USDA Natural Resources
Conservation Service

Ecological site F093AY006MN
Depressional Wet Hardwood Forest

Accessed: 04/20/2024

General information

Approved. An approved ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model, enough information to identify the ecological site, and full documentation for all ecosystem states contained in the state and transition model.

Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 093A–Superior and Rainy Stony and Rocky Till Plains and Moraines

The Superior Stony and Rocky Loamy Plains and Hills, Western Part is located and completely contained in northeastern Minnesota (Figure 1). This area has both the highest and lowest elevations in the state, as well as some of the state's most rugged topography (Ojakangas and Matsch, 1982). The MLRA was glaciated by numerous advances of the Superior, Rainy, and Des Moines glacial lobes during the Wisconsin glaciation as well as pre-Wisconsin glacial periods. The geomorphic surfaces in this MLRA are geologically very young (i.e., 10,000 to 20,000 years) and dominated by drumlin fields, moraines, small lake plains, outwash plains, and bedrock-controlled uplands (USDA-NRCS, 2006). There are thousands of lakes scattered throughout the region that were created by these glacial events. Most of these lakes are bedrock-controlled in comparison to adjacent glaciated regions where glacial drift deposits are much thicker and the lakes occur in depressions atop the glacial drift (Ojakangas and Matsch, 1982). In contrast to adjacent MLRAs, the depth to the predominantly crystalline or sandstone bedrock in MLRA 93A is relatively shallow because the most recent glacial events were more erosional than depositional (Ojakangas and Matsch, 1982).

Classification relationships

Major Land Resource Area (MLRA): Superior Stony and Rocky Loamy Plains and Hills, Western Part (93A)

USFS Subregions: Northern Superior Uplands Section (212L); North Shore Highlands Subsection (212Lb)

Ecological site concept

Depressional Wet Hardwood Forests are widespread throughout the distribution of the Superior Lobe glacial advance within MLRA 93A. These sites are developed primarily from low lying mineral soils, but can have up to sixteen inches of organic surface. Parent materials include both till and outwash from Superior lobe deposits. They occur on small to moderate sized closed depressions and shallow, low gradient drainage networks, surrounded by an upland forest matrix. Ponding occurs throughout the spring and much of the early growing season. Later in the growing season ponded usually recedes, but they will again pond during moderate to heavy rainfall events. Hummocks from fallen trees create unique micro-topography, with micro-depressions that may hold water all year and adjacent root wads that shed water. Soil texture is of limited importance since these sites are saturated nearly all year.

Plant communities include an array of species that are adapted to periods of prolonged ponding and soil saturation. Black ash (Fraxinus nigra) is the dominant tree species, along with northern white cedar (Thuja occidentalis). Yellow birch (Betula alleghaniensis) is often an important component in the subcanopy. Both northern white cedar and yellow birch find rooting medium in the aforementioned hummocks, created by fallen trees, and other large sized downed woody debris, usually from fallen black ash or northern white cedar.

Relative to other forested wetland communities in the MLRA, Depressional Wet Hardwood Forests are comparatively richer, and have a diverse assemblage of ground flora. Wetland species like yellow marsh marigold (Caltha palustris), fowl mannagrass (Glyceria striata), are almost always present. Interestingly, the drier conditions on hummocks allow a number of common upland species to persist. In contrast, the adjacent wet micro-depressions often host obligate wetland species that are characteristic of more permanent wetlands.

Associated sites

F093AY013MN	**Loamy Upland** This ecological site is surrounded by upland soils and landforms. There are often rims of somewhat poorly and poorly drained soils of the same parent material adjacent to this site. To date, Till Upland Mesic Hardwood Forests (093AY001) is the only associated ecological site description developed in the MLRA. In some cases, these are isolated depressions that are completely surrounded by a Till Upland Mesic Hardwood Forest matrix. In other cases, shallow drainageways meander back-and-forth through many adjacent ecological sites.

Table 1. Dominant plant species

Tree	(1) *Fraxinus nigra* (2) *Thuja occidentalis*
Shrub	(1) *Alnus incana* (2) *Acer spicatum*
Herbaceous	(1) *Glyceria striata* (2) *Caltha palustris*

Physiographic features

Wet Depressional Hardwood Forests are located on end moraines, ground moraines, outwash plains and inter-drumlins associated with the Automba and Nickerson phases of the Superior Lobe glacial advance (Table 1). The most common landforms are ponded depressions and subtle, concave areas. They can also occur in shallow, low gradient drainageways that may receive concentrated flow (e.g., incipient drainage ways). Slope shape can be either linear or concave up slope, and is always concave across slope. Individual sites can be quite small in size, ranging from less than one acre, to ten acres. These sites are ponded throughout the spring and early summer months, and generally dry out by August, and pond again in low to moderate rain events. During dry times the water table is generally within 10 inches, but can be as low as 24 inches. These sites receive runoff and lateral subsurface flow from adjacent, upslope ecological sites. They also produce runoff and lateral subsurface flow downslope, to streams, rivers, and large peatland basins. Elevation is mainly above 1,000 feet and below 1,600 feet.

Table 2. Representative physiographic features

Landforms	(1) Depression (2) Drainageway
Flooding frequency	None
Ponding duration	Brief (2 to 7 days) to very long (more than 30 days)
Ponding frequency	Occasional to frequent
Elevation	1,000–1,600 ft
Slope	0–1%
Ponding depth	0–6 in
Water table depth	0–24 in
Aspect	Aspect is not a significant factor

Climatic features

The average freeze-free period of this ecological site is about 140 days, and ranges from 131 to 149 days (Table 2). Average annual precipitation is 32 inches, which includes rainfall plus the water equivalent from snowfall. About 65 percent of the precipitation falls as rain during the growing season (from May through September), and about 21 percent falls as snow (Table 3). Most of the spring snowmelt runs off the steeply sloping or high relief surfaces into high gradient drainageways and then into wetlands, streams or lakes. Most of the rainfall during the growing season is transpired by plants, which leaves a small proportion of the total precipitation for deep aquifer recharge. Much of the distribution of this ecological site is located in the highlands above Lake Superior which receive the most snowfall in Minnesota, averaging over 70 inches annually (Flaccus and Ohmann, 1964; MN DNR, 2013a). This lake effect snow is the result of warm, moist air rising and moving inland from the lake, ultimately cooling to produce localized snowfall (Anderson and Fischer, 2015; MN DNR, 2013a). The average annual low and high temperatures are 28 and 48 degrees Fahrenheit, respectively (Table 3). Frost pockets and of cold air drainage from above make this ecological site colder and wetter than adjacent ecological sites (SNF, unpublished report a, b). As a result, snow and frost remain longer in the spring, thus resulting in shorter growing seasons than the adjacent uplands. Climate data and analyses are derived from 30-year averages gathered from four National Oceanic and Atmospheric Administration (NOAA) weather stations contained within the range of this ecological site, but were not necessarily located on correlated map units (Table 4).

Table 3. Representative climatic features

Frost-free period (average)	119 days
Freeze-free period (average)	139 days
Precipitation total (average)	34 in

Climate stations used

- (1) LUTSEN 3NNE [USC00214918], Lutsen, MN
- (2) WOLF RIDGE ELC [USC00219134], Finland, MN
- (3) DULUTH [USW00014913], Duluth, MN

Influencing water features

These sites can be incipient drainage networks, with small perennial streams, or they can be in closed, isolated depressions. Seasonal ponding is most prominent during March through June and October through November. Water tables and water table recharge closely mimics annual rainfall graphs. They are either at or above the surface much of the year, and may drop to a low of low of 12 inches during the dry months. In addition to precipitation inputs, these sites receive surface and subsurface water from surrounding sites. They also discharge water to lower elevation ecological sites, and ultimately to rivers, lakes, or large peatland basins. In these relatively young morainic landscapes, well established dendritic drainage networks have not yet been developed. Instead, these sites exhibit water flow though after significant rainfall events. Landforms behave like closed depressions until an overflow threshold is achieved, wherein they begin to behave like drainageways. It is a complex interaction that is dependent upon factors like relative elevation and degree of incision. Stream orders associated with these sites are first, second, third, and fourth (SNF, unpublished report b). These sites also provide deep percolation for water table recharge.

Depressional Wet Hardwood Forests are classified as a Palustrine System, Forested Wetland Class, and depending on the State of vegetation, either a Broadleaf Deciduous or Dead Subclass, as described by Cowardin et al. (1979).

Soil features

The parent material for these soils includes coarse-loamy and fine-loamy till, as well as outwash, from the Superior lobe glacial advance (Table 5). Although these are primarily mineral soils, up to 16 inches of organic parent material may be on the surface. On a given site, organic deposits (if existing) will be thickest near the center of the landform. In some cases there may be deeper organic surfaces that classify as true Histosols , but this is not typical condition of these landforms, and may be a relic of a past climatic or hydrologic time period. These soils are ponded, and as a result, are very poorly drained. However, wetness varies seasonally on these soils, which is a primary site factor defining this ecological site. Due to concave landforms and very poorly drained and ponded soils, soil textural classes are not a significant site factor for vegetation. Surface texture is loam or sandy loam, and subsurface textures range from loam to very gravelly coarse sand. Soil pH on contributes to the rich nature of these plant communities, and ranges from 5.5 (moderately acid) to 6.5 (slightly acid), which is relatively high when compared to other wetland ecological sites in the MLRA. Soil orders are Inceptisols, and taxonomic classes are either Typic or Histic Humaquepts. Giese, Twig, Wahbegon, and Hulligan are all representative soil series for this ecological site.

Table 4. Representative soil features

Parent material	(1) Ablation till–gabbro (2) Outwash–sandstone (3) Lodgment till–basalt
Surface texture	(1) Very gravelly loam (2) Sandy loam
Family particle size	(1) Loamy
Drainage class	Very poorly drained
Permeability class	Slow to rapid
Soil depth	80 in
Surface fragment cover <=3"	0–1%
Surface fragment cover >3"	0–1%
Soil reaction (1:1 water) (0-40in)	5.5–6.5
Subsurface fragment volume <=3" (Depth not specified)	8–65%
Subsurface fragment volume >3" (Depth not specified)	0–12%

Ecological dynamics

Seasonal variation in water table is the most important site factor defining Depressional Wet Hardwood Forests. Water tables limit the amount of oxygen available to plant roots; and oxygen levels determine the extent to which root respiration can take place, the level of organic litter decomposition, and the release of important nutrients for uptake by plants (MN DNR, 2011). Species characteristic of this ecological site are better able to handle this variation in water saturation, in comparison to species characteristic of both drier uplands and wetter, less hydrologically-dynamic peatland ecosystems. Similar black ash-dominated vernal wetlands are widely distributed throughout the upper Midwestern and Northeastern U.S. and into adjacent Canadian Provinces (NatureServe, 2013a, 2013b; Landfire, 2007). In MLRA 93A, they are on the Boreal fringe, and are often mixed with coniferous species and sub-boreal ground flora (Table 6). Northern white cedar is the most common coniferous species, along with white spruce and balsam fir. Tamarack (*Larix laricina*) may have historically been a component, but it has been on a considerable and continuing decline region-wide in all forest types (MN Div. of Forestry, 2013). To what degree this species was important to these sites historically is not known, and may never be known. Yellow birch and red maple are often important subcanopy species. The most common shrubs are speckled alder, mountain maple, American red raspberry, redosier dogwood, and beaked hazelnut. Ground flora diversity is very high in these forests. At a given location, as many as 60 or more plant species can be found in a small area. A number of site variables contribute to high diversity, such as: seasonal variation in water levels and soil saturation, dry and wet microsites created by fallen trees, and long-lived downed woody debris creating potential rooting medium. Yellow marsh marigold, northern bugleweed (*Lycopus uniflorus*), blue skullcap (Scuttelaria lateriflora), sensitive fern (*Onoclea sensibilis*), fowl mannagrass, bluejoint, and a variety of sedges (Carex spp.) are all indicative of the ground flora.

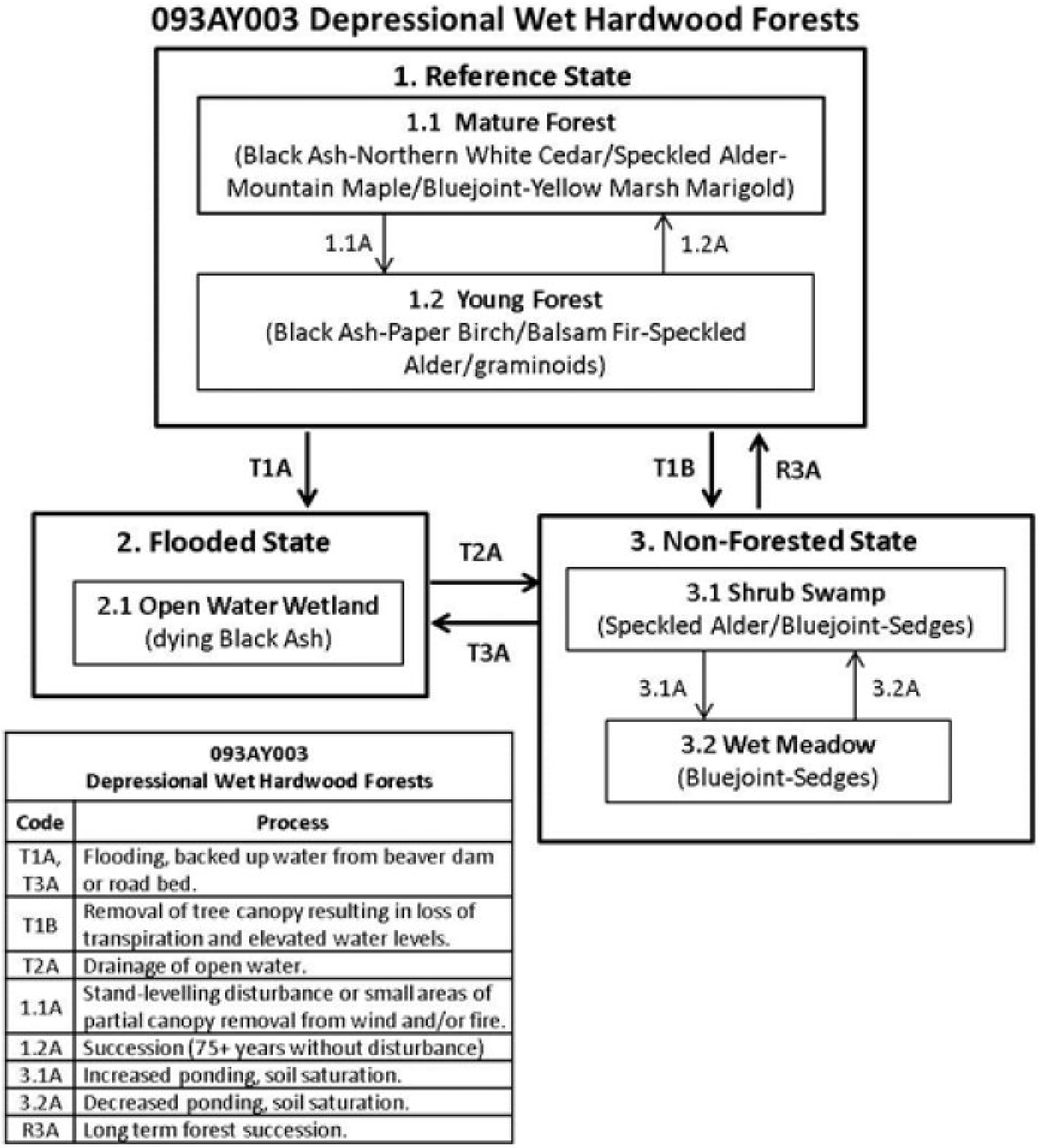
Historically, fire was not an important component of this ecological site, primarily because of lush vegetation with high water content. Average fire return intervals for stand replacing events have been estimated to be in excess of 1,000 years (MN DNR, 2014). In general, fire in wet forest communities was related to the surrounding matrix forest types (Landfire, 2007; Gucker, 2005). In the case of this ecological site, it is largely surrounded by mesic hardwood forests, where fire was uncommon. Thus, it can be inferred that fire was not a significant disturbance factor in Depressional Wet Hardwood Forests in MLRA 93A. Instead, historic variability in vegetation structure was primarily related to small and moderate sized canopy openings produced from either dead/dying trees or mature and over mature windthrown trees (MN DNR, 2014; Landfire, 2007; Gucker, 2005). Tree species common to this ecological site have shallow and spreading root systems, which is further exacerbated by a limited rooting zone resulting from frequent high water tables. As canopy trees reached the dominant canopy class they became more susceptible to these smaller scale, often microburst, wind events. Black ash are especially susceptible to this this type of windthrow (MN DNR, 2011; Wright and Rauscher, 1990). Climatic variation, both in terms of drought as well as excess precipitation, interacted with wind events to develop these canopy openings, whereby drought and extended ponding stressed trees to the point of being susceptible to disease and overall decline, and weakened their ability to withstand strong winds. These fine to moderate scale windthrow events likely occurred on an average 110 year rotation and possibly as frequent as 40 years (MN DNR, 2014; Landfire, 2007).

Currently, the dynamics of plant communities in this ecological site are similar to what they were historically. Although these sites are broadly distributed, they are generally small in size, and are part of a broader matrix of various upland forest types. As a result, they weren't affected as much as some forest types during the logging era following European settlement. There is some reference of early settlers using black ash as firewood, but it was probably used on a small scale and local basis (MN DNR, 2011). In some regions, northern white cedar and other softwoods were selectively logged, leaving monotypic black ash stands. Consequently, while black ash has always been dominant on these sites, it is possible that their abundance has increased during the last Century. Overall, these sites were largely left undeveloped, and a majority of Depressional Wet Forest ecological sites closely resemble communities described in the Reference State (Figure 2).

In general, alteration of natural hydrology is probably the most important driver of state change in this ecological site. Damming waterways backs up water and produces near permanent flooding, transitioning sites to open water wetlands. This can happen naturally as a result of beaver (Castor canadensis) activity, or as a result of human development (primarily road building). In some cases, road building activities can also block the flow of water to these sites, drying them out. This condition has not been documented within the MLRA, but it is surmised that such a condition would result in unique and novel plant communities. Another way hydrology can be altered is by the complete loss of forested canopy, which can cause significant alterations in effective transpiration of water, resulting in consistently higher water tables, and ultimately to a non-forested state (Mitsch and Gosselink, 2007; Palik et al., 2012; Erdmann et al., 1987). These situations result similar hydrology found in shrub swamps and wet meadows. This can result from poor silvicultural practices, extreme wind events, or significant insect or disease outbreaks.

Average site index at base age 50 for black ash averaged 46 feet, and ranged between 42 and 54. Site index curves were developed by Carmean (1978). This is relatively low for black ash in comparison to sites in some upland forests, which can be as high as 80 (Carmean, 1989). There may be some differences in productivity, species composition, or response to disturbance on small, isolated depressions compared to shallow drainage networks. It has been noted that a higher abundance of bluejoint, less structural development of the overstory, and less black ash regeneration occur in these situations (Chel Anderson, MN DNR Ecologist, personal communication). This may be related to dense till and perching of water. More research is needed to determine if there are significant differences.

State and transition model



093AY003 Depressional Wet Hardwood Forests	
Code	**Process**
T1A, T3A	Flooding, backed up water from beaver dam or road bed.
T1B	Removal of tree canopy resulting in loss of transpiration and elevated water levels.
T2A	Drainage of open water.
1.1A	Stand-levelling disturbance or small areas of partial canopy removal from wind and/or fire.
1.2A	Succession (75+ years without disturbance)
3.1A	Increased ponding, soil saturation.
3.2A	Decreased ponding, soil saturation.
R3A	Long term forest succession.

Figure 6. State-and-transition diagram.

State 1
Reference State

Community phases within the Reference State are related to scattered small and moderate sized canopy openings from dead and/or windthrown trees. Windthrown trees are primarily dominant, above the canopy, and more exposed to wind events. These trees, with shallow root systems, were likely previously weakened by either excessive drought or ponding, leaving them open to attack by forest pests (MN DNR, 2014). Standing dead trees from excessive ponding or drought may also provide these canopy openings. An estimated rotation of such events is 110 years (MN DNR, 2014; MN DNR, 2005). This produced a patchwork of young and mature forests, all dominated by black ash. Black ash is fairly shade tolerant as a seedling, and is often the only advanced regeneration present in the understory, and thus it tends to replace itself in many situations (Gucker, 2005; Erdmann et al., 1987). Black ash is also a long-lived species and can live to over 250 years old (Gucker, 2005). Without larger openings, structure and composition of mature stands can be nearly perpetual, and gradually regenerate new trees via small, one to many tree sized openings (Table 7). As a result of rather frequent, small scale openings, stands do not often become old growth (i.e., greater than 135 years; MN DNR, 2014). But in cases where they do, canopy structure is complex, and generally includes a component of long-lived and more shade tolerant white spruce and balsam fir. Northern white cedar and yellow birch often find their primary rooting substrate on downed woody debris associated with these openings. Both species regenerate well on mossy, rotting wood (i.e., nurse logs) that have consistent moisture (Smith, 2008 Erdmann, 1990; Johnston, 1990). Eventually, initial rooting media from downed woody debris can leave roots exposed to air and result in poorly formed trees (Figure 3). Northern white cedar can also regenerate by vegetation reproduction. These stems usually are developed from fallen trees and root from branches that come in contact with moist rooting media and are extremely shade tolerant (Erdmann, 1990). Hummocks and micro depressions resulting from windthrown trees are an important component of the Reference State. This variability in microsites provides opportunity for obligate wetland species in ponded micro depressions and upland species on the drier hummocks. Today, much of the distribution of this ecological site is in community phases very similar those in the Reference State.

Community 1.1
Mature Forest

Figure 7. Reference State (Community Phase 1.1 Mature Forest

Figure 8. Photo of a yellow birch with aerial roots, rooted

By stand age 75, a more characteristic, closed canopy and multi-tiered forest structure begins to develop (Table 8; Figure 4). Stands are initially dominated by black ash, but regeneration opportunities for northern white cedar, yellow birch, and white spruce begin to increase as the forest ages (Table 9). Also during this time, a build-up of down woody debris accumulates, as well as the characteristic hummocks and adjacent micro-depressions begin to increase micro-topography, and provide more sites for a diversity of ground flora species. Many sites will be essentially self-sustaining at this point, with periodic canopy openings keeping stands from attaining old growth status.

Table 5. Soil surface cover

Tree basal cover	1-10%
Shrub/vine/liana basal cover	4-13%

Grass/grasslike basal cover	9-15%
Forb basal cover	20-40%
Non-vascular plants	5-20%
Biological crusts	0%
Litter	10-30%
Surface fragments >0.25" and <=3"	0-1%
Surface fragments >3"	0-1%
Bedrock	0%
Water	1-3%
Bare ground	6-8%

Table 6. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	1-10%
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	1-8%
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	1-5%
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	0-2%
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	1-4%
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	20-80 per acre
Tree snag count** (hard***)	10-30 per acre

*** Decomposition Classes: N - no or little integration with the soil surface; I - partial to nearly full integration with the soil surface.**

**** >10.16cm diameter at 1.3716m above ground and >1.8288m height--if less diameter OR height use applicable down wood type; for pinyon and juniper, use 0.3048m above ground.**

***** Hard - tree is dead with most or all of bark intact; Soft - most of bark has sloughed off.**

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	0-1%	0-1%	1-5%	1-5%
>0.5 <= 1	1-5%	1-5%	5-25%	5-25%
>1 <= 2	5-10%	5-10%	25-50%	25-50%
>2 <= 4.5	5-40%	10-50%	5-15%	5-15%
>4.5 <= 13	10-40%	25-50%	–	–
>13 <= 40	25-50%	1-10%	–	–
>40 <= 80	35-65%	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Community 1.2
Young Forest

Figure 9. Reference State (Community Phase 1.2 Young Forest)

The initiation of stand development follows partial canopy loss by windthrow or canopy openings developed from pocket of dead trees (Figure 5). Black ash advanced regeneration is the dominant regenerating tree, but is accompanied by other hardwoods, such as paper birch, balsam poplar (Populus balsamea), or quaking aspen (*Populus tremuloides*). Increased light also favors some wetland shrubs and ground flora, particularly speckled alder and bluejoint. Co-dominant canopy trees generally reach a diameter of around eight inches before transitioning to a mature forest.

Pathway 1A
Community 1.1 to 1.2

Mature Forest

Young Forest

Stand-levelling disturbance or small areas of partial canopy openings from wind or dead trees.

Pathway 2A
Community 1.2 to 1.1

Young Forest

Mature Forest

Succession (75+ years without disturbance).

State 2
Flooded State

The Flooded State develops as a result of dammed or blocked waterways. Flooding is caused primarily by either beaver activity or development associated with road building. Only drainageway landforms are affected, and isolated depressions do not go through this state. Sites that have blocked water drainage from roads may become perpetual open water wetlands. In natural settings, the Flooded State can last for many years, but it ultimately depends on maintenance of high quality habitat conditions for beaver to proliferate. Once a site is abandoned, dams will gradually decline and ultimately drain, thereby beginning the transition to the Non-Forested State. Beaver populations in North America were drastically reduced by broad scale fur trapping during the Colonial time period, into the 1800s (Mitsch and Gosselink, 2007). As a result, natural conversion of these sites to the Flooded State may be less common today than it was prior to European settlement.

Community 2.1
Open Water Wetland

Figure 10. Flooded State of a black ash depression, similar t

The only community phase in this state is characterized as having dead or dying overstory trees, flooded by up to several feet of essentially permanent water (Figure 6). Depending on depth of water, there will be areas with emergent aquatic vegetation, as well as scattered areas of marsh-like conditions.

State 3
Non-Forested State

Sites can transition to this state by relatively sudden and complete loss of the tree canopy, thereby losing the transpiration of water from trees needed to keep water tables at bay and allow tree species to continually proliferate. This can happen as a result of intensive logging, forest pests, or general forest decline. This state will likely become common in the MLRA if the invasion of the exotic emerald ash borer (Agrilus planipennis) beetle is not halted (Slesak et al., 2014; Palik et al., 2012). Sites can also transition to this state from the Flooded State, following drainage of backed up water from beaver activity or road building. Initially, sites are wet meadows dominated by graminoids (e.g., bluejoint and sedges), eventually becoming invaded by wetland shrubs depending on level of ponding and soil saturation. These sites may have different soil characteristics depending on the extent and depth of sedimentation, which is largely dependent on how long the site was dammed (Naiman et al., 2005)and is also related to nearby land use and landscape-level soil geomorphology. More research is needed on how soil properties change following long term flooding from blocked hydrology. Other than a few scattered trees, these sites do not seem to regenerate trees well. Transition to the Reference State is relatively unknown, and will require long term ecological succession over the course of many decades. There is limited evidence that these communities succeed to a forested structure within a reasonable time frame (SNF, unpublished report b). Non-forested wetland conditions may persist for decades, and even centuries (Naiman et al., 2005; Terwilliger and Pastor, 1999). Viability of black ash seeds is only 8 years (Wright and Rauscher, 1990), so seeds are probably at least initially extirpated from the site. And since most sites are small and isolated, there may not be a reliable seed source nearby. The loss of important mycorrhizal relationships may also impede succession of forest trees. It has been shown that long-term flooding kills mycorrhizae that form essential relationships with tree species in other types of forested wetlands in the region, and recolonization following draining may be inhibited (Anderson and Fischer, 2015; Terwilliger and Pastor, 1999), which may be the case in this ecological site as well. All of this, in combination with extreme competition with resident vegetation, make succession to a forested state difficult.

Community 3.1
Shrub Swamp

Figure 11. Non-Forested State similar to Community Phase 3.1

In this phase, shrubs are greater than 25% cover (Figure 7; MN DNR, 2005). Dominant species are speckled alder, redosier dogwood, and willows (Salix spp.). Bluejoint and a variety of sedges are also dominant, along with a myriad of sun-loving wetland forb species. There may be scattered trees as well, but they comprise low cover and are not significant to the overall structure of the plant community. With a continued lowering of the water table, it is possible for this phase to succeed to the Reference State if black ash and other trees can successfully establish.

Community 3.2
Wet Meadow

Figure 12. Non-Forested State similar to community Phase 3.2

In this phase, shrubs are less than 25% cover (Figure 8; MN DNR, 2005). Bluejoint, sedges, and a variety of sun-loving wetland forbs dominate this phase. Lake sedge (*Carex lacustris*), the hummock-forming tussock sedge (*C. stricta*), and beaked sedge (*C. utriculata*) are the most common sedges, and can be dominant (MN DNR, 2005). The most common shrubs are speckled alder, redosier dogwood, and willows. There may be scattered trees as well, but they comprise low cover and are not significant to the overall structure of the plant community.

Pathway 1A
Community 3.1 to 3.2

Shrub Swamp **Wet Meadow**

Increased ponding, soil saturation.

Pathway 2A
Community 3.2 to 3.1

Wet Meadow

Shrub Swamp

Decreased ponding, soil saturation.

State 4
Non-Forested State

Sites can transition to this state by relatively sudden and complete loss of the tree canopy, thereby losing the transpiration of water from trees needed to keep water tables at bay and allow tree species to continually proliferate. This can happen as a result of intensive logging, forest pests, or general forest decline. This state will likely become common in the MLRA if the invasion of the exotic emerald ash borer (Agrilus planipennis) beetle is not halted (Slesak et al., 2014; Palik et al., 2012). Sites can also transition to this state from the Flooded State, following drainage of backed up water from beaver activity or road building. Initially, sites are wet meadows dominated by graminoids (e.g., bluejoint and sedges), eventually becoming invaded by wetland shrubs depending on level of ponding and soil saturation. These sites may have different soil characteristics depending on the extent and depth of sedimentation, which is largely dependent on how long the site was dammed (Naiman et al., 2005)and is also related to nearby land use and landscape-level soil geomorphology. More research is needed on how soil properties change following long term flooding from blocked hydrology. Other than a few scattered trees, these sites do not seem to regenerate trees well. Transition to the Reference State is relatively unknown, and will require long term ecological succession over the course of many decades. There is limited evidence that these communities succeed to a forested structure within a reasonable time frame (SNF, unpublished report b). Non-forested wetland conditions may persist for decades, and even centuries (Naiman et al., 2005; Terwilliger and Pastor, 1999). Viability of black ash seeds is only 8 years (Wright and Rauscher, 1990), so seeds are probably at least initially extirpated from the site. And since most sites are small and isolated, there may not be a reliable seed source nearby. The loss of important mycorrhizal relationships may also impede succession of forest trees. It has been shown that long-term flooding kills mycorrhizae that form essential relationships with tree species in other types of forested wetlands in the region, and recolonization following draining may be inhibited (Anderson and Fischer, 2015; Terwilliger and Pastor, 1999), which may be the case in this ecological site as well. All of this, in combination with extreme competition with resident vegetation, make succession to a forested state difficult.

Transition 1
State 1 to 2

Flooding, backed up water from beaver dam or road bed.

Transition 1B
State 1 to 3

Removal of tree canopy resulting in loss of transpiration and elevated water levels.

Transition 2A
State 2 to 3

Drainage of open water.

Restoration pathway 3A
State 3 to 1

Long term forest succession.

Transition 3A
State 3 to 2

Flooding, backed up water from beaver dam or road bed.

Additional community tables

Table 8. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)	Diameter (In)	Basal Area (Square Ft/Acre)
Tree							
black ash	FRNI	*Fraxinus nigra*	Native	16–80	50–75	8–15	–
arborvitae	THOC2	*Thuja occidentalis*	Native	16–50	5–25	12–20	–
yellow birch	BEAL2	*Betula alleghaniensis*	Native	16–40	5–25	5–10	–
balsam fir	ABBA	*Abies balsamea*	Native	16–40	1–5	3–8	–
white spruce	PIGL	*Picea glauca*	Native	16–40	1–5	3–8	–

Table 9. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (Ft)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
fowl mannagrass	GLST	*Glyceria striata*	Native	0.1–3	10–50
bluejoint	CACA4	*Calamagrostis canadensis*	Native	0.1–3	10–50
bluejoint	CACA4	*Calamagrostis canadensis*	Native	0.1–3	10–50
bristlystalked sedge	CALE10	*Carex leptalea*	Native	0.1–2	5–15
greater bladder sedge	CAIN12	*Carex intumescens*	Native	0.1–2	1–10
awlfruit sedge	CAST5	*Carex stipata*	Native	0.1–1	1–10
graceful sedge	CAGR2	*Carex gracillima*	Native	0.1–1	1–10
softleaf sedge	CADI6	*Carex disperma*	Native	0.1–1	1–10
fringed brome	BRCI2	*Bromus ciliatus*	Native	0.1–2	1–5
Forb/Herb					
yellow marsh marigold	CAPA5	*Caltha palustris*	Native	0.1–1	10–50
northern bugleweed	LYUN	*Lycopus uniflorus*	Native	0.1–1	5–25
dwarf red blackberry	RUPU	*Rubus pubescens*	Native	0.1–1	5–15
blue skullcap	SCLA2	*Scutellaria lateriflora*	Native	0.1–1	5–15
touch-me-not	IMPAT	*Impatiens*	Native	0.1–3	5–15
purplestem aster	SYPUP	*Symphyotrichum puniceum var. puniceum*	Native	0.1–3	5–15
parasol whitetop	DOUMU	*Doellingeria umbellata var. umbellata*	Native	0.1–3	1–10
wild sarsaparilla	ARNU2	*Aralia nudicaulis*	Native	0.1–2	1–5
starflower	TRBO2	*Trientalis borealis*	Native	0.1–1	1–5
arctic sweet coltsfoot	PEFR5	*Petasites frigidus*	Native	0.1–1	1–5
spotted joe pye weed	EUMA9	*Eutrochium maculatum*	Native	0.1–3	1–5
naked miterwort	MINU3	*Mitella nuda*	Native	0.1–1	1–5
harlequin blueflag	IRVE2	*Iris versicolor*	Native	0.1–2	1–5
tall bluebells	MEPA	*Mertensia paniculata*	Native	0.1–1	1–5
woodland horsetail	EQSY	*Equisetum sylvaticum*	Native	0.1–1	1–5
threeleaf goldthread	COTR2	*Coptis trifolia*	Native	0.1–1	1–5

Jack in the pulpit	ARTR	*Arisaema triphyllum*	Native	0.1–2	1–5
small enchanter's nightshade	CIAL	*Circaea alpina*	Native	0.1–1	1–5
giant goldenrod	SOGI	*Solidago gigantea*	Native	0.1–3	1–5
eastern swamp saxifrage	SAPE8	*Saxifraga pensylvanica*	Native	0.1–2	1–5
wood anemone	ANQU	*Anemone quinquefolia*	Native	0.1–1	1–5
Canada mayflower	MACA4	*Maianthemum canadense*	Native	0.1–1	1–5
bunchberry dogwood	COCA13	*Cornus canadensis*	Native	0.1–1	1–5
purple meadow-rue	THDA	*Thalictrum dasycarpum*	Native	0.1–3	1–2
Fern/fern ally					
common ladyfern	ATFI	*Athyrium filix-femina*	Native	0.1–2	5–25
intermediate woodfern	DRIN5	*Dryopteris intermedia*	Native	0.1–1	5–15
sensitive fern	ONSE	*Onoclea sensibilis*	Native	0.1–2	5–15
western oakfern	GYDR	*Gymnocarpium dryopteris*	Native	0.1–1	1–5
ostrich fern	MAST	*Matteuccia struthiopteris*	Native	0.1–3	1–5
long beechfern	PHCO24	*Phegopteris connectilis*	Native	0.1–1	1–5
Shrub/Subshrub					
speckled alder	ALINR	*Alnus incana ssp. rugosa*	Native	1–16	25–75
redosier dogwood	COSE16	*Cornus sericea*	Native	1–10	1–15
beaked hazelnut	COCO6	*Corylus cornuta*	Native	1–10	1–15
American fly honeysuckle	LOCA7	*Lonicera canadensis*	Native	1–5	1–5
American cranberrybush	VIOPA2	*Viburnum opulus var. americanum*	Native	1–5	1–5
red currant	RITR	*Ribes triste*	Native	1–5	1–5
Tree					
mountain maple	ACSP2	*Acer spicatum*	Native	1–16	5–25
American red raspberry	RUID	*Rubus idaeus*	Native	1–10	1–15
black ash	FRNI	*Fraxinus nigra*	Native	1–10	1–15
chokecherry	PRVI	*Prunus virginiana*	Native	1–10	1–5

Inventory data references

A total of 12 integrated plots, ranging from Tier 2 to Tier 3 intensity, were used as a basis for this ecological site. Three of these were Type Locations representing the data-supported Community Phase 1.1 in the state-and-transition model (Figure 2), and included all necessary data elements for a Tier 3 dataset (Table 10). No other community phases were supported with quantitative data analysis. All 12 plots had soil pedon and site data collected by a professional soil scientist using a form equivalent to SF-232. Pits were hand-dug using spade shovels, sharpshooters, and/or bucket augers. Of the 12 plots, two were located at established MN DNR relevé points, obtained and used with permission from the MN DNR County Biological Survey. List of MN DNR relevé plots used with verified soils data: 3475 and 8301.

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Contributors

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	
Contact for lead author	
Date	
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

2. **Presence of water flow patterns:**

3. **Number and height of erosional pedestals or terracettes:**

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

5. **Number of gullies and erosion associated with gullies:**

6. **Extent of wind scoured, blowouts and/or depositional areas:**

7. **Amount of litter movement (describe size and distance expected to travel):**

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

14. **Average percent litter cover (%) and depth (in):**

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

17. **Perennial plant reproductive capability:**