marsh seems to imply that something other than open marsh lay further to the east within the marsh basin. The size of the trees in the central basin noted eighty years later in 1876 suggest that the trees were established many years previous perhaps indicating forested conditions within the central basin in presettlement times. Observations made during the
time of early settlement as discussed in the ecological history (Chapter 2) suggest that the central basin was forested during presettlement times. Early settlers speak of picking their way through the swamp forest from log to log to make their way from Mentor Headlands to the southern bank of the marsh (Gault, 1959).

Comparing plant species tolerance with ecological condition

The tree species that are recorded by Pease (1796) as the dominants for the area surveyed include all of the primary dominants of the vegetative community type denoted in the scientific literature as the elm-ash-soft maple swamp forest in Ohio (Sampson, 1930; Anderson, 1982; Fineran, 1999). Pease’s observation of birch (yellow birch, *Betula alleghaniensis*) as a co-dominant tree species within the swamp forest agrees with later vegetative surveys of swamp forest within the marsh basin and is a variant of the elm-ash-soft maple community associated with more northern deciduous swamp forests. Although not specifically listed by Pease and Holley, the shrub and herbaceous plants species later recorded as occurring within the elm-ash-soft maple swamp forest of Mentor Marsh probably occurred at this time as well. However, it was not the practice of the surveyors to list herbaceous plant species in their field notes, as these were not generally useful for marking the survey line for later use. Table 3.1 shows that these swamp forest tree species have low to medium flood stress tolerance as compared to the high flood stress tolerance of the shrub scrub speckled alder and emergent plant species. This agrees with the low flood stress conditions indicated by low Lake Erie water levels in presettlement times (Section 3.4.1.1) and the direct drainage of the marsh to Lake Erie (Section 3.4.1.2).
Phragmites in the Lake Erie watershed

Pease and Holley make no mention of *Phragmites australis* within the eastern basin during the time of their survey in August 1796. This, of course, does not mean *Phragmites* was not present in the marsh basin but if it was present, we have no record of it. There has been some question about whether *Phragmites australis* is an exotic plant species. To address this issue and because of the future importance of *Phragmites* in the vegetative dynamics of the marsh basin, I include an excerpt from Amzi Atwater’s diary (1796) recording the presence of a plant meeting the description of *Phragmites australis* observed within the upper reaches of the Cuyahoga River watershed. When surveying the line between Townships 6 and 7, near the middle of Range 7, Atwater states:

> About the middle of 33\textsuperscript{rd} mile is a small swamp, in it there is a kind of reeds, about 12 feet high, and one half an inch in diameter.

This location is in present day Geauga County, in the upper reaches of the Cuyahoga River watershed. This is one of the earliest records for *Phragmites* in the Lake Erie region. This tells that a plant meeting the description of *Phragmites australis* was in the Lake Erie watershed in 1796. But it does not tell us whether the *Phragmites australis* in the marsh basin today is a native species or a more invasive biotype of *Phragmites australis*. 
As described in the methods section, percent cover for each wetland community type was estimated for the year 1796. The analysis yielded the following values for percent cover for 1796:

- Swamp forest: 66%
- Shrub scrub: 4%
- Emergent: 1%
- Open marsh: 29%

The condition of the environmental stress regime (i.e., flood stress, salt stress, and fire disturbance, and shade stress) in 1796 was low flood stress, no salt stress (i.e., freshwater conditions), no frequent fire disturbance, and high shade stress (i.e., forested condition).

3.4.4.2 Change in vegetation, 1796 to 1876 A.D.

Overview

From 1796 to 1876 there was an increase in flood stress (Section 3.4.1) accompanied by a shift toward more flood-tolerant vegetation within the marsh basin. Dead trees within the relict meander bend (Figure 1.3) indicate that a shift in vegetative community type from swamp forest to more flood-tolerant vegetation occurred at that location. The northern portion of the eastern basin was dominated by swamp grass in 1876 as compared to swamp forest in 1796. Alder dominated the southern portion of the eastern basin in 1876 as compared to swamp forest in 1796. The central basin was covered with dense stands of alder with large trees scattered throughout in 1876 suggesting die-off of the smaller, less
flood-tolerant trees and the lack of germination of trees owing to the higher flood stress. The western basin was still dominated by an open marsh in 1876. But, large dead trees surrounded by swamp grass along its inland portion indicate a shift to more flood-tolerant vegetation had occurred along its perimeter, increasing the areal extent of the open marsh. Increased flood stress in the western basin of the marsh is attributed primarily to the wetter climate (Section 3.4.1.1) because no anthropogenic modifications appeared to have been made to the western basin between 1796 and 1876. The increase in flood stress in the eastern basin and the relict meander bend can be attributed to both the damming of the stream draining the eastern basin (Section 2.5 and Section 3.4.1.2) and a wetter climate. It is uncertain if the damming of the stream in the eastern basin would have had any effect on flood stress in the west central and western basins. There is a minor drainage divide between these two areas and a distance of approximately 4 and half miles separates them. It seems likely that the magnitude of the effect may have been dissipated over such a long distance and complex channel configuration. Three historic maps made by the Corps of Engineers in 1865, 1874, and 1876 provide the best information available on the vegetative condition of the marsh basin at the end of the first time interval.

_The 1865 map of Grand River Harbor depicting the relict meander bend_

The Corps of Engineers made a map of Grand River Harbor in 1865 (Raynolds). The condition of the 1865 map, as I was able to obtain it, was insufficient for it to be clearly presented here but a discussion of what it depicts is presented. This map shows the stream that drains the eastern basin of the marsh dammed by beach accretion. The stream is disconnected from Lake Erie and redirected toward the Grand River through the relict
meander bend (Figure 1.3) in the old path of the Grand River although in the opposite direction. A pond, formed by the damming of the stream, is in the same location as the stream that drained the eastern basin in 1796. The map shows the relict meander bend as a marshy area covered with dead trees and the stream draining the pond terminates before reaching a point of confluence with the Grand River. The standing dead trees within this marshy area indicate tree die-off had occurred owing to higher flood stress in this area. Specifically, prior to the occurrence of beach accretion, the relict meander bend appears to have been forested, but the inadvertent redirecting of the stream’s flow path towards the Grand River, through the relict meander bend, increased the volume of water entering this area, and caused tree die-off.

**The 1874 map of Mentor Marsh**

The 1874 map provides the most complete picture of the marsh vegetation at the end of the first time interval (Figure 3.43). Beginning in the area of the relict meander bend between the Grand River and the northeastern marsh basin, we find that this area had become a low-lying open marsh, as is also indicated on the 1865 map. Symbols denoting a marsh area (small grass-like symbols) connect the western side of the Grand River floodplain with the marsh basin depicting the relict meander bend as a low lying floodplain covered with open marsh vegetation. The 1874 map does not mention the standing dead trees noted on the 1865 map perhaps indicating that nine years later they were no longer there (i.e., they had fallen over and decomposed). A note on the 1874 map
Figure 3.43: 1874 map showing all of the marsh basin.
tells us that, “During spring freshets and whenever the water in the river rises, this bottom is more or less over flowed.” From this description, we know that Mentor Marsh was periodically connected with the Grand River at that time.

**Eastern basin**

The 1874 map depicts the vegetation of the eastern basin as swamp grass and open water bogs in the northeast and alder in the southeast (Figure 3.44; Figure 3.45). The alder bush increased in density further to the south. The woods were isolated to the east towards the Richmond terrace. This indicates that a significant change in the vegetative condition of the eastern basin occurred sometime between 1796 and 1874. Recall that in 1796, the eastern basin was covered with swamp forest dominated by red and silver maple and thick alders in the northeastern portion and a swamp forest dominated by yellow birch, pine, “blue ash” (likely black ash), and American elm in the southeastern portion (Pease, 1796). This indicates a marked shift in wetland vegetative community type from less flood-tolerant to more flood-tolerant vegetation (Table 3.1) within the eastern basin had occurred since 1796. The analysis of climate change (Section 3.4.1.1) suggested that flood stress increased substantially beginning with the high water year of 1838. The analysis of beach accretion (Section 3.4.1.2) showed that 82% of the beach accretion to the west of the piers occurred between 1826 and 1839 suggesting that increase in flood stress owing to anthropogenic modifications occurred at about the same time as the increase in flood stress owing to a wetter climate. The timing of these events corresponds with the condition of the vegetation as recorded in 1874. Specifically, the shift to more
Figure 3.44: Portion of the 1874 map showing the eastern basin.
Figure 3.45: Note indicating the vegetative condition of the eastern basin in 1874 (Blunt, 1874).
flood-tolerant vegetation had occurred at some time prior to 1874 with enough time having elapsed that most of the standing dead trees were gone and alder and swamp grass were growing where the swamp forest had been in 1796.

**East central basin**

A note between the southeastern marsh basin and the mouth of Blackbrook describes the vegetation as dominated by alder bush of “various height and density” with trees present “…of all kind and sizes scattering” (Figure 3.46, top). It is also interesting to note that the small delta-like deposit at the mouth of Blackbrook is still forested. This area has the highest elevation (781.5 feet: Kucera, 1966) within the marsh basin and appears to have retained a small area of more dense (closed canopy) swamp forest (Figure 3.46, bottom).

**Central basin**

The area east of the northern end of Corduroy Road has a note describing the vegetation as, “Bogs; Alders & other trees” and “Vegetation less dense” (Figure 3.47, top). The central basin around Corduroy Road is described as having scattered large trees with dense stands of alder (Figure 3.47, top). The large size of the remaining trees is also indicated by the note telling us that the view from either bank is obstructed by the trees within the marsh basin (Figure 3.47; top). The banks around the marsh in this area are approximately 25 to 30 feet above the marsh basin (USGS, 1992; Blunt, 1874) indicating that the remaining trees in the central basin were very tall. This is another piece of evidence for the forested condition of the central basin in presettlement time (i.e., seventy
Figure 3.46: Notes on 1874 describing the southeastern marsh basin (top) and Blackbrook confluence with the marsh basin (bottom). The mouth of the Blackbrook tributary has the highest elevation in the marsh. Notice its forested condition.
Figure 3.47: Notes on 1874 describing the central basin around Corduroy Road (top), west central basin (bottom).
years prior to the 1874 survey). And, again we note the low density of tree cover and the presence of alder bush. Without a detailed record of what the vegetation was like in the central basin of the marsh in 1796, it is not possible to make an exact comparison. The central basin, however, appears to be experiencing a similar shift in wetland community type as indicated by the density of alder interspersed with large trees (Figure 3.46). The presence of scattered large trees surrounded by more flood tolerant vegetation such as alder (Table 3.1) is another indication of increased flood stress because large older trees are known to be more tolerant to flood stress than small younger trees. So, it appears that the younger trees succumbed to flood stress leaving a scattering of large older trees interspersed with the more flood-tolerant alder. As discussed earlier, the increased flood stress is thought to have begun around the late 1830’s. The increase in flood stress appears to have been high enough to cause die-off of some of the smaller and less flood-tolerant trees and prevent the germination of trees since that time, but not high enough to cause the die-off of the large older trees, which had germinated and grew to maturity when flood stress was much lower (i.e., pre-1838).

*West central basin*

The marsh basin further to the west, near present day Wake Robin Trail, was also dominated by alder with scattered large trees (Figure 3.47, bottom). The southern edge of the marsh basin near the large ravine is marked as “Woods” indicating a more closed canopy. This was probably an area of swamp forest that survived the increased flood stress because of its location at a point of higher elevation (578.5 feet: Kucera, 1966) as compared to the area north of this where elevations are substantially lower (577.0 to
576.5 feet: Kucera, 1966). Interestingly, this is the location of one of the few remaining areas of swamp forest within the marsh basin today, which is also a time of high flood stress (Section 3.4.1.1).

The vegetation of the west central marsh basin (Figure 3.47, bottom), to the west of present day Wake Robin Trail, is described as,

Swampy, with bogs formed by the intertwining of the roots of alder bushes and large trees scattering difficult to cross on account of density of vegetation and the danger of stepping between bogs where soft mud and water holes are abundant.

At this location we also find alder bushes interspersed with large trees and open bogs. The many open water bogs and mud holes in deeper areas interspersed with alder and large trees also reflects the diverse microtopography of the marsh basin a feature that is associated with northern deciduous swamp forests in Ohio (Sampson, 1930; Anderson, 1992; Fineran, 1999).

*Western Basin*

The western basin is shown in Figure 3.48 (top). There is no evidence that the basin morphology within the western basin as shown in this figure had changed from its presettlement condition owing to any anthropogenic modifications. But, there is some indication that there had been an increase in flood stress within the western basin owing to the wetter climate. This is seen in the note along the perimeter of the open marsh describing stumps of large trees surrounded by swamp grass (Figure 3.48, bottom).
Figure 3.48: Western basin of Mentor Marsh in 1874. Portion of map (top) showing entire western basin. Portion of map (bottom) showing note regarding vegetation along the southern perimeter of open marsh in the western basin.
The map (Figure 3.48, top) shows a stream channel formed in the middle of the western basin just downstream from the Marsh Creek confluence with the marsh basin. Marsh Creek has a much larger watershed than Blackbrook but because it joins the water flowing within the marsh basin near the marsh basin’s western confluence with Lake Erie it only affects the western basin. An exception would be in times of flow reversal such as during strong seiche events. The stream divides and circles around both sides of what appears to be a slightly elevated area in the basin and then rejoins on the northern side and then opens into a pooled area along the northern bank. The stream spreads in a northwestern direction until it encounters the sand bar formed across the mouth of the confluence between the western end of Mentor Marsh and Lake Erie. It flows westward along the sand bar to a location a few hundred yards west of what is today Mentor Harbor until it reaches its outlet into Lake Erie shown as a breach in the sand bar (Figures 3.49). The breach is indicated with arrows pointing out into Lake Erie. A note reads, “During spring freshets the water in the marsh forces its way through the sandbar at this point.” This indicates a seasonal draw-down of water levels in the marsh and the effect of seasonal flood events on the periodicity of water levels near points of confluence with the Lake as discussed earlier. It is also interesting to note the depth of water within the channel near the western end of the sand bar: 5.3 to 10.2 feet.

The vegetation near the Marsh Creek confluence (Figure 3.48, bottom) is described as,

“Swampy covered with bogs of various sizes, between them mud holes hence dangerous to cross here Vegetation: low swamp grass and stumps of large trees scattering.”
Figure 3.49: Note on the 1874 map describing the seasonal blowout of sandbars at the mouth of the western basin.
The map (1874) shows that the western basin of the marsh is still dominated by open marsh as described by Holley in 1796. The note regarding the scattered stumps of large trees surrounded by swamp grass is further evidence that water levels had increased at the western end of the marsh basin as discussed previously.

A note recording the water level behind the sand bar (Figure 3.50) blocking the mouth of the western basin tells us that water levels were 2.36 feet above lake level behind the sand bar indicating that the occurrence of a sand bar at this point of confluence had the potential to temporarily elevate water levels (increase retention time) thereby increasing the duration of flood stress within this area of the marsh basin. This is an interesting note regarding the spatio-temporal dynamics of sand bars and the role of the long shore movement of sand in the landscape dynamics for Lake Erie coastal systems and their natural flow regimes. Disturbance of these regimes no doubt had ecological consequences for the plant assemblages in these coastal environments.

The Lake survey map of Mentor Marsh: 1876

The Corps of Engineers also made a survey map that shows Mentor Marsh in 1876. The map was done as part of a survey of the coastline of the “N. & N.W. Lakes” (Figure 3.51). The map focuses on the shoreline providing soundings for the near shore area of Lake Erie. This is in contrast to the 1874 map, which focuses on the “old basin of the Grand River” (i.e., Mentor Marsh) itself. Compared with the 1874 map, the 1876 map provides little detail on the vegetation or hydrology of the marsh during that time period. But, it does indicate density of tree cover using symbols. The 1874 map described the
Figure 3.51: 1876 map showing all of the marsh basin.
density of tree cover as “scattering” in many locations within the marsh basin. The 1876 map provides a graphical representation of tree cover in the marsh basin. Obviously, the use of the tree symbols on the 1876 map does not mean that each tree symbol used within the marsh basin depicts an individual tree but rather that we should look at the different density of symbols used across the map as a whole to get an idea of the range in density the cartographer is attempting to convey and then evaluate the density of tree cover within the basin in a relative, qualitative manner. Using this approach we see that the northeastern basin was devoid of trees by 1876 (Figure 3.52). The southeastern basin had trees scattered throughout (Figure 3.52). The east central basin had no trees where the marsh basin is quite narrow (Figure 3.53). The central basin and west central basin also had trees scattered throughout (Figures 3.53 and 3.54). The western basin is shown with very few trees except along its southern perimeter (Figure 3.54). The edge between the open marsh and the more heavily forested area to the east of the Marsh Creek confluence with the marsh basin is depicted quite clearly in Figure 3.55.

Comparing plant species tolerance with ecological condition

The decrease in abundance of the swamp forest recorded by Pease and Holley in 1796 and the increase in abundance of alder and swamp grass corresponds with the difference in the plants’ flood stress tolerance. According to Table 3.1, the swamp forest tree species have low to moderate flood stress tolerance as compared to alder’s high flood stress tolerance. Although not represented by a particular plant species, the increase in open marsh also corresponds with increased flood stress. The scientific name of the plant species referred to as “swamp grass” is not known. The term “low” swamp grass is used
Figure 3.52: The portion of 1876 map showing the tree cover density in the eastern basin (left) and the portion of the Pease and Holley survey line describing the vegetative cover in 1796.
Figure 3.53: Portion of 1876 map showing the tree cover density in the east central basin (USCOE, 1876).
Figure 3.54: Portion of 1876 map showing the tree cover density in the west central basin (USCOE, 1876).
Figure 3.55: Portion of 1876 map showing the tree cover density in the western basin (USCOE, 1876).
when describing it in the western basin. It is possible that this term was used to describe burr reed (*Sparganium* spp.), which is known to occur in these areas of the marsh basin (Bissell pers. comm., 2003) but this is uncertain. For the purposes of estimating percent cover of wetland plant community type and for later use in the ecological model it is assumed that “swamp grass” is indicative of open marsh conditions rather than emergent vegetation.

*Wetland plant community type percent cover for 1874*

Vegetative change from 1796 to 1876 is one of die-off of swamp forest in the eastern basin and die-back of swamp forest within the central basin with increasing dominance by swamp grass, shrub scrub, and open bogs as well as an increase in the areal extent of open marsh within the western basin. These changes correspond to the concurrent increase in flood stress discussed in Section 3.4.1. As described in the methods section, percent cover for each wetland community type was estimated for the year 1874. The analysis yielded the following values for percent cover for 1874:

- Swamp forest: 30%
- Shrub scrub: 32%
- Emergent: 1%
- Open marsh: 37%

*Environmental stress regime in 1874*

The condition of the environmental stress regime in 1874 was moderate to high flood stress, no salt stress (i.e., freshwater conditions), no frequent fire disturbance, and moderate shade stress (i.e., less forested).
3.4.4.3 Change in vegetation, 1876 to 1959 A.D.

Overview

The change in vegetative condition between 1876 and 1959 was also quite dramatic. The growth (re-growth) of a dense swamp forest within the eastern and central basins during this time interval corresponds with a decrease in flood stress owing to several interacting factors. A drier climate is indicated by generally lower Lake Erie water levels and many years of below average annual precipitation (Section 3.4.1.1). Anthropogenic modifications in the drainage patterns at the eastern and westerns points of confluence with Lake Erie also had the potential to effect flood stress (Section 3.4.1.2).

By 1959, a dense swamp forest covered most of the marsh basin (Figures 3.56-60). The eastern basin and many areas of the central and west central basins were covered with swamp forest by 1937. An aerial view of Corduroy Road is partially obstructed by the dense growth of swamp forest that surrounds in 1937 (Figure 3.61). However, the north portion of the west central basin (Figure 3.61) and the area immediately adjacent to Shipman Pond (Figure 3.19) were less densely vegetated in 1937 than other parts of the marsh basin. The swamp forest continued to expand until 1959-1960 (Figure 3.61; Figures 3:56-60). The western basin continued as an open marsh until 1924 when Mentor Harbor was developed at this location as a harbor for pleasure craft (Section 3.4.1.2). And, the effect of the drought years of the 1930’s on the water levels within the marsh is shown quite clearly in the dry condition of Shipman Pond (Figure 3.19). The pond in this photograph, taken in 1937, is separated into two water bodies, large areas of shoreline are exposed, and the pond had no drainage into the relict meander bend at that time.
Figure 3.56: A series of four oblique aerial photographs showing the entire Mentor Marsh basin in 1960 (individual photographs shown in the following four figures: Figures 3.57, 3.58, 3.59, 3.60).
Figure 3.57: 1960 oblique aerial photograph of the eastern basin.
Figure 3.58: 1960 oblique aerial photograph showing the east central basin.
Figure 3.59: 1960 oblique aerial photograph showing west central basin.
Figure 3.60: 1960 oblique aerial photograph of western basin.
Figure 3.61: Aerial photograph taken in 1937 showing tree canopy cover over Corduroy Road and less dense tree cover in the northern west central basin.
The tremendous growth (re-growth) of swamp forest that occurred during the second time interval probably had begun by the late 1890’s concurrent with the drier climate (Section 3.4.1.1). The many large trees scattered across the marsh basin that had survive the prolonged period of flood stress as well as the remnant swamp forest along the edges of the marsh provided ample seed source when conditions became favorable for tree germination (i.e., lower flood stress). The seed bank probably also contributed to the rapid expansion of the swamp forest under the favorable conditions of low flood stress. We know that by 1937 a dense swamp forest once again dominated the marsh basin (Figure 3.62, top) and continued to increase in density until 1959 (Figure 3.62, bottom; Figures 3.56-3.60). The density and extent of the swamp forest within the marsh basin is most clearly shown in the series of oblique air photos of the marsh flown in 1960 presented above (Figure 3.56-60).

Analysis of Aldrich’s 1937 study of Mentor Marsh
A study performed by John Aldrich (1937; 1943) of the marsh during the 1930’s provides some of our best information on the vegetative communities growing in the marsh basin during this time. Aldrich did a study of the swamps and bogs in northeastern Ohio in the 1930’s selecting Mentor Marsh as an example of the swamp forest community in this region. As part of this study, he describes the swamp forest, a buttonbush and alder community, and the vegetation of Norton Pond (known today as Shipman Pond) at Mentor Marsh.
Figure 3.62: Aerial photographs taken in 1937 (top) and 1951 (bottom) showing extent of swamp forest within the marsh basin.
Aldrich’s study focused on the vegetative communities within the eastern basin. He ran a transect from east to west across Norton Pond and sampled a 45-meter quadrat somewhere within the swamp forest. He also provided a description of an area dominated by alder and buttonbush (Aldrich, 1937). Unfortunately, neither his dissertation (Aldrich, 1937), nor his paper published in the American Midland Naturalist (Aldrich, 1943), provide an exact location for his study areas.

Aldrich described the dominant vegetative community at Mentor Marsh during the time of his study as a maple-elm-ash swamp forest (Aldrich, 1943; Aldrich, 1937). The 1937 aerial photograph (Figure 3.61, top), shown above, supports Aldrich’s observation that a swamp forest dominated the marsh basin at that time.

The following is an excerpt from the American Midland Naturalist, Aldrich (1943), in which Aldrich described an area of swamp forest at Mentor Marsh:

This is the swamp forest of the true climatic prisere of northeastern Ohio commonly mentioned in the literature as characteristic of the deciduous forest region of northeastern North America. In the area covered by this report the red maple (Acer rubrum), silver maple (Acer saccharinum), white elm (Ulmus americana), black ash (Fraxinus nigra), white ash (Fraxinus americana), swamp white oak (Quercus bicolor), and pin oak (Quercus palustris), are the primary dominants. Sampson (1930) has adequately treated this community with respect to the major aspects of its tree composition. The presence of the black ash as a primary dominant should probably be considered as an indication of the intergradation between bog and typical swamp conditions, although the species is frequently present in swamp forest of otherwise non-boreal aspect. The black ash is also a characteristic tree of bog succession farther north, and it is replaced by white and other species of ash farther south.
Notice that Aldrich mentions many of the same species as that recorded by Pease and Holley in 1796 when flood stress was also low. The swamp forest had reoccupied the eastern basin with many of the same species present.

Aldrich provides a photograph of the swamp forest at Mentor Marsh in the journal article (Aldrich, 1943). The caption of the photograph states, “Acer-Ulmus-Fraxinus Associes at Mentor Marsh” and describes the swamp forest as having a “Dense ground cover of Royal Fern, Sensitive Fern and Lizard’s Tail,” which is visible in the foreground of the photograph. Anyone who has visited the small areas of remnant swamp forest located on the south side of the west central basin today (Figure 1.3) will notice the striking similarity between Aldrich’s description of the swamp forest that dominated the marsh basin during the time of his study and the small remnant areas that exist today. Figure 3.63 is a photograph taken within the remnant swamp forest on the southern edge of the west central basin in 2002. Two of the herbs pictured in the foreground of the photograph are royal fern (Osmunda regalis L.) and lizard tail (Saururus cernuus L.). Aldrich (1937) also lists yellow birch as a secondary dominant. This agrees with Pease and Holley’s field notes on the dominant tree species within the swamp forest in the eastern basin in presettlement times (1796) and with studies done in the swamp forest remnants in later studies (Greenwald et al., 1980; Hildebrant, 1991; CMNH, 2000).
Figure 3.63: Remnant swamp forest on the southern edge of the west central basin in 2002 showing herbaceous plant species in the foreground. The tall ferns are royal fern and the smaller herbs with the drooping white flower are lizard tail.
Aldrich (1943) describes the physical environment of the swamp forest in Mentor Marsh and its hydroperiod:

The substratum of the *Acer-Ulmus-Fraxinus* Associes is composed of firmly packed peat, particularly on the surface where it is firmly held together by the roots of trees and lesser plants. Although flooded with water in the winter and spring, during the summer the peat frequently becomes exceedingly dry.

Table 3.3 summarizes the results from Aldrich (1937) 45-meter quadrat of swamp forest at Mentor Marsh.

Aldrich (1943) also describes the *Cephalanthus-Alnus* Associes (Buttonbush-Alder community) using a site at Mentor Marsh as an example. The two plant species that dominate this community type are buttonbush (*Cephalanthus occidentalis* L.) and speckled alder (*Alnus rugosa* (Duroi) Sprengel). This site was probably just south of Norton Pond because it was recorded as dominating this area a few years later by Isard (1966), but, again, its exact location is not provided by Aldrich.

Aldrich (1943) describes the immediate physical environment of the area dominated by buttonbush-alder and its hydroperiod:

In primary succession the swamp shrub stage in northeastern Ohio has buttonbush (*Cephalanthus occidentalis*) or smooth alder (*Alnus rugosa*) or both as primary dominant species. The substratum is usually a soft oozy peat difficult to walk on except where the roots of the shrubs have formed a frail platform. The soil is covered with water except during the summer and autumn and even then the water seldom gets more than a few centimeters below the surface.

Again, notice the presence of alder (*Alnus rugosa*) within the marsh. At this point in time, alder appears to be restricted to the area south of Shipman Pond. Compare this with the
<table>
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<th>Estimated number per hectare</th>
<th>acre</th>
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</tr>
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<td>14.8</td>
<td>5.9</td>
</tr>
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<td>Winterberry</td>
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<td>4.9</td>
<td>0.9</td>
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<tr>
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<td>4.9</td>
<td>1.9</td>
</tr>
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<td>Poison ivy</td>
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<td></td>
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</tr>
<tr>
<td>Royal fern</td>
<td>Rank growth</td>
<td></td>
<td></td>
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<td>Spotted touch-me-not</td>
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</tr>
<tr>
<td>Bitter-sweet</td>
<td>Scarce</td>
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</tr>
</tbody>
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Table 3.4: Results from Aldrich (1937) study using a 45-meter quadrat within the swamp forest at Mentor Marsh performed September 1936.
description on the 1874 map indicating the dominance of alder over most of southeastern portion of the marsh basin and alder bush with large trees scattering in the central basin. The area described by Aldrich above was covered in swamp grass with much standing water in 1874 (Blunt, 1874).

A belt transect across Norton Pond was sampled in October of 1931. The transect’s location was described by Aldrich (1943) as “extending from a hawthorn pasture on one side of the pond across open water to a pin oak swamp forest on the other side.” The primary dominant plant species as recorded by Aldrich for this transect in 1931 are: pond-weeds spp.; large yellow water-lily; swamp loosestrife; buttonbush; pin oak; and willow spp. A photograph taken by C.M. Shipman in the early 1900’s shows dense vegetation surrounding Shipman Pond (Figure 3.64).

**Phragmites within the marsh basin**

It appears *Phragmites australis* has been present within the marsh basin for at least one hundred years or more. The Cleveland Museum of Natural History’s herbarium has a voucher of *Phragmites australis* collected from Mentor Marsh in the 1892 by William C. Werner (Bissell, pers. comm., 2003). Another piece of evidence showing that *Phragmites australis* was present at Mentor Marsh before its rapid expansion during the third and fourth time intervals is a photograph depicting *Phragmites* within the marsh basin taken during the second time interval in the late 1920’s (Figure 3.65). So it appears that *Phragmites* was present at Mentor Marsh during the early time intervals but not very abundant.
Figure 3.64: Hand-painted lantern slide taken of Shipman Pond in the early 1900’s by CM Shipman. Photograph reproduced with the kind permission of Gretta Pallister and the Cleveland Museum of Natural History.
Figure 3.65: *Phragmites* at Mentor Marsh in the late 1920’s. Hand painted lantern slide by C.M. Shipman (reproduced with the kind permission of Gretta Pallister and the Cleveland Museum of Natural History).
Comparing plant species tolerance with ecological condition

The shift to a drier climate, as indicated by generally low lake levels and several periods of below average annual rainfall (Section 3.4.1.1), indicates that the second time interval was a time of decreased flood stress within the marsh basin. Changes at hydrologic control points, such as the reestablishment of a stream draining the eastern basin and the filling of wetlands in the relict meander bend (Section 3.4.1.2), may also have kept flood stress low during this time. The dramatic growth of swamp forest within the marsh basin between 1876 and 1959 corresponds to the shift to a drier climate and is most evident when comparing the 1874 map to the 1960 oblique air photo (Figure 3.43 and Figures 3.56-60 respectively). Aldrich’s study within the marsh basin and Shipman’s beautifully hand-painted lantern slide also clearly portray the vegetative condition of Mentor Marsh within the marsh basin during this time period. Table 3.1 shows the low flood stress during this time period was favorable for the expansion of swamp forest within the marsh basin because many of the tree species recorded by Aldrich have low to moderate flood stress tolerance.

Wetland plant community type percent cover for 1951

As described in the methods section, percent cover for each wetland community type was estimated for the year 1951. The analysis yielded the following values for percent cover for 1951:

- Swamp forest: 86%
- Shrub scrub: 12%
- Emergent: 1%
- Open marsh: 1%
The very low value for open marsh is because of the loss of the extensive wetland in the western basin owing to the development of Mentor Harbor in 1924 (Figure 3.15; Section 3.4.1.2).

*Environmental stress regime in 1951*

The condition of the environmental stress regime in 1951 was low flood stress, no salt stress (i.e., freshwater conditions), no frequent fire disturbance, and high shade stress (i.e., heavily forested).

The outstanding ecological attributes of Mentor Marsh led to its designation as a Natural History Landmark of the United States on May 12, 1966. But, both natural and anthropogenic changes in the landscape during the decades to follow would once again lead to changes in vegetative community type within the marsh basin. These changes would threaten to completely eliminate swamp forest from the Mentor Marsh basin by the year 2000 despite its almost total dominance of the marsh basin in 1951. It is important to note that the changes that led to this occurred from outside of the marsh’s boundaries and therefore outside of its jurisdictional protection from harm at that time.

**3.4.4.4 Change in vegetation, 1959 to 1976 A.D.**

*Overview*

The change in vegetative condition between 1959 and 1976 was quite dramatic. Reports of tree die-off began as early as 1959. Local citizens who had grown up in the area and had spent much of their childhood playing in and around the swamp forest were deeply
moved as they watched the forest succumb. A forest of tall gray standing dead trees began to cover large areas of the marsh basin. People began to ask why the trees were dying and what could be done to stop it. A strong sense of local heritage and a conservation ethic led many to organize to try to protect the swamp forest from further loss and studies were undertaken to determine the cause of tree die-off. Analysis of historical records suggests the die-off of the swamp forest was the result of several interacting factors.

The co-occurrence of another period of increased flood stress and the beginning of salt stress within the marsh created conditions that caused the shift in the vegetative condition of the marsh basin from swamp forest to emergent vegetation. Salt stress in the marsh basin is clearly attributed to anthropogenic pollution both from the waters of Blackbrook, a tributary entering the marsh basin at its extreme southeastern corner and, to a lesser extent, the fugitive salt dust from the salt storage piles within the relict meander bend. The salt pollution entering the Blackbrook tributary to Mentor Marsh had the potential to flow throughout the marsh basin, both to the east to Shipman Pond and to the west to Mentor Harbor because of the flow reversal that had occurred within the marsh basin sometime before presettlement, as discussed previously (Section 2.2.6). Therefore, the salt pollution of Blackbrook had the potential to affect the entire marsh basin. Both the brine well fields and a salt fill placed within the watershed of the Blackbrook tributary to Mentor Marsh contributed major amounts of salt pollution to the marsh basin during the third time interval; 1959 to 1976.
Another factor contributing to the shift in wetland community at this time was increased flood stress. A wetter climate, as indicated by higher Lake Erie water levels and above average annual precipitation (Section 3.4.1.1), was reinforced by several obstructions to flow introduced during this time (Section 3.4.1.2). Comparison of the 1960 aerial photographs (Figures 3.56-60) and a 1975 aerial photograph (Figure 3.66) shows the dramatic change in vegetation that occurred during this time interval.

*Analysis of Isard’s 1966 study of Mentor Marsh*

Between 1959 and 1966, as large areas of the swamp forest died, emergent vegetation, primarily *Typha* spp. (cattails), replaced it. Interestingly, ten years later (from 1966 to 1976) *Phragmites australis* had increased in areal extent until it was the dominant plant, replacing the *Typha* spp. in many areas of the marsh basin.

In 1966, Isard did a vegetative study of the marsh basin including an assessment of the changes in vegetation that had occurred since the swamp forest began to die in 1959. Isard’s findings provide information on change in wetland community type and his views, at that time, on the cause of die-off in different areas of the marsh basin.
Figure 3.66: 1975 oblique aerial photograph showing Mentor Marsh with standing dead trees, shrub, and emergent vegetation.
In the summer of 1966, Isard identified five plant communities within the Mentor Marsh basin:

1.) American Beech-Sugar Maple Forest;

2.) Mixed Oak Swamp Forest;

3.) Red maple-White Ash-American Elm Swamp Forest;

4.) Cattail-Nightshade Community; and

5.) Buttonbush-Willow Community.

He provides a site map depicting the location and areal extent of each of these communities within the marsh basin (Figure 3.67).

The beech-maple community described by Isard was located in the upland so I do not include it in my study of plant community change within the marsh basin.

The mixed oak swamp forest discussed by Isard was located along the eastern edge of the marsh bordering State Route 44. For this location, Isard describes a stand of pin oak in the extreme north. Further south, black oak and swamp white oak dominated the forest stand with American elm, red maple, and sugar maple described as the “secondary dominants.” Within the mixed oak swamp forest, “in the wettest portions” there were buttonbush and speckled alder. Isard describes this area as being completely flooded in spring. Early to mid-summer there were isolated areas with water up to one foot in depth. By late summer, no standing water was found in this area. Isard tells us this area blends
Figure 3.67: Isard’s (1966) map of Mentor Marsh showing the location and extent of the 5 different plant communities he identifies during the time of his study.
gradually into the elm-ash-maple swamp forest to the east. Isard’s description of this area in 1966 is very similar to Aldrich’s description in the 1930’s (see Section 3.4.4.3).

In fact, for his description of the buttonbush-willow community he refers the reader to Aldrich’s (1937) work performed in 1931, stating “Although this site has been reduced in size by natural plant succession since 1931, the work done by Dr. Aldrich is probably still applicable.”

Isard estimates the area covered by the maple-ash elm swamp forest in 1966 to be 450 acres and states that it is “the most extensive plant community at Mentor Marsh.” He also tells us, “the largest unbroken stand of this forest type encompasses the entire northern and eastern extremes of the marsh.” He also notes a “narrow band along most of the southern border.” This latter site corresponds to the location of the largest area of remnant swamp forest within the marsh basin today. There are very small remnant areas along the western edge of the northeastern basin today as well (Figure 1.3).

To assess the maple-ash-elm swamp forest community, Isard used four line transects 150 meters in length that ran from the southern edge of the marsh to the cattail-nightshade community located to the north. These four transects were located within the west central basin (to the west of Corduroy Road) within the “narrow band” of swamp forest that covered “most of the southern border” in this area in 1966. The exact location of the transects within this “narrow band” is uncertain. Photographs taken by Isard as he proceeded from south to north along one of the transects are shown in Figure 3.68. The
Figure 3.68: Photographs taken in 1966 by Isard along a transect proceeding from the remnant swamp forest along the southern edge of the west central basin (top left) to the north into the open marsh dominated by standing dead trees and *Typha* spp. (bottom right).
photographs portray quite clearly the transition from swamp forest thickly vegetated with many of the species observed in 1796 by Pease and Holley, by Aldrich in 1936, and today to an area with standing dead trees surrounded by *Typha* spp. (cattails).

The tree species that dominated the swamp forest varied in relative abundance among the different locations of swamp forest within the marsh basin. Isard noted that in the eastern basin, which was the largest area of swamp forest at that time, American elm, white ash, and red maple were the dominant tree species; listed in order of abundance. In the central basin along the southern border of the marsh basin, red maple, yellow birch, white ash, American elm and black ash were the dominant tree species, again in order of abundance. Isard tells us that the zone of dead trees began 60 meters north of the break in slope along the southern border of the marsh basin. This leads Isard to conclude that a “soil moisture gradient was a significant factor to the 1959 tree kill which took place in this area.” The ash identified as white ash by Isard was probably pumpkin ash (*Fraxinus profunda* (Bush) Bush) (Bissell pers. comm., 2003).

Isard mentions three types of shrubs growing in the central basin along the southern border of the marsh when he sampled: speckled alder, highbush blueberry (*Vaccinium corymbosum* L.), and winterberry (*Ilex verticillata* (L.) A. Gray). The speckled alder he notes as being in “isolated dense stands” to the south but decreasing in abundance further to the north near the open marsh. Both the highbush blueberry and winterberry were associated with the hummocks of the swamp forest as they are today in the remnant swamp forest within this area.
The herbaceous plant species Isard listed for this area includes: royal fern, cinnamon fern, sensitive fern (*Onoclea sensibilis* L.), and lizard tail. These species were also noted by Aldrich (1937) as growing in the swamp forest of the eastern basin in the 1930’s. Royal fern, cinnamon fern, and lizard tail are characteristic of the swamp forest in this location today as discussed previously.

The cattail-nightshade community is located in the central basin (Figure 3.67). Isard tells us that both *Typha angustifolia* L. (narrow-leaved cattail) and *Typha latifolia* L. (broad-leaved cattail) occur within the cattail stand. Isard describes the cattail stand as having many standing dead trees. On the hummocks surrounding the larger of the dead trees he notes the growth of American elm, red maple and white ash seedlings and saplings as well as other shrub and herbaceous species some of which were commonly associated with swamp forest community.

Isard states that within the central basin there is a very clear line separating the living trees from the dead trees. But, there is no clear line between the living trees and the dead trees within the eastern basin. He tells us that both dead and living trees are found together and that there are trees with only one or two living branches near the top and trees with only living branches on one side of the trunk. If wind blown salt was a contributing factor this could account for the death of branches along only one side of a tree, although Isard does not tell us which side of the trees were affected. It is interesting to note that there were no large areas of *Phragmites* at this time. Instead, the area where the swamp forest had died was dominated by *Typha* spp (cattails).
Isard does mention _Phragmites_ (referred to as giant reed) as occurring in the marsh basin and describes where it is located:

In addition to the cattails and nightshade, stands of giant reed are quite conspicuous as they grow to heights of five to seven feet. The most extensive stands of this plant are located to the east of the elevated sewer line and along both sides of Corduroy Road.

The height of _Phragmites_ within the marsh basin in 1966 is recorded as 5 to 7 ft. Later, as _Phragmites_ increased in dominance, the height of _Phragmites_ within the marsh basin reached approximately 12 ft. It is interesting to note that Corduroy Road, where Isard notes that _Phragmites_ first expanded in the marsh basin, had the highest water salinity levels within the marsh basin when water salinity was measured in 1969 by Rand Corporation (Rand, 1969). This will be discussed in more detail later in this section.

_Wetland plant community type percent cover for 1966_

Because of the rapid change in the vegetative condition of the marsh during the third interval, percent cover was estimated at two points in time to represent better vegetative change as it occurred. As described in the methods section, percent cover for each wetland community type was estimated for the year 1966. The analysis yielded the following values for percent cover for 1966:

- Swamp forest: 47%
- Shrub scrub: 2%
- Emergent: 50%
- Open marsh: 1%
Distinguishing between the two emergent plant species yields the following results for estimated percent cover for 1966:

- Swamp forest: 47%
- Shrub scrub: 2%
- *Typha* spp.: 49%
- *Phragmites*: 1%
- Open marsh: 1%

**Environmental stress regime in 1966**

The condition of the environmental stress regime in 1966 was moderate to high flood stress, moderate to high salt stress (i.e., oligosaline conditions), no frequent fire disturbance, and moderate shade stress (i.e., partially forested).

**Analysis of Bernstein’s 1976 study of Mentor Marsh**

Bernstein (1977; 1980; 1981) conducted a study of red-winged blackbirds (*Agelaius phoeniceus*) at Mentor Marsh in the spring, summer, and fall of 1976. He provides information on ecological change at Mentor Marsh by comparing his observations on the vegetative condition of the marsh basin with Isard’s (1966) findings.

Bernstein selected three study areas for his fieldwork which he designated Study Area A, B, and C (Figure 3.69). Study Area A was located northeast of Corduroy Road. The approximate dimensions of Study Area A were 70m (measured perpendicular to the edge of the marsh) by 100 m (measured parallel to the edge of the marsh) with an area of approximately 17.3 acres. Bernstein tells us the dominant plant species of Study Area A in 1976 was *Typha* spp., but *Phragmites* was also present. He also notes an
Figure 3.69: Map showing Bernstein’s (1977) study areas for his field work at Mentor Marsh conducted in 1976.
area of swamp forest along the edge of the marsh at this location with white ash, red
maple, silver maple, and American elm. The swamp forest extends from the edge of the
marsh to approximately 20 meters into the basin. An area of dense ferns with cinnamon
fern, royal fern and sensitive fern is found about 20 to 30 meters from the edge of the
marsh basin growing on hummocks within an area of standing water 3 to 4 feet in depth.
Cattails dominated the area from 50 to 70 meters from the edge of the marsh basin with
many dead trees with plants growing on their hummocks. Bernstein also noted several
areas of open water in this area. This area is entirely dominated by *Phragmites* today
(2002) transitioning to upland forest at the marsh basin’s edge. This indicates swamp
forest was lost in that area sometime between the time of Bernstein’s study in 1976 and
present day (2002).

Study Area B was located southwest of Corduroy Road (Figure 3.69). The approximate
dimensions of Study Area B were 50 m (measured perpendicular to the edge of the
marsh) by 100 m (measured parallel to the edge of the marsh) with an area of
approximately 12.36 acres. Bernstein tells us the first 10 to 15 meters of this area was
dominated by swamp forest including white ash, red maple, swamp white oak, and
American elm. A band of *Typha* spp. dominated the area that extended another 35 to 40
meters into the marsh basin and was then replaced by *Phragmites* near “the border of the
study area.” Again, the ash identified by Bernstein as white ash was probably pumpkin
ash (Bissell pers. comm., 2003).
Study Area C was located east of Corduroy Road along the southern edge of the marsh basin near the Kervin Trail Lookout (Figure 1.3) just west of the old mouth of Blackbrook (Figure 3.69). The approximate dimensions of Study Area C were 60 m (measured perpendicular to the edge of the marsh) by 100 m (measured parallel to the edge of the marsh) with an area of approximately 14.83 acres. Bernstein tells us Study Area C was “an almost uniform stand of common reed.” He did note the occurrence of *Typha* spp. around the edge of a small open pond in this area. He tells us that the only other plants observed were “occasional vines of bittersweet nightshade and poison ivy.” This sounds very reminiscent of Isard’s photographs of the area taken in 1966 (Figure 3.68, bottom right).

From Bernstein’s descriptions the central basin had remnant areas of swamp forest near the edges of the marsh basin, cattails adjacent to the swamp forest remnants, with *Phragmites* in the middle of the marsh basin and near the mouth of Blackbrook.

Bernstein also discussed vegetative change within the marsh basin. He states that the buttonbush willow community at Shipman Pond observed by both Aldrich in 1931 and Isard in 1966 is no longer there, which he attributes to increased water levels owing to the beaver dams at the northeast corner of Shipman Pond. He also tells us that the mixed-oak swamp forest and the maple-elm-ash swamp forest of the eastern basin as described by Isard in 1966 were almost all dead trees at the time of his study in 1976. And, he tells us that the large stand of maple-elm-ash swamp forest located in the western basin (extending from the eastern edge of Becker Pond to the northwestern corner of the marsh
as described by Isard in 1966, see Figure 3.67) was also dead by 1976. Of the areas of swamp forest discussed by Isard, only the swamp forest along the southern border of the marsh basin (beginning west of Corduroy Road and extending to Becker Pond) remained in 1976. Bernstein tells us that the central and southeast portion of the marsh, which Isard describes as the cattail-nightshade community in 1966, had been almost entirely replaced by *Phragmites* by 1976. From Bernstein’s description, it appears that there were very drastic changes in wetland community type during this ten year time period.

Bernstein summarizes his observations of the vegetative condition of Mentor Marsh in 1976 by stating that much of the marsh was covered by emergent marsh vegetation with *Phragmites* “now the dominant marsh plant.” He estimates *Phragmites* covered 60 to 70 percent of the marsh basin.

*Wetland plant community type percent cover for 1976*

As described in the methods section, percent cover for each wetland community type was estimated for the year 1976. The analysis yielded the following values for percent cover for 1976:

- Swamp forest: 10%
- Shrub scrub: 1%
- Emergent: 89%
- Open marsh: 1%
Distinguishing between the two emergent plant species yields the following results for estimated percent cover for 1976:

- Swamp forest: 10%
- Shrub scrub: 1%
- *Typha* spp.: 24%
- *Phragmites*: 65%
- Open marsh: 1%

**Comparing plant species tolerance with ecological condition**

The shift to a wetter climate, as indicated by high lake levels and above average annual rainfall (Section 3.4.1.1), indicates that the third time interval was a time of increased flood stress within the marsh basin. Changes at hydrologic control points, such as the filling of the stream draining the eastern basin in 1959, beaver dams at the mouth of Shipman Pond, and several hydrologic obstructions within the marsh basin (Section 3.4.1.2) may also increased flood stress during this time. The rapid and complete die-off swamp forest of all ages, sizes, and species in most areas of the marsh basin between 1959 and 1976 exceeds the expected response of the vegetation to increased levels of flood stress alone. Looking back to the years of high flood stress within the marsh basin in the first time interval (1838 to 1876) we would expect to see a die-back of swamp forest in many parts of the marsh basin especially in the central basin with the larger trees able to withstand the increased flood stress for a longer period of time. But, during the third time interval there is a complete die-off of swamp forest over almost all the areas that were forested. According to Table 3.1, the loss of the swamp forest plant species corresponds to their expected response to higher flood stress because of their low to moderate flood stress tolerance. It is important to note, however, that unlike the first time
interval of increased flood stress, speckled alder did not increase in abundance with the occurrence of higher flood stress. A clue to why it did not is speckled alder’s inability to tolerate salt stress. Speckled alder has no salt stress tolerance (Table 3.1). The increase in salt stress kept speckled alder from expanding into areas of the marsh basin that were experiencing increased flood stress because of the high levels of salt stress in these areas. Isard describes the zonation of alder along the southern edge of the west central basin stating that it was in “isolated dense stands” to the south but decreased in abundance further to the north near the open marsh. This is quite different from the response of the vegetation in the west central basin in 1874 to increased flood stress when this area was dominated by speckled alder and interspersed with many large trees (Figure 3.47; Figure 3.54). Also of importance is the switch in dominance from the emergent Typha spp. to the emergent Phragmites between 1966 and 1976. Both plant species have high flood stress tolerance. Phragmites, however, has higher salt stress tolerance than does Typha spp (Rechav, 1967; van der Toorn, 1972). And, interestingly, the difference in their levels of salt stress tolerance appears to have acted as a sorting mechanism that is portrayed quite clearly when comparing the water salinity results presented in Section 3.4.2.4 with the plant species’ salt tolerance.

Comparing water salinity with plant tolerance for the third time interval

Using Cowardwin et al’s (1979) salinity modifiers as discussed in Section 3.4.2.4, freshwater condition is represented 500 mg/L, which is used for the maximum chloride concentration for the “no risk” category. The range 500 to 5,000 mg/L represents oligosaline conditions for inland wetlands. Oligosaline, a subcategory of the mixosaline
category, commonly known as brackish water, is the level of salt stress most commonly measured in Mentor Marsh since the beginning of salt pollution to the marsh basin in 1959 (Section 3.4.2.4). Therefore, we find that the chloride concentrations addressed in this study usually vary between freshwater conditions (0 to 500 mg/L) and the lower range of the mixosaline (oligosaline) category of 500 to 5,000 mg/L. But, as discussed previously (Section 3.4.2.4), events of hypersaline salt intrusions did occur during the third time interval creating saline conditions beyond what any of the vegetation available in the marsh basin could survive for any prolonged exposure. The more typical range of 500 to 5,000 mg/L happens to be the range of salinity to act as a sorting mechanism between those wetland plant community types present in the marsh basin at the time of salt stress. It is interesting to note that in marine coastal environments, such as along the Atlantic coast in the eastern United States that the potential salinity levels for that environment act as a sorting mechanism between those wetland plant community types. The interesting difference is that *Phragmites* is one of the less salt stress tolerant plants (favored within the oligohaline, 500 to 5,000 mg/L, subcategory of the mixosaline category) as compared to other plants present in these environments such as the more salt tolerant *Spartina alterniflora* (favored within the polyhaline, 18,000 to 30,000 mg/L, subcategory of the mixohaline) (Chambers et al., 2002). Although there are additional factors to consider in these environments as well, such as flooding depth, frequency and sulfide concentrations suggesting restoration strategies for the control of *Phragmites australis* in these environments (Chambers et al., 2002). Unlike these coastal marine environments, the plant species of the freshwater coastal environment of the Great Lakes are not adapted to salt stress. In this environment, *Phragmites* is the most salt tolerant.
plant species present and therefore water salinity ranging between freshwater and brackish conditions acts to sort plant species in favor of *Phragmites* abundance. This is an interesting example of the need to consider all three of Gleason’s points in his individualistic plant community concept: plant species requirements, environmental conditions, and the plant species present (or available – seed dispersal, seed bank, etc.) at a site. It also demonstrates the need for restoration strategies designed to restore native plant communities to be tailored for local site conditions within a historical context. For example, *Phragmites australis* may be controlled by manipulating water salinity to less than 500 mg/L for restoration of swamp forest or speckled alder community types at Mentor Marsh in the freshwater environment of the Lake Erie coast, as compared to the reestablishment of marine intrusions to produce polysaline conditions, 18,000 to 30,000 mg/L to restore *Spartina alterniflora* (saltmarsh cordgrass) in the estuarine, intertidal, emergent wetlands on the Atlantic coast.

In light of the above discussion and results for the vegetative analyses of the third time interval, the salinity hazard criteria discussed in the methods section are presented using the results of water salinity analyses of Section 3.4.2.4. Specifically, the water salinity at different locations within the marsh basin is compared to the salt tolerance of the plant species occupying the sites to assess the potential impact of salt stress on the marsh vegetation.

Figure 3.70 shows water salinity at Blackbrook in 1969 was well above the maximum salinity tolerance of any of the plant species including *Phragmites australis* (red line). In
Figure 3.70: Comparison of water salinity at Blackbrook from 1969 to 1975 to maximum chloride tolerance for plant species. Water salinity is the average water salinity measured at the Blackbrook location for each study period. Based on data from Rand (1969), Hauser (1971), and Jones (1976).
1971, the water salinity at Blackbrook was in the no risk zone (below the blue line) and in 1975 the water salinity exceeded the tolerance limit of all plant species except *Phragmites*. Bernstein tells us that *Phragmites* dominated the area around Blackbrook’s confluence with the marsh basin in 1976.

Figure 3.71 shows water salinity for Shipman Pond located in the northeastern basin. In 1969 and in 1975, water salinity at Shipman Pond exceeded the tolerance limits of the sensitive swamp forest plant species but did not exceed the tolerance limits of either *Typha* spp. or *Phragmites*. In 1971, water salinity was in the zone where the swamp forest was experiencing salt stress but not above its maximum tolerance limit. Sometime between 1966 and 1976 the swamp forest began to die in the eastern basin, which Bernstein describes in 1976 as almost all standing dead trees.

Figure 3.72 shows water salinity for Corduroy Road located in the central basin. In 1969, water salinity exceeded the tolerance limits of all plant species including *Phragmites*. In 1971, water salinity at Corduroy Road exceed the tolerance limit of the swamp forest plant species and the *Typha* spp. were experiencing some salinity stress but not beyond its maximum tolerance limit. In 1975, water salinity was exceeded the tolerance limits of
Figure 3.71: Comparison of water salinity at Shipman Pond from 1969 to 1975 to maximum chloride tolerance for plant species. Water salinity is the average water salinity measured at the Shipman Pond location for each study period. Based on data from Rand (1969), Hauser (1971), and Jones (1976).
Figure 3.72: Comparison of water salinity at Corduroy Road from 1969 to 1975 to maximum chloride tolerance for plant species. Water salinity is the average water salinity measured at the Corduroy Road location for each study period. Based on data from Rand (1969), Hauser (1971), and Jones (1976).
all plants species except *Phragmites*. Isard shows this as the cattail-nightshade community in 1966. Bernstein describes this area as completely dominated by *Phragmites* in 1976.

Figure 3.73 shows water salinity in the west central basin. In 1969, 1971, and 1975, water salinity in the west central basin exceeded the maximum tolerance limit for swamp forest. The water salinity for all three years was also high enough to cause salt stress for *Typha* spp. but not above its maximum tolerance limit. The water salinity was also well below the tolerance limit for *Phragmites*.

It should be recognized that these measurement were made relatively infrequently during a long period of salt stress within the marsh basin. The episodic nature of salt intrusions from the brine wells active in the Mentor Marsh watershed from the late 1950’s to 1976 (Section 3.4.2.2) suggest that not all salt pollution events were captured by the above measurements. Also, these are measurements of water salinity rather than pore water salinity at the root zone of the plants so that there may a discrepancy between what the plant was experiencing at the cellular level and the water salinity measured at sampling locations within the marsh basin. The cumulative nature (i.e., accumulation of salt in the soil) is also not considered in this analysis. The variability of salt tolerance by individual plants within a species according to life stage, size, and other site conditions (e.g., other environmental stresses) are also not considered. Despite these factors to consider, the
Figure 3.73: Comparison of water salinity in the west central basin from 1969 to 1975 to maximum chloride tolerance for plant species. Water salinity is the average water salinity measured in the west central basin for each study period (1969: culvert at Mentor Harbor; 1971: Becker Pond; 1975: Becker Pond). Based on data from Rand (1969), Hauser (1971), and Jones (1976).
above results show that the vegetation of Mentor Marsh was experiencing salt stress sufficient to account for the tremendous change in vegetative condition witnessed during this time interval.

The dramatic change in the vegetative condition of Mentor Marsh between 1959 and 1976 was the result of an increasingly complex environmental stress regime that the swamp forest was not able to tolerate. In addition to increased flood stress, there were large intrusions of salt pollution into the marsh as discussed in Section 3.4.2. The above analysis suggests that the emergent species, *Typha* spp. and *Phragmites*, were able to tolerate better the change in the environmental conditions (i.e., increased flood stress and increased salt stress) than the swamp forest plant species or the shrub scrub, speckled alder.

The role of the invasive nature of *Phragmites australis* and *Typha glauca* in the proliferation of emergent plant species within the marsh basin during this time period should also be considered. Galatowitsch et al. (1999) discuss the role of “invasion windows” in the dominance of wetland ecosystems by invasive species and remark that the removal of “botanical” and “non-botanical” barriers can lead to invasion by species such as *Phragmites australis* and *Typha glauca*. In the case of Mentor Marsh, the “invasion window” for these emergent plant species was created by the removal of swamp forest, which could be viewed as a botanical barrier to invasion because of its ability to outcompete *Phragmites* and *Typha* spp. by exerting shade stress. The “invasion window” was also created by the removal of a “non-botanical” barrier to invasion by the
change in water quality (e.g., increase in water salinity) at the site. Therefore, the
“invasion window” can be attributed to both increases in flood stress and salt pollution to
the marsh basin during the third time interval that led to removal of the swamp forest
over large areas of the marsh basin. Interestingly, Galatowitsch et al state “there is
evidence that hydrologic alterations could facilitate invasion by Typha x glauca and
Phalaris arundinacea and that increased salinity promoted spread of Typha angustifolia
(parental taxon) and Phragmites australis.”

_Environmental stress regime in 1976_

The condition of the environmental stress regime in 1976 was high flood stress, moderate
to high salt stress (i.e., oligosaline conditions), no frequent fire disturbance, and low
shade stress (i.e., very little forest).

3.4.4.5 _Change in vegetation, 1976 to 2000 A.D._

_Overview_

The change in vegetative condition within the marsh basin between 1976 and 2000 is
classified by the rapid expansion of Phragmites australis within the marsh basin. By
2000, Phragmites completely dominated the marsh basin with only a few small stands of
Typha spp. (cattails) interspersed with the _Phragmites_ within the west central basin.
Small areas of swamp forest remained along the southern edge of the west central basin
and along the western edge of the eastern basin.
The co-occurrence of high levels of salt stress, continued increase in flood stress, and the beginning of fire disturbance within the marsh during the time period 1976 to 2000 A.D. created conditions that reinforced the shift in the vegetative condition of the marsh basin towards increasing dominance by *Phragmites australis*. Salt stress in the marsh basin during this time period is clearly attributed to continued anthropogenic pollution of the waters of Blackbrook from the salt fill just upstream from Blackbrook’s confluence with the Mentor Marsh basin (Sections 3.4.2.3 and 3.4.2.4). A continued wetter climate maintained a high level of flood stress within the marsh basin during this time as well. This is indicated by a trend of higher lake levels and above average annual precipitation between 1976 and 2000 (Section 3.4.1.1). And, hydrologic obstructions to flow continued to reinforce high water levels and duration of flooding within the marsh basin during this time period (Section 3.4.1.2). The beginning of fire disturbance as a frequent occurrence within the marsh basin also acted to decrease swamp forest within the marsh basin and increase the abundance of *Phragmites* between 1979 and 2000 (Section 3.4.3).

*Greenwald’s study of remnant swamp forest in 1980*

In August 1980, Greenwald et al, working for the Cleveland Museum of Natural History, established a permanent transect that crosses the remnant swamp forest located along the southern edge of the west central basin. The transect was located using survey techniques referencing property lines along nearby Links Road and a permanent marker was established. Since their study in 1980, the transect has been resampled every 10 years (Hildebrant, 1991; CMNH, 2000).
The tree species that dominated the transect within the marsh basin were identified by Greenwald et al as red maple (*Acer rubrum*), white ash (*Fraxinus americana* L.), American elm (*Ulmus americana*), yellow birch (*Betula alleghaniensis*), and silver maple (*Acer saccharinum*). They indicate that royal fern (*Osmunda regalis*) was the dominant herbaceous species along the edge of the marsh basin, lizard’s tail (*Saururus cernuus*) was common from the edge of the marsh basin to approximately 100 meters, and winterberry (*Ilex verticillata*) was found all along the transect within the marsh basin. A stand of cattails (*Typha* spp.) dominated the transect from 65 meters to 165 meters, as measured from the edge of the marsh basin. *Typha x glauca* Godron, which is a hybrid of *Typha latifolia* and *Typha angustifolia*, is reported in the *Typha* stand also. The invasive nature of *Typha x glauca* is discussed by Galatowitsch et al (1999) suggesting that introgressive hybridization may contribute to its rapid spread in many wetland ecosystems in recent years. This study does not attempt to distinguish between the species of *Typha* found at the marsh but it is possible that *Typha x glauca*’s invasive behavior has played a role in the increase in abundance of *Typha* species within the marsh basin since the beginning of salt pollution to the marsh basin in 1959. This is uncertain. Greenwald et al’s study reports the presence of *Phragmites* approximately 165 meters from the edge of the marsh basin and the dominance by *Phragmites* at 205 meters. Greenwald et al also measured conductivity as a measure of water salinity. They state, “Conductivity readings are highest past the 200 meter mark” (185 meters from the edge of the marsh basin) “where the *Phragmites* begins to outcompete the cattails.” The
conductivity readings generally increased further into the marsh basin with the highest readings at the end of the transect, which was approximately 205 meters from the southern edge of the marsh basin.

Hildebrant’s study of remnant swamp forest in 1991

In 1991, Hildebrant et al (1992) re-sampled the transect established by Greenwald et al in 1980 and found that by 1991 the cattail (Typha spp.) stand had been reduced both by the expansion of swamp forest trees from the south and Phragmites from the north. Swamp forest trees replaced 10 meters of the cattail stand and Phragmites replaced approximately 30 meters of the cattail stand.

Ecotone vegetative dynamics

Today there are no Typha observed between the swamp forest to the south and the Phragmites to the north. This ecotone now consists of an interface between swamp forest trees and Phragmites. The ecotone is characterized by interesting features that suggest the possible role of shade stress in the vegetative dynamics at the site. The ecotone is a relatively narrow band of overlap between the two community types (Figure 3.74; Figure 3.75) with pockets of Phragmites within some canopy openings in the swamp forest to the south (Figure 3.76) and swamp forest saplings growing within less dense stands of Phragmites directly to the north (Figure 3.77). Herbaceous plants usually associated with the swamp forest, such as skunk cabbage, grow within the edge of the Phragmites stand (Figure 3.78) and an occasional Phragmites plant is seen growing within the swamp forest with other herbs in the early spring before leaf out conditions (Figures 3.79).
Figure 3.74: Ecotone on south side of the west central basin looking from *Phragmites* stand to the north into swamp forest to the south. Photograph taken in the spring of 2001. *Phragmites* shown just emerging for the growing season. Beginning of leaf out conditions in the swamp forest.
Figure 3.75: Ecotone on south side of the west central basin looking from swamp forest in the south to *Phragmites* stand in the north. Photograph taken in summer of 2001. Leaf out conditions in the swamp forest.
Figure 3.76: *Phragmites* growing in a canopy opening in the swamp forest in the summer of 2001.
Figure 3.77: Swamp forest trees growing within the *Phragmites* stand to the north of the swamp forest.
Figure 3.78: Swamp forest herbaceous plants growing in the ecotone between the swamp forest to the south and the *Phragmites* stand to the north. Photograph taken in spring 2001 before leaf out conditions.
Figure 3.79: Phragmites plant growing among swamp forest herbs in the swamp forest remnant in the west central basin in the spring of 2001.
ecotone appears to be a moving front of swamp forest trees currently advancing toward
the middle of the marsh basin. The middle of the marsh basin is heavily dominated by
Phragmites in its present condition. The areal extent and density of Phragmites in the
middle of the marsh basin are shown in Figure 3.80. The advance of swamp forest into
the Phragmites stand appears to be driven by the forest ability to produce shade stress on
the adjacent Phragmites within the ecotone area reducing the density of Phragmites until
the Phragmites stand is open enough to allow tree germination. The advance of the
swamp forest – Phragmites ecotone towards the middle of the marsh basin is limited by
the factors of flood stress, salt stress, and fire disturbance.

The Cleveland Museum of Natural History resampled the transect in the remnant swamp
forest in 2000 A.D. The report, however, is not yet available. The results of the study will
be of particular note to determine if any measured advance of swamp forest toward the
middle of the marsh basin has occurred along the permanent transect since it was sampled
in 1991.

Comparing water salinity with plant tolerance for the fourth time interval
The water salinity measured in 1983 (Lass) before the rerouting of Blackbrook indicates
high salt stress. The results show much less variation than the previous studies’ results
(Rand, 1969; Hauser, 1972; Jones, 1975). This is attributed to the persistent nature of salt
pollution leaching into the marsh from the inactive salt fill over the Blackbrook tributary
in the early to mid 1980’s as discussed in Section 3.4.2.4. Persistent salt stress continued
to affect the vegetative dynamics of the marsh basin until the rerouting of Blackbrook in
Figure 3.80: *Phragmites* in the marsh basin in 2001. Top photograph shows view across the marsh basin. Bottom photograph taken within *Phragmites* stand near Blackbrook’s confluence with the marsh basin.
1988. The continued rapid expansion of *Phragmites australis* during fourth time interval corresponds to the high water salinity levels measured during this time period. Areas of swamp forest, shrub scrub, and even *Typha spp.* were further reduced in areal extent to be replaced by *Phragmites*. This change in the vegetative condition of the marsh between 1976 and 2000 corresponds to the expected physiological response of the plant species to the high levels of salt stress (Rechav, 1967; van der Toorn, 1972).

The results for water salinity in 1983 and 1997 (Lass, 1983; Whipple, 1999) are compared with plant species’ salt tolerance. Figure 3.81 compares water salinity at several locations within the marsh in 1983 (Lass, 1984) with plant species salt tolerance. Blackbrook sampling location shows water salinity well above the maximum salinity tolerance of all plant species except *Phragmites australis* (red line) in May and August of 1983 and even above the salt tolerance of *Phragmites* in June and July. The Kervin Trail Lookout sampling location shows water salinity producing stress for *Typha* species but below that tolerated by *Phragmites*. Corduroy Road also has high salt stress above the tolerance of *Typha* spp in June and July but not exceeded the tolerance limit for *Phragmites*. The Shipman Pond sampling location in the eastern basin had water salinity above that tolerated by swamp forest but does not exceed the tolerance range of *Typha* spp. in the results shown for 1983.

Figure 3.82 compares water salinity at several locations within the marsh in 1997 (Whipple, 1999) with plant species salt tolerance. All locations depicted on the graph show water salinity below the maximum tolerance level of the sensitive swamp forest.
Figure 3.81: Comparison of water salinity for the year 1983 to maximum chloride tolerance for plant species; water salinity data is monthly average based on Lass (1984) data.
Figure 3.82: Comparison of water salinity for the year 1997 to maximum chloride tolerance for plant species; water salinity data from Whipple (1997). A logarithmic scale is used for the y-axis to better represent the variability of water salinity during this time period. Kervin Lookout was not sampled in June, August, or September and Wake Robin Trail was not sampled in September owing to low water levels (Whipple, 1999).
plant species (less than 1,000 mg/L). Water salinity at the Kervin Trail Lookout sampling location and at Corduroy Road show the highest water salinity measured within the marsh basin in the summer of 1997. The water salinity at those locations is high enough to produce salt stress for sensitive swamp forest species precluding their re-growth in these areas. Figure 3.83-3.86 shows water salinity at four locations within the marsh basin between 1969 and 1997 in relation to plant salt tolerance.

Comparing fire disturbance with plant tolerance for the fourth time interval
Since 1979, several intense fires have burned large areas of the marsh basin. Their cumulative effect is that more than half of the marsh has burned sometime in the last twenty years including areas of recovering swamp forest. Many areas such as the eastern basin and the west central basin have burned repeatedly. The occurrence of frequent fire disturbance has played an important role in the vegetative dynamics of the marsh since 1979. The last major fire to occur within the marsh basin was in 1998 (ODNR, 2002b). As shown in Table 3.1, Phragmites is tolerant to fire. Phragmites is a member of the grass family and quickly regenerates after a fire has occurred. In contrast, many of the plant species associated with the swamp forest are not tolerant to frequent fire (Table 3.1). High intensity fires have the potential to decimate a swamp forest. Swamp forests require many years free from high intensity fire to regenerate to a closed canopy condition so that it may support many of the plant species associated with its mature structure.
Figure 3.83: Comparison of water salinity at Shipman Pond from 1969 to 1997 to maximum chloride tolerance for plant species. Water salinity is the average water salinity measured at the Shipman Pond location for each study period. Based on data from Rand (1969), Hauser (1972), Jones (1976), Lass, 1984, and Whipple, 1999.
Figure 3.84: Comparison of water salinity at Blackbrook from 1969 to 1997 to maximum chloride tolerance for plant species. Water salinity is the average water salinity measured at the Blackbrook location for each study period. The 1997 sampling location was north of Kervin Trail Lookout, near the old mouth of Blackbrook. Based on data from Rand (1969), Hauser (1972), Jones (1976), Lass, 1984, and Whipple, 1999.
Figure 3.85: Comparison of water salinity at Corduroy Road from 1969 to 1997 to maximum chloride tolerance for plant species. Water salinity is the average water salinity measured at the Corduroy Road location for each study period. Based on data from Rand (1969), Hauser (1972), Jones (1976), Lass, 1984, and Whipple, 1999.
Figure 3.86: Comparison of water salinity in the Western basin from 1969 to 1997 to maximum chloride tolerance for plant species. Water salinity is the average water salinity measured in the western basin for each study period. Based on data from Rand (1969), Hauser (1972), Jones (1976), Lass, 1984, and Whipple, 1999.
Fire is the most recent change in the environmental stress regime of the Mentor Marsh and is attributed to the presence of the highly flammable plant species *Phragmites* that came to dominate the marsh basin by the late 70’s and to anthropogenic behavior (primarily arson perpetrated by juveniles). Fire has acted as a positive feedback mechanism for the proliferation of *Phragmites* within the marsh basin; clearing areas of other vegetation and thereby allowing *Phragmites* to increase in areal extent. In turn, the increased abundance of *Phragmites* increases the likelihood of future fires in the marsh basin. It has been noted at other sites that *Phragmites* is able to spread rapidly and dominate sites that have been cleared of other vegetation by catastrophic disturbances such as fire (Wijte and Gallagher, 1996; Haslam, 1970).

*Comparing plant species tolerance with ecological condition*

The shift to a much wetter climate, as indicated by very high Lake Erie water levels and many years above average annual rainfall (Section 3.4.1.1), indicates that the fourth time interval was a time of increased flood stress within the marsh basin. The dams that beaver continued to build at the mouth of Shipman Pond acted to increase flood stress in the eastern basin. The other hydrologic obstructions discussed in the previous section continued to affect flood stress during the fourth time interval as well. The reestablishment of a stream draining the eastern basin in June of 1997 as discussed in Section 3.4.1.2 (Figure 3.23) is of particular note. It appears that the marsh’s natural flow regime, in accord with it’s surrounding topography, acts to reestablish itself when conditions favor such an occurrence. During high water years, during a wet time of year, and when storm events occur, the water flowing from the marsh basin breaches the
confines of several drainage ditches and forms a meandering channel of comparable width and size of that which existed over two hundred years ago as observed and recorded by Pease and Holley on August 27, 1796. The length of the stream across the beach is now much longer than in 1796 because of anthropogenically induced beach accretion. Although the reestablishment of the direct connection between the marsh and Lake Erie could have acted to reduce flood stress within the marsh basin during this time interval it was filled to maintain the beach to its current design as a State Park. This interesting phenomenon suggests possible restoration strategies that will be discussed in greater detail in Chapter 5.

The dramatic expansion of *Phragmites* within the marsh basin between 1976 and 2000 corresponds to the shift to a wetter climate, persistent salt stress, and the beginning of frequent fire disturbance in the marsh basin. Hildebrant’s study does show that possible recovery of swamp forest may be occurring along the edge of swamp forest remnants. The threat fire plays to these recovery areas of swamp forest was presented in Section 3.4.3. High flood stress, salt stress, and frequent fire disturbance favor the growth and expansion of *Phragmites* more than any other plant species in the marsh basin (Table 3.1; Rechav, 1967; van der Toorn, 1972). Shade stress may also have played a role in the shift in dominance between *Typha* spp. and *Phragmites* between 1966 and 2000 A.D.
As described in the methods section, percent cover for each wetland community type was estimated for the year 2000. The analysis yielded the following values for percent cover for 2000:

- Swamp forest: 8%
- Shrub scrub: 1%
- Emergent: 90%
- Open marsh: 1%

Distinguishing between the two emergent plant species yields the following results for estimated percent cover for 2000:

- Swamp forest: 8%
- Shrub scrub: 1%
- *Typha* spp.: 4%
- *Phragmites*: 86%
- Open marsh: 1%

**Summary of changes in wetland plant community type percent cover, 1796 to 2000 A.D.**

Table 3.5 summarizes the change in wetland plant community type percent cover between 1796 and 2000 A.D. These values are estimated based on available historical records and scientific studies. As discussed in the methods section, there is uncertainty involved with these estimates. Figure 3.87 illustrates the results for change in wetland plant community type percent cover between 1796 and 2000 A.D. Several important patterns are evident in these results.

The results for 1796 show dominance of the marsh basin by swamp forest and a high percentage of open marsh. The dominance by swamp forest corresponds with the low
<table>
<thead>
<tr>
<th>Year</th>
<th>Swamp forest</th>
<th>Shrub scrub</th>
<th>Emergent Species</th>
<th>Cattails</th>
<th>Phragmites</th>
<th>Open marsh</th>
</tr>
</thead>
<tbody>
<tr>
<td>1796</td>
<td>66</td>
<td>4</td>
<td></td>
<td>0.5</td>
<td>0.5</td>
<td>29</td>
</tr>
<tr>
<td>1874</td>
<td>30</td>
<td>32</td>
<td></td>
<td>0.5</td>
<td>0.5</td>
<td>37</td>
</tr>
<tr>
<td>1951</td>
<td>86</td>
<td>12</td>
<td></td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>1966</td>
<td>47</td>
<td>2</td>
<td></td>
<td>49</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1976</td>
<td>10</td>
<td>1</td>
<td></td>
<td>24</td>
<td>65</td>
<td>1</td>
</tr>
<tr>
<td>2000</td>
<td>8</td>
<td>1</td>
<td></td>
<td>4</td>
<td>86</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3.5: Estimated percent cover for wetland plant community types for selected years between 1796 and 2000 A.D.
Figure 3.87: Graphs showing the estimated areal extent (% cover) for wetland plant community type between 1796 and 2000 A.D. The top graph shows emergent vegetation as one category. The bottom graph separates the emergent vegetation into *Typha* spp. and *Phragmites australis*. 
flood stress that characterized the marsh’s presettlement condition. The occurrence of speckled alder noted by Pease and Holley in 1796 tells us that it was present within the marsh basin, which would facilitate its expansion under a different set of environmental stresses. This is seen in the vegetative condition in 1874 as shown in Figure 3.87. After a period of prolonged flood stress owing to a wetter climate and anthropogenic modifications to drainage patterns in the eastern basin, we see a relative balance between swamp forest, shrub scrub, and open marsh. The swamp forest died-off in areas of the marsh basin that were most susceptible to increased flood stress such as the northeastern basin and the narrow section of the marsh basin in the east central portion. In other areas, the swamp forest died-back with only the more flood-tolerant larger (older) trees remaining then surrounded by flood-tolerant shrub scrub. Open marsh expanded in areas of the marsh basin where basin elevations support higher flood stress namely in the western basin and also in areas that were affected by the higher flood stress caused by beach accretion (northeastern basin). Then, after a prolonged period of low flood stress within the marsh as indicated by the low Lake Erie water levels and low annual precipitation, the swamp forest expanded within the marsh basin and by 1951 had reached an abundance comparable to that of 1796 (Figure 3.87). The almost complete loss of open marsh within the marsh basin is attributed to the development of Mentor Harbor in the western basin and the contraction of open marsh in the eastern basin owing to the decrease in flood stress and the corresponding encroachment by swamp forest in this area. In 1966, we see the effect of a new environmental stress, salt stress. With the beginning of salt stress we see the rapid expansion of emergent vegetation within the marsh basin for the first time in this history. Although present in the marsh basin since at
least 1892 (Werner voucher: Bissell, pers. comm., 2003; Section 3.4.4.3), emergent vegetation now begins to dominate portions of the marsh basin because of the death of salt-intolerant swamp forest tree species denuding large areas of the marsh basin and decreasing shade stress. Both *Typha* spp and *Phragmites* have the highest salt tolerance of any plant species known to dominate the marsh basin during this two hundred year history. It is most significant to note that even though flood stress began to return to levels comparable to the 1874 levels, shrub scrub, though present in some sections of the marsh, did not expand. This can be explained by speckled alder’s complete intolerance of salt stress (Table 3.1). Also, the die-off of all sizes (ages) of swamp forest trees in affected areas within the marsh basin in 1966, instead of the survival of the more flood tolerant larger (older) trees as occurred in the mid-1800’s, suggest the important role of salt stress in 1966. By 1976, we see the continued decline of swamp forest owing to both persistent salt stress and a continued wetter climate (Figure 3.87). The switch in dominance between *Typha* spp. and *Phragmites* between 1966 and 1976 is indicative of the role of salt stress in sorting the plant species in accordance with their salt tolerance. The level of salt stress within the marsh basin was often in the range to favor *Phragmites* but cause stress for the less salt tolerant *Typha* spp. *Phragmites*’ greater height compared with *Typha* spp. also favors its dominance over *Typha* spp. owing to vegetative shading. This switch in dominance between these two plant species is a particularly interesting phenomenon captured in the data during this period of study. It portrays the sorting effect of plant species consistent with the individualistic concept of vegetative dynamics. The continued decline of swamp forest and the rapid expansion of the emergent species, *Phragmites*, between 1976 and 2000 corresponds with continued flood stress, continued
salt stress, and the beginning of fire disturbance within the marsh basin as shown in the results for wetland plant community type percent cover (Figure 3.87). Because *Phragmites* is a grass species it is tolerant of frequent fire disturbance (Table 3.1).

Swamp forest, however, is particularly unsuited to frequent fire disturbance because of the time required for its trees to grow to maturity and form closed canopy conditions which facilitates its expansion and dominance over other wetland plant communities types associated with the marsh basin. As discussed previously, the high return interval for fire in the marsh basin is owing to anthropogenic behavior in most cases (Table 3.3). When a fire was naturally occurring, such as the lightening strike in August of 1988, the tremendous fuel source of the several hundred acres of *Phragmites* in dense stands and often twelve feet in height produced a high potential for intense uncontrollable fires. As these fires burn, the ecotone areas of swamp forest-*Phragmites* are susceptible to fire damage, setting back any advance by the swamp forest into the *Phragmites* stand.

Therefore, we see fire acting as another environmental stress favoring the proliferation of *Phragmites* within the marsh basin both through *Phragmites* high tolerance of fire as a grass species and the associated damage to recovering areas of swamp forest caused by fire. The continued decrease in the abundance of *Typha* spp is attributed to *Phragmites*’ greater height causing vegetative shading stress for *Typha* spp.

It is important to note that although the factors discussed above are seen as primary factors in the vegetative dynamics at Mentor Marsh and are based on known tolerances
for these plant species, ecological systems are complex and other factors may also be acting to drive the change in wetland plant community type percent cover over time (Table 3.5; Figure 3.87).

*Environmental stress regime in 2000*

Based on these results, the condition of the environmental stress regime in 2000 was high flood stress, salt stress (i.e., oligosaline conditions), frequent fire disturbance, and low shade stress (i.e., small areal extent of forest).
3.5 Conclusions

The results for the ecological synthesis suggest that changes in the environmental stress regime of the marsh between 1796 and 2000 A.D. have contributed to dramatic shifts in the relative abundance of wetland plant community types. These changes show strong spatial and temporal patterns of behavior corresponding to expected plant physiological response to changing environmental conditions. The results provide support for the four hypotheses discussed in the introduction, Chapter 1. Specifically, that flood stress, salt stress, and fire disturbance have acted to influence the spatial and temporal distribution of wetland plant community types between 1796 and 2000 A.D. Shade stress appears to act as an overriding factor of control when other environmental stress conditions facilitate its occurrence. The primary mechanism of shading within the marsh basin over time appears to be vegetative shade stress owing to the difference in vertical structure and density of vegetation between community types. The mechanism of shading through hillslope and aspect may provide added support for shade tolerant vegetation’s persistence and eventual advance with the return of more favorable stress regimes for these assemblages.

The findings of the ecological synthesis support the hypothesis which states that changes in vegetation at Mentor Marsh at the community level of organization have been the result of the interaction between changes in the physical environment of the marsh, plant species requirements, and plant species availability to the site itself (Hypothesis 1, Section 1.3). This is demonstrated in the linkage between change in environmental stress
at the site as documented in the ecological synthesis and landscape history and the studies to which they refer and the expected and realized responses of the plant species at Mentor Marsh between 1796 and 2000 A.D.

The changing site conditions described for the marsh basin since 1959 agree with the type of changes typically associated with “invasion windows” as discussed by Galatowitsch et al (1999) as presented in the literature review (Section 3.2). The removal of swamp forest by salt disturbance and stress and the changes in water quality (e.g., increase in water salinity) created an opportunity for the invasive wetland plant species Phragmites australis and Typha glauca to increase in abundance until Phragmites now dominates approximately 90% of the marsh basin.

The hydrogeomorphic factors discussed by Keough et al (1999) used to formulate Hypothesis 2 (Section 1.3) have also played a role in the vegetative dynamics at Mentor Marsh. Anthropogenic changes at points of hydrologic control and long-term changes in Lake Erie water level and annual precipitation have been shown to play an important role in wetland plant community type spatial and temporal distribution at Mentor Marsh. Keough et al observe that “anthropogenic perturbation regimes are superimposed on the hierarchy of natural variation” when discussing Great Lake’s ecosystem response to changing hydrogeomorphic factors. This is in agreement with the findings of this study where the effect of anthropogenic modifications to the marsh basin and its landscape setting are superimposed on the response of the vegetation to long-term changes in climate. The difference in response of the wetland plant community types percent cover
Research questions revisited

In the introduction (Chapter 1), several of the research questions that guided my study of the vegetative dynamics at Mentor Marsh were listed. The findings of the landscape history (Chapter 2) and the ecological synthesis (Chapter 3) provide information that help to answer these questions and also identifies those topics that require further research including field investigation, experimentation, and site monitoring. The results show Mentor Marsh has supported a variety of plant species including several different wetland plant community types during the past two hundred years. The dominant wetland plant community type during this time period has been swamp forest. The dominant tree species of this plant community type have varied spatially within the marsh basin but include silver maple (Acer saccharinum), red maple (Acer rubrum), black ash (Fraxinus nigra), green ash (Fraxinus pennsylvanica), pumpkin ash (Fraxinus profunda), yellow birch (Betula alleghaniensis), and American elm (Ulmus americana). These tree species include all the dominant tree species of the northern deciduous swamp forest as it occurs in northern Ohio (Sampson, 1930). The importance of this wetland plant community type for conservation and restoration goals within Ohio landscapes should be assessed in light of the fact that the 90% loss of wetlands within Ohio since presettlement times (Mitsch and Gosselink, 1993) is made up largely of loss of swamp forest that covered large areas of Ohio when European American settlement began (Gordon, 1960). Shrub and
herbaceous plant species typically associated with the swamp forest at Mentor Marsh have included spicebush (Lindera benzoin (L.) Blume), royal fern (Osmunda regalis), cinnamon fern (Osmunda cinnamonea L.), sensitive fern (Onoclea sensibilis L.), and lizard’s tail (Saururus cernuus L.). The shrub scrub wetland plant community has been dominated by speckled alder (Alnus rugosa (Duroi) Sprengel) and buttonbush (Cephanlanthus occidentalis L.). The emergent plant species include cattails (Typha latifolia L. and Typha angustifolia L.) and common reed (Phragmites australis (Cav.) Steudel). The cattail hybrid (Typha x glauca Godron) has also been documented at Mentor Marsh (Greenwald et al., 1980). The open marsh plant species were not documented as well as the other wetland plant community types but include “floating yellow water lily” (Aldrich, 1943), “pond weeds” (Aldrich, 1943) probably Potamogeton spp., and swamp grass, which may be burr-reed (Sparganium spp.; Bissell pers. comm., 2003). This is not a complete list of all of the plant species that have occurred at Mentor Marsh but rather those plant species that are mentioned commonly in historical records between 1796 and 2000 A.D. The Cleveland Museum of Natural History maintains a list of those plant species identified within and near Mentor Marsh since 1974. The ecological synthesis for Mentor Marsh documents tremendous change in vegetation both temporally and spatially that has occurred since presettlement times (Section 3.4.4). The increase in abundance of emergent plant species within Mentor Marsh in recent times seems to be linked to both favorable site conditions (Section 3.4) and changes in these species’ regional availability since presettlement times (Bissell pers. comm., 2003). A more through investigation of changes in plant species availability at a regional scale would be beneficial to understanding its role in the vegetative dynamics at Mentor Marsh.
Future vegetative studies at the marsh would be useful to determine continued change in plant species abundance especially in ecotone areas. The environmental conditions (including flood stress, salt stress, fire disturbance, and shade stress) should be assessed spatially in conjunction with these vegetative studies as possible. Seed bank studies would also provide an added dimension to our understanding of vegetative dynamics at Mentor Marsh.

The soils at Mentor Marsh were discussed briefly in Section 2.2.4. The soils of the marsh are classified as Carlisle muck, a hydric soil commonly associated with wetland areas in this region. The presence of this hydric soil is both indicative and supportive of the occurrence of wetland plants within the marsh basin. Future research within the marsh should include soil studies to determine the spatial variability of soil salinity within the marsh basin and define better the relict riverine morphology of the marsh basin as it is captured in the soil record at the site. Deep cores at multiple locations in the basin may shed light on the historical geomorphology and sedimentology of Mentor Marsh, from its role as the prior Grand River estuary through the events resulting in the development of the eastern confluence.

The topography of the marsh basin and its surrounding landscape and the changes that have occurred in it’s topography are captured in a series of maps, historic narratives, and aerial photographs for the site as summarized in the landscape history and ecological synthesis. It is recommended that this information be incorporated in a Geographic Information System (GIS) for the site to allow linkage between the information provided
by this study and other scientific studies at Mentor Marsh and the site’s topography to define better the role of spatial variability in the processes and functions that drive the vegetative dynamics at the site. A digital elevation model and comprehensive GIS for Mentor Marsh has been produced as part of concurrent research with this study. Linkage between the two would provide a more powerful interpretation of the many issues important to the conservation and restoration of this site.

The glacial history, subsurface geology, and potential groundwater contribution to the marsh were addressed in Section 2.2. Hydrologic monitoring of the site should be continued and expanded to develop a more detailed understanding of the role of water level change and its timing in the spatial and temporal distribution of plant species within the marsh basin. Research should include the quantification of groundwater contribution to the Mentor Marsh by installing several three points systems of groundwater monitoring wells at the site to augment the system of wells already in place. Surface water monitoring measuring water level, flow velocity, magnitude of flow, direction of flow, and changes in water quality (including salinity and turbidity) at key points as they have been identified in this study should be conducted as part of a long-term monitoring strategy for the site. This could be compared with Lake Erie water level and annual precipitation variability to increase our understanding of the interaction of the marsh with both its watershed and Lake Erie.

The results of the landscape history and the ecological synthesis show that the changes that have occurred in the physical and biological condition of the marsh basin since 1796
have been driven by both anthropogenic and non-anthropogenic factors. Careful examination of the linkages between change in the landscape and vegetative system response produces better-defined questions to assist in future research at the marsh and identifies topics to be addressed in management, conservation, and restoration strategies within and surrounding the marsh basin. These issues will be discussed in more detail in Chapter 5.
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