Mapping Plant Alliances of the Fort Custer Training Center

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Cover photo: White Oak - (Northern Red Oak, Hickory species) Forest Alliance surrounding kettle depression wetland with Common Buttonbush Semipermanently Flooded Shrubland Alliance (foreground) and Leatherleaf Saturated Dwarf-shrubland Alliance (Photo by Steve A. Thomas).

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INTRODUCTION

Efforts to conserve biological diversity and manage natural resources have often focused on protecting and managing natural communities. Natural communities constitute the habitat in which species interact with biotic and abiotic components and provide the critical ecosystem functions (e.g., nutrient cycling) on which all life depends. In the past, protection and management of natural communities at regional and national levels has been complicated by the lack of consistent definitions for many natural community types. The U.S. National Vegetation Classification (USNVC) provides a standardized classification system of natural communities for the U.S. that allows natural vegetation types to be consistently classified and mapped across administrative and political boundaries (Anderson et al. 1998, Grossman et al. 1998, Faber-Langendoen 2001, Rapp et al. 2005). Because the USNVC is hierarchical, it allows vegetation to be classified and mapped at multiple scales, thus facilitating comparisons among sites at the local, regional, and national levels. Applications of the USNVC, such as regional assessments of conservation and restoration needs often require mapping vegetation to the plant alliance level. Plant alliances are based upon dominant or diagnostic plant species in the uppermost vegetation strata and their link to fundamental environmental attributes (Grossman et al. 1998).

The benefits of using a consistent hierarchically based vegetation classification system such as the USNVC are numerous. For example, it enables comparisons of ecological community richness (number of communities in a given area) and variability across regions and administrative boundaries; it provides information on the geographic distribution of community types; and it helps elucidate relationships between natural communities and ecological processes and disturbance regimes (Grossman et al. 1998). A detailed map of plant alliances at Fort Custer Training Center (FCTC) will facilitate a more thorough understanding of its ecosystems and its importance to regional biodiversity. In addition, it will provide land managers with a useful tool for setting conservation and stewardship priorities and monitoring changes in the vegetation, and it will help facilitate communication with other agencies.

In 2009 the Michigan Natural Features Inventory (MNFI) created a digital map of plant alliances at FCTC. This work involved a combination of natural community interpretation, GIS modeling, aerial photograph interpretation, extensive ground truthing, and map production. This report provides description of the methods employed to develop FCTC's plant alliance map, results, summary of findings, and discussion of the map's limitations and applications.

STUDY AREA

Fort Custer Training Center is located between the cities of Battle Creek and Kalamazoo in the southwestern Lower Michigan. Approximately two-thirds of its land area lies in Kalamazoo County, and the remainder lies to the east in Calhoun County (Figure 1). FCTC includes all or portions of T1S, R9W Section 36; T1S, R8W Section 31; T2S, R9W Sections 1, 10, 11, 12, 13, 14, 15, 16, 21, 22, 23, and 24; and T2S, R8W Sections 6, 7, 17, 18, 19, and 20. Its 7,570 acres of land are leased by the Department of Military and Veterans Affairs (DMVA) from the Federal Government.

Ecoregional Context

Fort Custer Training Center is located within the Battle Creek Outwash Plain Sub-subsection (VI.2.1) of the Kalamazoo Interlobate Subsection (VI.2) of the regional landscape ecosystems as described by Albert (1995) (Figure 1). This Sub-subsection lies within a 225-320 m (750-1050 ft) range of elevation and is underlain by Mississippian-age shale (Albert 1995). The Battle Creek Outwash Plain contains relatively broad and flat outwash plains, and steeper hill slopes and ridges derived from ice-contact deposits and ground moraine (Figure 2) (Farrand and Bell 1982). Lakes and wetlands frequently occur on the outwash plain and in kettle depressions within moraines (Albert 1995, Lee et al. 2002). Average annual precipitation is approximately 89 cm (35 in) (NRCS 2008). The Great Lake influence on the climate of FCTC is buffered by an approximate distance of 64 km (40 miles) from Lake Michigan's shore, and most precipitation is associated with passing cold fronts or air mass instability rather than lake-effect showers. The growing season is about 151 days and average extreme annual minimum temperature is -23º C (9 Fº) (Albert 1995, Legge et al. 1995).

Historical Conditions

Circa 1800 vegetation types of the Battle Creek Outwash Plain Sub-subsection are mapped as oak-hickory forest, mixed oak forest, beech-sugar maple forest, oak savanna, oak openings, and prairie in upland areas, and mixed hardwood swamp, mixed conifer

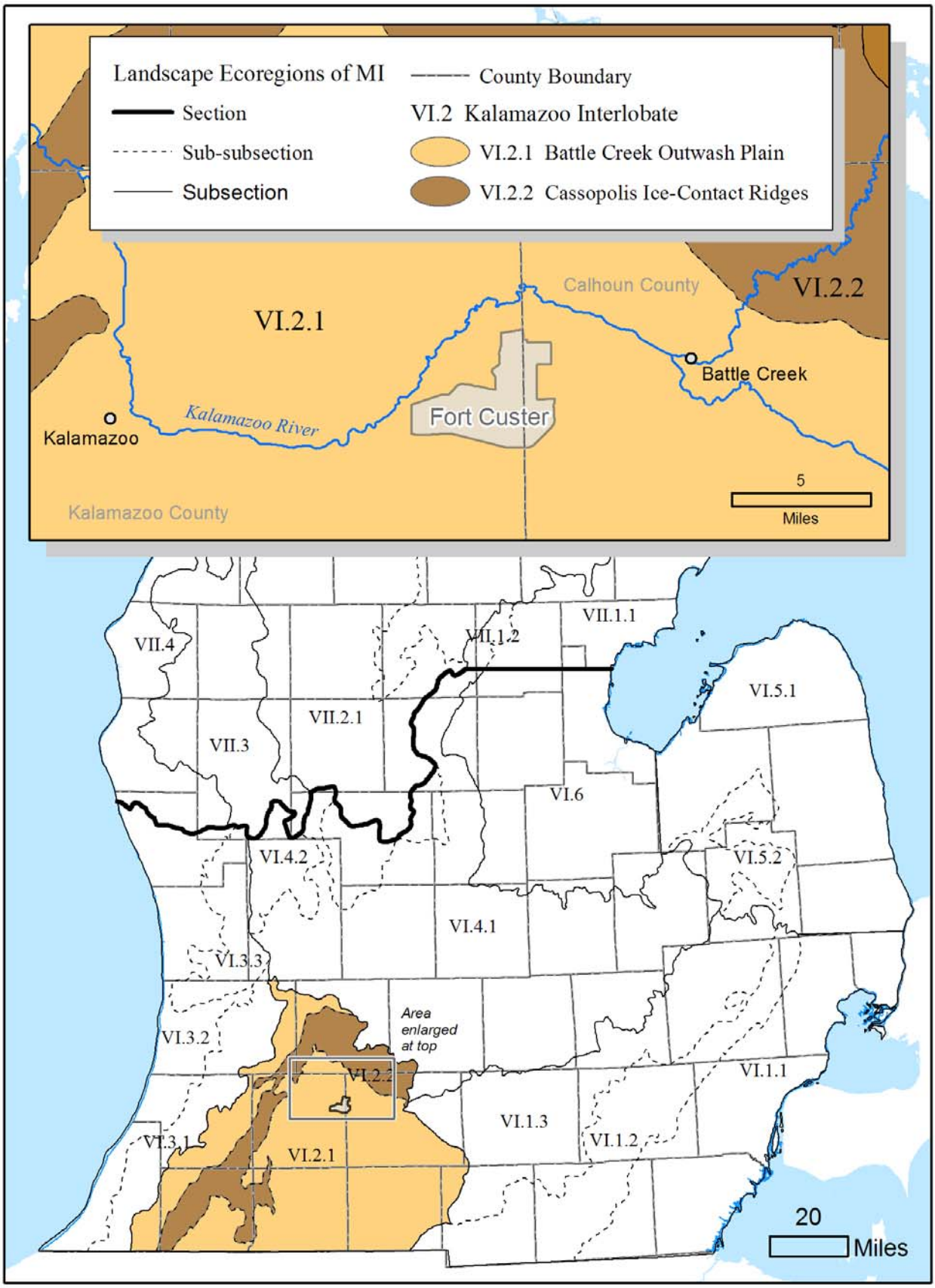

Figure 1. Ecoregions of Southern Lower Michigan (Albert 1995). Fort Custer Training Center occurs within the Battle Creek Outwash Plain Sub-subsection (VI.2.1) of the Kalamazoo Interlobate Subsection (VI.2).

swamp, wet prairie, lakes, bogs, and shrub swamp/emergent marsh in wetland areas (Figure 3) (Comer et al. 1995). The distributions of these communities were established by patterns of surface fire, hydrology, topography, and Native American activities. Within FCTC, oak-hickory forest was often on hill slopes and ridges, and was the predominant mapped cover type (approximately 60%) (Figure 3). Oak openings or mixed oak savanna were often mapped on flat to gently rolling uplands, and covered approximately 25% of FCTC. Throughout FCTC, scattered wetlands occur in drainage ways or depressions. Most wetlands were mapped as mixed hardwood swamps (often within narrower drainage channels) or shrub swamp/emergent marshes (often within broader drainage channels), but small areas of bog and lake were also mapped within depressions (Comer et al. 1995, Legge et al. 1995).

METHODS

Michigan Natural Features Inventory staff conducted aerial photograph interpretation of 1938 black-and-white aerial imagery (1938 black and white panchromatic film, 1:20,000, National Archives and Records Administration) (Figure 4), 1998 color infrared aerial imagery (1998 Digital Orthophoto County Mosaics, leaf off, 1:12,000, 1 m pixel Michigan DNR) (Figure 5), 2005 color aerial imagery (2005 NAIP Digital Orthophoto County Mosaics, leaf on, 1:12,000, 1 m pixel Michigan DNR), and 2005 black-and-white high resolution (1 ft pixel) aerial imagery (State of Michigan and Kalamazoo County). In addition, digitized topographic maps (1:24,000 USGS georeferenced Digital Raster Graphics quadrangles in 8 bit TIFF file format, Michigan DNR) were inspected. Areas with unique aerial color, pattern signatures, and/or slope positions were visited, geographically recorded with GPS, described in the field, and digitized using GIS. At least five points were visited within each full quarter-section (160-acre square block) occurring within FCTC.

Areas with natural vegetation were grouped into plant alliances based upon field and alliance descriptions (NatureServe 2009). In addition to field descriptions, circa 1800 vegetation maps (Comer et al. 1995), prior MNFI surveys on FCTC, and previously mapped natural community element occurrences (Legge et al 1995, Cohen et al. 2009, MNFI 2009) were reviewed to help determine appropriate plant alliances. Areas with anthropogenically disturbed vegetation, for which plant alliances are inapplicable, were grouped into "disturbed units" based upon similarity of condition. Three classes of disturbed units were identified: "field", "developed", and "potential plant alliance". "Fields" were areas that were likely cleared and farmed and have remained open, many as military firing ranges or training grounds. "Developed" areas include barracks, training facilities, gravel pits, and extensively paved areas (i.e., parking lots). Areas which had severe anthropogenic disturbance (e.g., areas converted to row crop) that have since developed a tree or shrub canopy have been mapped as "potential plant alliance." Historical aerial imagery (i.e., from 1938) was used to separate areas of natural plant alliance, which often appear wooded in 1938 photos, from areas of potential plant alliance, which appear open in 1938 photos. Large areas of open water were grouped into an "open water" category while smaller areas of water surrounded by forest were included in a "vernal wetland" unit.

Map features were digitized using ESRI ArcMap 9.2 software (Environmental Systems Research Institute, 2006). Areas of similar alliance type were delineated manually onscreen using a backdrop of the digital data mentioned previously, and a nominal minimum mapping unit of approximately > 0.5 acres.

RESULTS

A total of 21 plant alliances and three disturbed units were identified at FCTC, and two additional categories of "vernal wetland" and "open water" were utilized (Table 1, Figure 6). Natural plant alliances occur on approximately 27 % of FCTC. Among those areas containing plant alliances, the seven upland alliances and 16 wetland alliances (including open water and vernal wetland) cover approximately 17 % and 10 % of the site, respectively. By far the most common plant alliance at FCTC is the White Oak - (Northern Red Oak, Hickory species) Forest Alliance (Photograph 1 in Appendix II), which constitutes approximately 12 % of FCTC and 70 % of all areas ascribable to an upland alliance. Among the 16 wetland alliance types, distribution was more even. The most extensive wetland alliance was the Black Ash - Red Maple Saturated Forest Alliance (Photograph 10 in Appendix II), which accounted for 3 % of FCTC and contained approximately 27 % of all wetland acreage. Red-osier Dogwood - Willow species Seasonally Flooded Shrubland Alliance and Tussock Sedge Seasonally

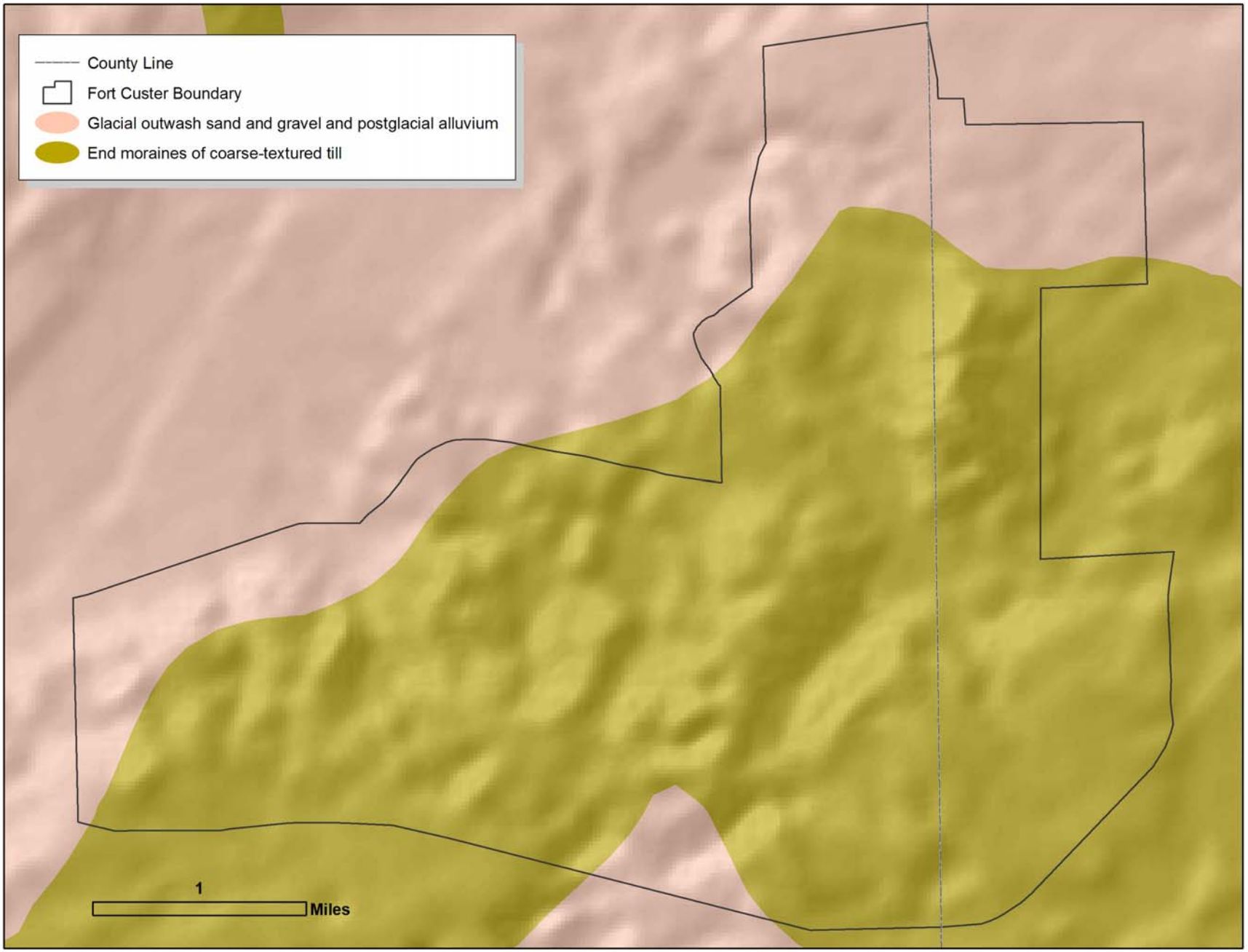

Figure 2. Glacial landforms of the Fort Custer Training Center (Farrand and Bell 1982).

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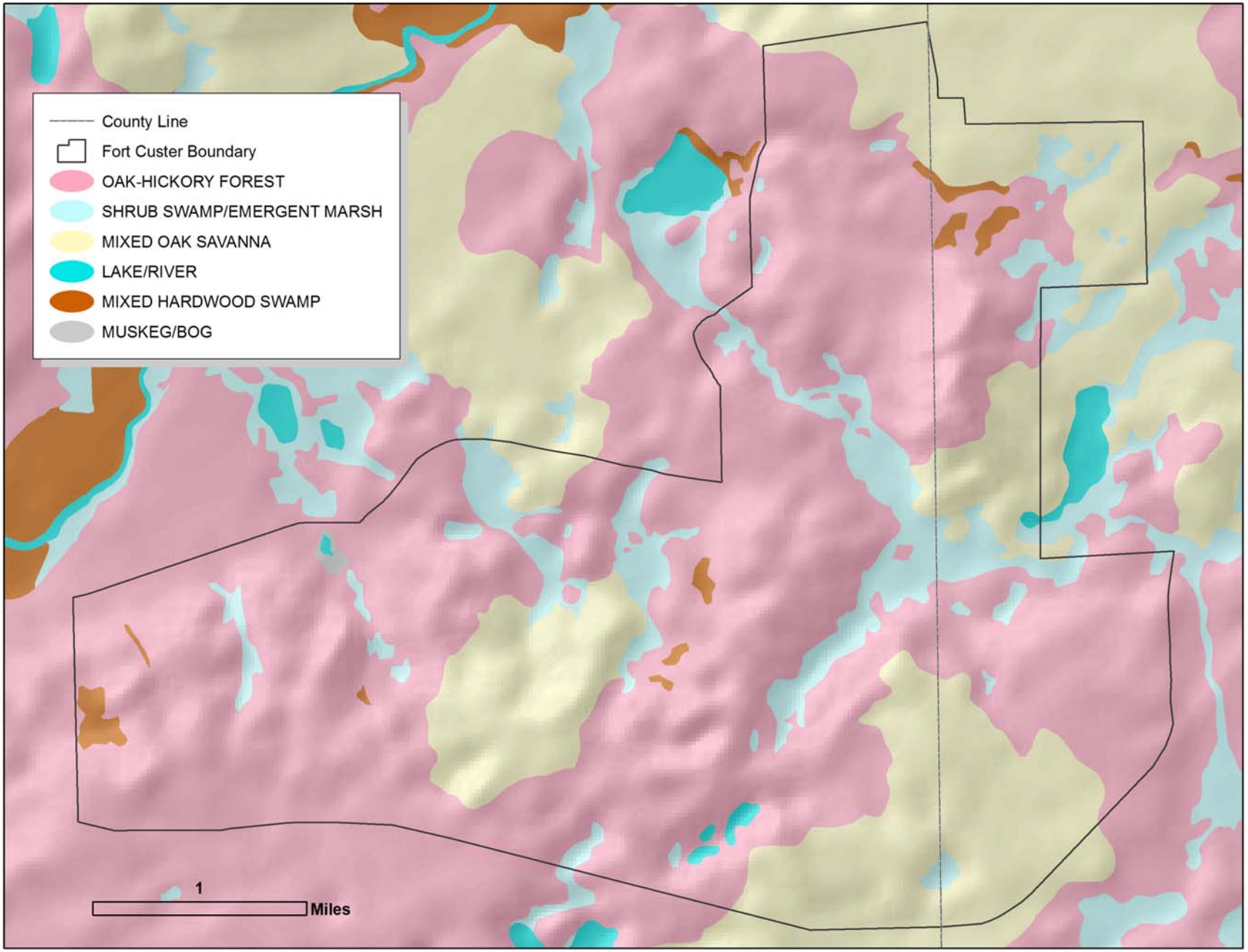

Figure 3. Vegetation circa 1800 of the Fort Custer Training Center and surrounding area (Comer et al. 1995).

Figure 4. 1938 black-and-white aerial imagery of the Fort Custer Training Center.

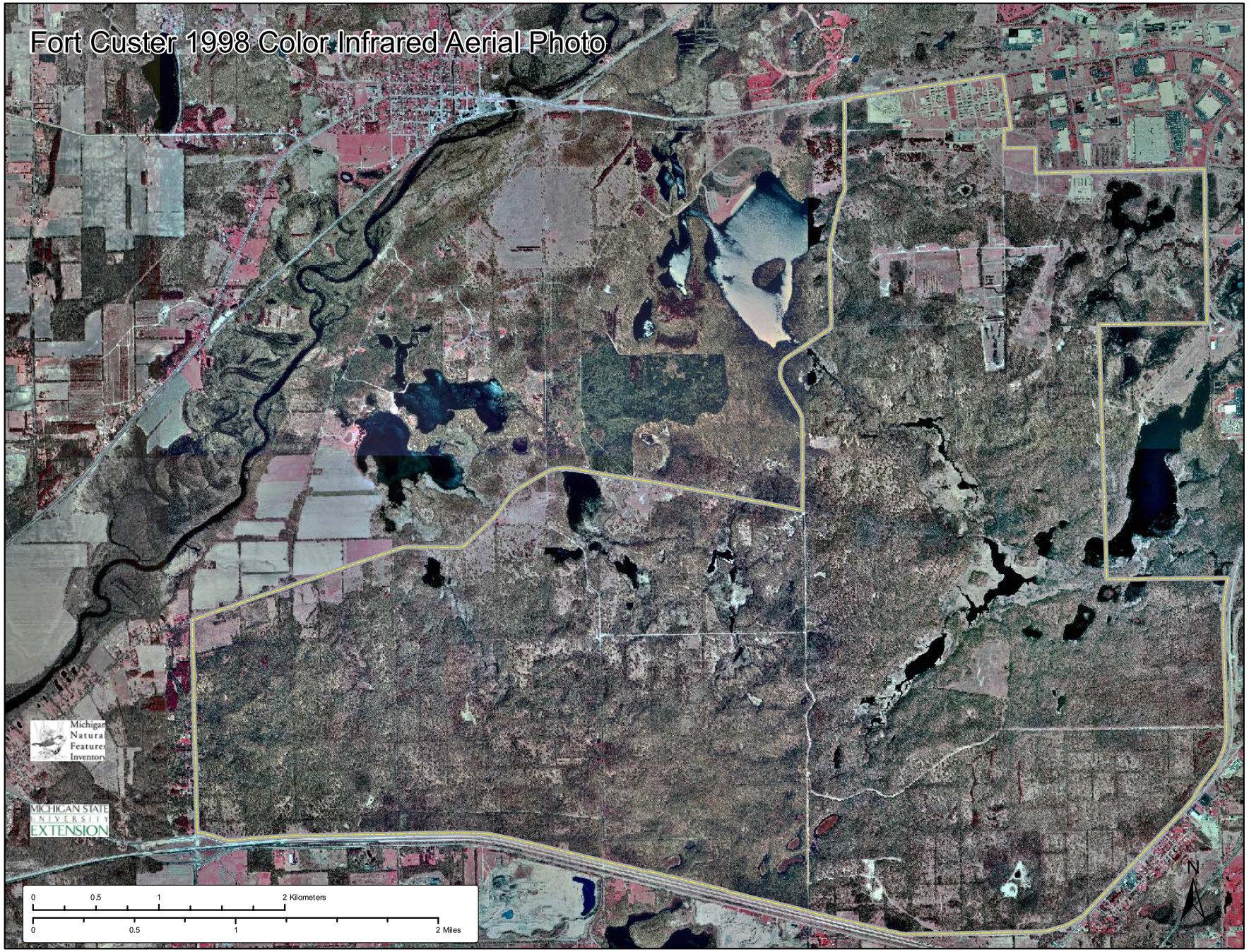

Figure 5. 1998 color infrared aerial imagery of the Fort Custer Training Center.

Table 1. Acreage of plant alliances of the Fort Custer Training Center and crosswalk to MNFI natural communnity classification.

Alliance Common Name or [Non-Alliance Name]	Alliance Code	MNFI Natural Community	Acreage	Percent Area
Little Bluestem - Yellow Indiangrass Herbaceous Alliance	A.1198	Dry-mesic Prairie	0.36	0.00
Big Bluestem - (Yellow Indiangrass) Herbaceous Alliance	A.1192	Mesic Sand Prairie	2.57	0.03
Bur Oak - (White Oak) Wooded Herbaceous Alliance	A.1491	Bur Oak Plains	25.61	0.34
Black Oak - (Northern Pin Oak) Wooded Herbaceous Alliance	A.1492	Oak Barrens	100.77	1.34
White Oak - (Northern Red Oak, Hickory species) Forest Alliance	A.239	Dry-mesic Southern Forest	883.84	11.79
American Beech - Sugar Maple - (Tuliptree) Forest Alliance	A.227	Mesic Southern Forest	39.55	0.53
Northern Red Oak - (Sugar Maple) Forest Alliance	A.251	Mesic Southern Forest	216.93	2.89
[Vernal Wetland]	NA	NA	1.55	0.02
Pin Oak - (Swamp White Oak) Seasonally Flooded Forest Alliance	A.329	Wet-mesic Flatwoods	13.05	0.17
Green Ash - American Elm - (Common Hackberry, Sugarberry) Temporarily Flooded Forest Alliance	A.286	Floodplain Forest	33.52	0.45
Black Ash - Red Maple Saturated Forest Alliance	A.347	Southern Hardwood Swamp	207.02	2.76
Red Maple - Green Ash Seasonally Flooded Forest Alliance	A.316	Southern Hardwood Swamp	22.48	0.30
Tamarack Saturated Forest Alliance	A.349	Rich Tamarack Swamp	1.08	0.01
Red-osier Dogwood - Willow species Seasonally Flooded Shrubland Alliance	A.989	Southern Shrub-carr	134.53	1.79
Common Buttonbush Semipermanently Flooded Shrubland Alliance	A.1011	Inundated Shrub Swamp	23.77	0.32
Leatherleaf Saturated Dwarf-shrubland Alliance	A.1092	Bog	11.19	0.15
Shrubby-cinquefoil / (Yellow Sedge, Inland Sedge, Wiregrass Sedge, Sterile Sedge) Saturated Shrub Herbaceous Alliance	A.1562	Prairie Fen	32.98	0.44
Skunk-cabbage - Yellow Marsh-marigold Saturated Herbaceous Alliance	A.1694	Southern Wet Meadow	17.33	0.23
Tussock Sedge Seasonally Flooded Herbaceous Alliance (non-isolated, free draining)	A.1397	Southern Wet Meadow	105.57	1.41
Tussock Sedge Seasonally Flooded Herbaceous Alliance (isolated, inundated)	A.1397	Southern Wet Meadow or Emergent Marsh	32.28	0.43
(Narrowleaf Cattail, Broadleaf Cattail) - (Clubrush species) Semipermanently Flooded Herbaceous Alliance	A.1436	Emergent Marsh	48.16	0.64
American White Water-lily - Yellow Pond-lily species Permanently Flooded Temperate Herbaceous Alliance	A.1984	Submergent Marsh	18.21	0.24
[Open Water]	NA	NA	72.25	0.96
[Potential Plant Alliance]	NA	NA	4721.68	62.97
[Field]	NA	NA	558.92	7.45
[Developed]	NA	NA	172.67	2.30

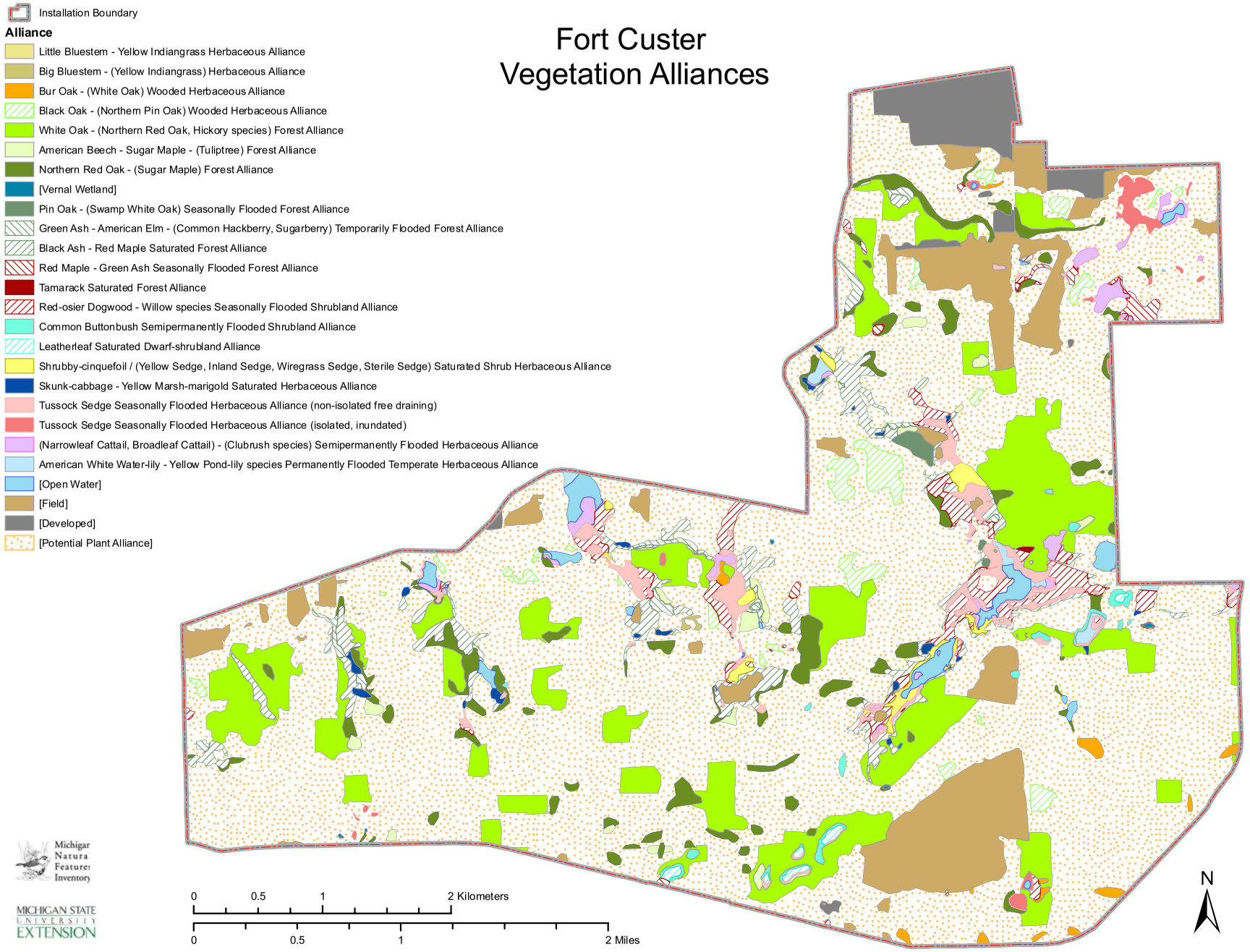

Figure 6. Plant alliances of the Fort Custer Training Center.

Flooded Herbaceous Alliance both account for approximately 17% of all wetland area. Isolated, inundated depressions containing occurrences of the Tussock Sedge Seasonally Flooded Herbaceous Alliance appeared to have significantly different vegetation than those occurrences in non-isolated, free-draining contexts; therefore this single alliance was split into two subunits on both the table and map (Table 1, Figure 6). Disturbed units contain areas of developed land, open field, and potential plant alliance, which hold approximately 2 %, 7 %, and 63 % respectively, of FCTC's total acreage. Field descriptions and photographs of all alliances and mapped types found at FCTC are presented in Appendices I and II, respectively.

DISCUSSION

A plant alliance map of FCTC can provide numerous benefits. Alliance mapping can facilitate standardized and hierarchical assessment of ecological community richness, distribution, and extent across multiple spatial and temporal scales. It can play a role in a national effort to map alliances. Such national efforts are of critical importance for conservation of locally rare and globally rare communities (e.g., oak savanna), for providing more accurate assessments of community extent and distribution, for assessing the success of restoration efforts, and for establishing conservation and stewardship priorities. Alliance maps can serve as a monitoring tool at the local scale. For example, as ecosystem management practices continue at FCTC, areas now mapped as potential plant alliance may shift toward natural plant alliances. Periodic re-mapping of alliances may serve as a coarse tool to track this change through time.

The effort to develop a plant alliance map of FCTC can yield valuable lessons for similar projects. For example, not all alliance boundaries are clearly discernable on existing aerial photography, and efforts to map similar landscapes should take this into account and include a ground truthing component to enhance the accuracy of the map product. Boundaries between alliances were relatively discernable when the alliance combinations tended to be those with completely different moisture levels (such as wetland versus upland) or physiognomies (such as forested versus herbaceous versus open water). In contrast, those alliances with similar physiognomies and/or intergrading moisture levels (such as adjacent upland forests representing two different alliances) often looked very similar remotely and could not be separated from imagery color or pattern alone. Also, alliance units which are small (e.g., less than one acre) could not be reliably interpreted from aerial and/or topographic map imagery due to resolution of the data. Therefore, the smaller the acreage of a given alliance unit at FCTC, the less likely it is to be shown on the map. In general, the most discernable plant alliances are those that have unique aerial photographic signatures and/or those that occur on discrete landscape features. Few alliances at FCTC had fully unique aerial photographic signatures. Bogs (Leatherleaf Saturated Dwarf-shrubland Alliance), which have a unique reddish hue on color infrared photographs and occur within kettle depressions, can be mapped with reasonable accuracy using aerial imagery and topographic maps. In summary, coarse plant alliance mapping can be conducted with aerial imagery, but precise determination and delineation of most alliance types and boundaries requires mapping or surveying in the field.

Extensive anthropogenic disturbance at FCTC contributed to the challenge of mapping plant alliances. Every area within FCTC has probably been altered to some degree from its Presettlement character. Alterations have occurred and occur because human activities have altered and continue to alter natural communities. These activities have included or include crop production, livestock grazing, hydrologic alteration (i.e., draining for agriculture), logging, burning, fire suppression, and hunting. Alterations can cause the plant alliance of a given area to shift towards another plant alliance, or in the case of severe and sustained disturbance, towards an anthropogenically disturbed system. For example, several decades of fire suppression of Black Oak - (Northern Pin Oak) Wooded Herbaceous Alliance (oak barrens) can cause its species composition to shift toward White Oak - (Northern Red Oak, Hickory species) Forest Alliance (dry-mesic southern forest). Many areas viewed during ground truthing in FCTC appeared to have shifted due to repeated land uses over the decades since European settlement. Regardless of alliance shifts that have occurred, MNFI attempted to map existing plant alliances, rather than map those which were thought to have occurred in years prior.

By acreage, the largest category on the map is the potential plant alliance (Table 1, Figure 6). Potential

plant alliances are typically areas which were originally wooded (i.e., forest, savanna, or barrens) but were cleared for agriculture. These areas now contain native and/or non-native trees. Regardless of tree composition, they have in common relatively young stand age (e.g., less than 60 years old) and relatively disturbed groundlayer species composition, including a significant component of non-native invasive shrubs. Potential plant alliances are believed to have the capacity to mature or revert to natural plant alliances over time, depending upon sustained management. A regiment of continued periodic prescribed burning and invasive species control, for example, may allow many acres of potential plant alliance to shift toward the White Oak - (Northern Red Oak, Hickory species) Forest Alliance and the Black Oak - (Northern Pin Oak) Wooded Herbaceous Alliance.

Finally one should be aware of inherent limitations of the USNVC's plant alliance classification system. Alliance descriptions encompass large geographic regions and numerous local plant associations. While this broad approach facilitates regional communication and comparison, alliance descriptions alone do not address local attributes and variability. Thus, while an understanding of the natural communities at FCTC can be enhanced by a review of alliance descriptions, these descriptions should not be used as uniform substitutes for other local sources of information, such as state-wide natural community classification systems or observations of the natural communities themselves.

CONCLUSION

As a result of this mapping project, we suggest that coarse-level mapping of the alliances of the FCTC area can be conducted through aerial photograph interpretation in conjunction with ground-truthing. This methodology is fairly accurate for mapping boundaries between alliances with contrasting cover types or moisture levels, but provides only approximate results for boundaries between closely related or superficially similar alliances. For higher accuracy alliance mapping we recommend field mapping, delineation, and/or surveying. Finally should FCTC desire a more detailed description and understanding of plant communities present than is supplied through alliance descriptions, we recommend the development of detailed natural community descriptions through more intensive and systematic field inspections.

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Appendix 1
Field Descriptions of Plant Alliances from Fort Custer Training Center

Alliance Common Name or [Non-Alliance Name]	Field Description
Little Bluestem - Yellow Indiangrass Herbaceous Alliance	Upland prairie. Dry mesic, sandy or gravelly loams. Flat to gently or moderately sloped. Common species: little bluestem (*Andropogon scoparius*), thimbleweed (*Anemone cylindrica*), wild bergamot (*Monarda fistulosa*), bush clovers (*Lespedeza spp.*), and Indian grass (*Sorghastrum nutans*).
Big Bluestem - (Yellow Indiangrass) Herbaceous Alliance	Upland prairie. Mesic soils, gently sloped. Common species: sassafras (*Sassafras albidum*), raspberries/blackberries (*Rubus spp.*), tall coreopsis (*Coreopsis tripteris*), golden ragwort (*Senecio aureus*), violet (*Viola sp.*), Virginia mountain mint (*Pycnanthemum virginianum*), goldenrods (*Solidago spp.*), tick trefoils (*Desmodium spp.*), golden alexanders (*Zizia aurea*), wild bergamot (*Monarda fistulosa*), common boneset (*Eupatorium perfoliatum*), grass-leaved goldenrod (*Euthamia graminifolia*), and little bluestem (*Andropogon scoparius*).
Bur Oak - (White Oak) Wooded Herbaceous Alliance	Current degraded form is forested uplands, but occurred historically as a savanna. Mesic, occasionally dry-mesic or wet-mesic. Sandy loam or loam soils. On broad, somewhat flat ridges or shallow swales. Existing degraded status is due to fire suppression. Common species: bur oak (*Quercus macrocarpa*), white oak (*Quercus alba*), hickories (*Carya spp.*), and black walnut (*Juglans nigra*).
Black Oak - (Northern Pin Oak) Wooded Herbaceous Alliance	Open woodland or barrens-like communities. Usually dry-mesic to dry, but occasionally mesic. Sandy soils with thin A-horizon. Terrain often somewhat flat to gently rolling. Common species: white oak (*Quercus alba*), black oak (*Quercus velutina*), Pennsylvania sedge (*Carex pensylvanica*), Indian grass (*Sorghastrum nutans*), tall coreopsis (*Coreopsis tripteris*), wild strawberry (*Fragaria virginiana*), and wood betony (*Pedicularis canadensis*).
White Oak - (Northern Red Oak, Hickory species) Forest Alliance	Forested uplands. Usually dry-mesic, occasionally mesic, and rarely wet-mesic. Often on rocky sandy loams, but sometimes on loamy sands. Often on gentle to moderate slopes, and sometimes steep slopes. Common species: black oak (*Quercus velutina*), pignut hickory (*Carya glabra*), red maple (*Acer rubrum*), black cherry (*Prunus serotina*), big-toothed aspen (*Populus grandidentata*), white oak (*Quercus alba*), sassafras (*Sassafras albidum*), multiflora rose (*Rosa multiflora*), raspberries/blackberries (*Rubus spp.*), Pennsylvania sedge (*Carex pensylvanica*), bottlebrush grass (*Hystrix patula*), and sedges (*Carex spp.*).

Alliance Common Name or [Non-Alliance Name]	Field Description
American Beech - Sugar Maple - (Tuliptree) Forest Alliance	Forested uplands. Mesic or dry-mesic, sometimes wet-mesic, on sandy or loamy soils. Often on steep slopes, in ravines, on north slopes, and where there is some protection from fire. Common species: basswood (*Tilia americana*), sugar maple (*Acer saccharum*), black cherry (*Prunus serotina*), red oak (*Quercus rubra*), American beech (*Fagus grandifolia*), tulip tree (*Liriodendron tulipifera*), red maple (*Acer rubrum*), sometimes black oak (*Quercus velutina*) or white oak (*Quercus alba*), and spring beauty (*Claytonia virginica*).
Northern Red Oak - (Sugar Maple) Forest Alliance	Forested uplands. Wet-mesic or sometimes mesic on sandy-loams, silt-loams, or sandy clay-loam soils. In ravine heads or landscape pits or hollows. Common species: tulip tree (*Liriodendron tulipifera*), red oak (*Quercus rubra*), big-toothed aspen (*Populus grandidentata*), bitternut hickory (*Carya cordiformis*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), black walnut (*Juglans nigra*), red maple (*Acer rubrum*), spicebush (*Lindera benzoin*), Japanese barberry (*Berberis thunbergii*), and multiflora rose (*Rosa multiflora*).
[Vernal Wetland]	Wet, inundated pockets surrounded by upland forest. Sandy clay bottoms. Largely unvegetated in spring but by summer likely to contain species such as false nettle (*Boehmeria cylindrica*), clearweeds (*Pilea spp.*), jewelweed (*Impatiens capensis*), and trees seedlings such as red maple (*Acer rubrum*).
Pin Oak - (Swamp White Oak) Seasonally Flooded Forest Alliance	Forested wetlands. Usually wet-mesic. Soil with relatively high clay content. Characterized by flat areas or pit and mound topography. Common species: bitternut hickory (*Carya cordiformis*), red maple (*Acer rubrum*), red oak (*Quercus rubra*), sugar maple (*Acer saccharum*), swamp white oak (*Quercus bicolor*), spicebush (Lindera benzoin), sedge (*Carex bromoides*), ragwort (*Senecio sp.*), skunk cabbage (*Symplocarpus foetidus*), and Pennsylvania sedge (*Carex pensylvanica*).
Green Ash - American Elm - (Common Hackberry, Sugarberry) Temporarily Flooded Forest Alliance	Forested wetlands. Wet to wet-mesic terraces adjacent to streams. Muck soil or high organic mineral soil. Flat to gently sloped. Common species: American elm (*Ulmus americana*), basswood (*Tilia americana*), black walnut (*Juglans nigra*), red maple (*Acer rubrum*), swamp white oak (*Quercus bicolor*), hackberry (*Celtis occidentalis*), tulip tree (*Liriodendron tulipifera*), musclewood (Carpinus caroliniana), spicebush (Lindera benzoin), poison ivy (*Toxicodendron radicans*), and skunk cabbage (*Symplocarpus foetidus*). On slightly higher points, sugar maple (*Acer saccharum*), black cherry (*Prunus serotina*), and red oak (*Quercus rubra*).

Alliance Common Name or [Non-Alliance Name]	Field Description
Black Ash - Red Maple Saturated Forest Alliance	Forested or densely shrubby wetlands with groundwater flow at or below the surface. Muck soils on gentle to steep slopes. Common species: red oak (*Quercus rubra*), musclewood (*Carpinus caroliniana*), ironwood (*Ostrya virginiana*), chinquapin oak (*Quercus muehlenbergii*), basswood (*Tilia americana*), shagbark hickory (*Carya ovata*), black ash (*Fraxinus nigra*), red maple (*Acer rubrum*), swamp white oak (*Quercus bicolor*) (in more open areas), spicebush (*Lindera benzoin*), skunk cabbage (*Symplocarpus foetidus*), sharp-lobed hepatica (*Hepatica acutiloba*), sedges (*Carex spp.*), golden ragwort (*Senecio aureus*), and spring cress (*Cardamine sp.*).
Red Maple - Green Ash Seasonally Flooded Forest Alliance	Forested wetlands with 1 to 2 feet of standing water in spring. Sandy clay bottoms. Occur in depressions. Often fewer trees in areas of deeper water. Common species: American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), peach-leaved willow or black willow (*Salix amygdaloides* or *Salix nigra*). Edges contain black walnut (*Juglans nigra*), hackberry (*Celtis occidentalis*), and shagbark hickory (C*arya ovata*).
Tamarack Saturated Forest Alliance	Forested and shrubby wetlands. Wet due to high water tables or seasonal inundation. Occuring on mucks or highly organic mineral soils. Flat topography. Common species: tamarack (*Larix laricina*), peach-leaved willow or black willow (*Salix amygdaloides* or *Salix nigra*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), red maple (*Acer rubrum*), pussy willow (*Salix discolor*), silky dogwood (*Cornus amomum*), red-osier dogwood (*Cornus stolonifera*), gray dogwood (*Cornus foemina*), poison sumac (*Toxicodendron vernix*), sedges (*Carex spp.*), bluejoint grass (*Calamagrostis canadensis*), wool-grass (*Scirpus cyperinus*), and goldenrods (*Solidago spp.*).
Red-osier Dogwood - Willow species Seasonally Flooded Shrubland Alliance	Shrubby wetlands. Wet due to high water tables or seasonal inundation. Occuring on mucks or highly organic mineral soils. Flat to gently sloped. Can include scattered trees and patches of wet meadow. Common species: peach-leaved or black willow (*Salix amygdaloides* or *Salix nigra*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), red maple (*Acer rubrum*), pussy willow (*Salix discolor*), silky dogwood (*Cornus amomum*), red-osier dogwood (*Cornus stolonifera*), gray dogwood (*Cornus foemina*), poison sumac (*Toxicodendron vernix*), sedges (*Carex spp.*), bluejoint grass (*Calamagrostis canadensis*), wool-grass (*Scirpus cyperinus*), and goldenrods (*Solidago spp.*).
Common Buttonbush Semipermanently Flooded Shrubland Alliance	Shrubby wetlands. Wet and inundated in spring (24" to 36" or more standing water in deepest areas). Clayey or silty loam bottoms. Closed depressions. Common species: buttonbush (*Cephalanthus occidentalis*), southern blue flag (*Iris virginica*), and small duckweed (*Lemna minor*).

Alliance Common Name or [Non-Alliance Name]	Field Description
Leatherleaf Saturated Dwarf-shrubland Alliance	Shrubby inundated wetlands (24" to 36" or more standing water in deepest areas). Vegetation mass and peat may be floating on water surface. Closed depressions. Dominant species: leatherleaf (*Chamaedaphne calyculata*) and mosses (*Sphagnum spp.*).
Shrubby-cinquefoil / (Yellow Sedge, Inland Sedge, Wiregrass Sedge, Sterile Sedge) Saturated Shrub Herbaceous Alliance	Open to semi-shrubby wetlands with groundwater flow at or below the surface. Muck or marl soils on gentle to moderate slopes. Common species: shrubby cinquefoil (*Potentilla fruticosa*), big bluestem (*Andropogon gerardii*), sedges (*Carex spp.*), spike-rushes (*Eleocharis spp.*), and Ohio goldenrod (*Solidago ohioensis*).
Skunk-cabbage - Yellow Marsh-marigold Saturated Herbaceous Alliance	Open to semi-shrubby wetlands with groundwater flow at or below the surface. Muck soils on gentle to moderate slopes. Common species: poison sumac (*Toxicodendron vernix*), silky dogwood (*Cornus amomum*), willows (*Salix spp.*), spicebush (*Lindera benzoin*), red-osier dogwood (*Cornus stolonifera*), winterberry (*Ilex verticillata*), elderberry (*Sambucus canadensis*), marsh timothy/satin grass (*Muhlenbergia spp.*), skunk cabbage (*Symplocarpus foetidus*), swamp goldenrod (*Solidago patula*), spring cress (*Cardamine sp.*), golden ragwort (*Senecio aureus*), marsh marigold (*Caltha palustris*), sedges (*Carex spp.*), willowherb (*Epilobium coloratum*), sensitive fern (*Onoclea sensibilis*), and joe-pyeweed (*Eupatorium maculatum*).
Tussock Sedge Seasonally Flooded Herbaceous Alliance (non-isolated, free draining)	Wet, highly organic soils, open wetland with some shrubs at least on edges. Often gently sloped with slow surface or groundwater movement. Common species: poison sumac (*Toxicodendron vernix*), red-osier dogwood (*Cornus stolonifera*), willows (*Salix spp.*), tussock sedge (*Carex stricta*), lake sedge (*Carex lacustris*), broad-leaved cat-tail (*Typha latifolia*), joe-pyeweed (*Eupatorium maculatum*), and bluejoint grass (*Calamagrostis canadensis*).
Tussock Sedge Seasonally Flooded Herbaceous Alliance (isolated, inundated)	Wet, seasonally flooded wetlands. Often with 12" or more standing water in spring, but likely only saturated by summer. Clayey or silty loam bottoms. Closed depressions. Common species: willows (*Salix spp.*), dewberry (*Rubus pensylvanicus*), bluejoint grass (*Calamagrostis canadensis*), broad-leaved cat-tail (*Typha latifolia*), reed canary grass (*Phalaris arundinacea*), late goldenrod (*Solidago gigantea*), and stinging nettle (*Urtica dioica*).
(Narrowleaf Cattail, Broadleaf Cattail) - (Clubrush species) Semipermanently Flooded Herbaceous Alliance	Wet marshes. Inundated to a depth of approximately 12" to 24" in spring. Probably saturated through the growing season. Mucky soils on lake or pond margins or sometimes within closed depressions. Common species: broad-leaved cat-tail (*Typha latifolia*), whorled loosestrife (*Decodon verticillatus*), and bulrushes (*Schoenoplectus spp.*).
American White Water-lily - Yellow Pond-lily species Permanently Flooded Temperate Herbaceous Alliance	Ponded areas with submergent or floating-leaved plants. Several feet of water depth in spring and likely throughout growing season. Dominated by yellow pond-lily (*Nuphar sp.*).
[Open Water]	Lakes, ponds, or other water bodies with no apparent vegetation.

Alliance Common Name or [Non-Alliance Name]	Field Description
[Potential Plant Alliance]	Adventive or planted woodlands or shrublands. Usually dry-mesic or mesic, occasionally wet-mesic. Usually occur on loamy sands or sandy loams on flat or gently sloping areas. Common species: black oak (*Quercus velutina*), black cherry (*Prunus serotina*), black walnut (*Juglans nigra*), white pine (*Pinus strobus*), black locust (*Robinia pseudoacacia*), red cedar (*Juniperus virginiana*), sassafras (*Sassafras albidum*), pignut hickory (*Carya glabra*), black raspberry (Rubus occidentalis), Eurasian honeysuckle (*Lonicera maackii*), Japanese barberry (*Berberis thunbergii*), multiflora rose (*Rosa multiflora*), orchardgrass (*Dactylis glomerata*), tall goldenrod (*Solidago altissima*), and garlic mustard (*Alliaria petiolata*).
[Field]	Fields containing native and non-native graminoid, herbaceous, and shrub species. Usually dry-mesic with sandy soils on flatter areas. Could transform into native wooded or prairie type depending upon management. Some of these areas have been planted with native prairie grass. Common species: raspberries/blackberries (*Rubus spp.*), spotted knapweed (*Centaurea maculosa*), wild bergamot (*Monarda fistulosa*), bush clovers (*Lespedeza spp.*), wild carrot (*Daucus carota*), timothy (*Phleum pratense*), quack grass (*Agropyron repens*), big bluestem (*Andropogon gerardii*), broomsedge (*Andropogon virginicus*), Canada bluegrass (*Poa compressa*), and smooth brome (*Bromus inermis*).
[Developed]	Developed areas with buildings, gravel pits, parking lots, etc.

Appendix 2
Photographs of Plant Alliances from Fort Custer Training Center

Photograph 1. Little Bluestem - Yellow Indiangrass Herbaceous Alliance (Photo by Steve A. Thomas)

Photograph 2. Big Bluestem (Yellow Indiangrass) Herbaceous Alliance (Photo by Joshua G. Cohen)

Photographs 3 and 4. Black Oak - (Northern Pin Oak) Wooded Herbaceous Alliance (Top photo by Steve A. Thomas and bottom photo by Joshua G. Cohen)

Photographs 5 and 6. White Oak - (Northern Red Oak, Hickory species) Forest Alliance (Top photo by Steve A. Thomas and bottom photo by Joshua G. Cohen)

Photograph 7. American Beech - Sugar Maple - (Tuliptree) Forest Alliance (Photo by Steve A. Thomas)

Photograph 8. Northern Red Oak - (Sugar Maple) Forest Alliance (Photo by Steve A. Thomas)

Photographs 9 and 10. Vernal Wetland (Top photo by Steve A. Thomas and bottom photo by Joshua G. Cohen)

Photograph 11. Pin Oak - (Swamp White Oak) Seasonally Flooded Forest Alliance (Photo by Steve A. Thomas)

Photograph 12. Green Ash - American Elm - (Common Hackberry, Sugarberry) Temporarily Flooded Forest Alliance (Photo by Steve A. Thomas)

Photograph 13. Green Ash - American Elm - (Common Hackberry, Sugarberry) Temporarily Flooded Forest Alliance (Photo by Joshua G. Cohen)

Photograph 14. Black Ash - Red Maple Saturated Forest Alliance (Photo by Steve A. Thomas)

Photograph 15. Red Maple - Green Ash Seasonally Flooded Forest Alliance (Photo by Steve A. Thomas)

Photograph 16. Tamarack Saturated Forest Alliance (Photo by Joshua G. Cohen)

Photographs 17 and 18. Red-osier Dogwood - Willow species Seasonally Flooded Shrubland Alliance (Top photo by Steve A. Thomas and bottom photo by Joshua G. Cohen)

Photographs 19 and 20. Common Buttonbush Semipermanently Flooded Shrubland Alliance (Top photo by Steve A. Thomas and bottom photo by Joshua G. Cohen)

Photograph 21. Leatherleaf Saturated Dwarf-shrubland Alliance (Photo by Joshua G. Cohen)

Photograph 22. Shrubby-cinquefoil / (Yellow Sedge, Inland Sedge, Wiregrass Sedge, Sterile Sedge) Saturated Shrub Herbaceous Alliance (Photo by Joshua G. Cohen)

Photographs 23 and 24. Skunk-cabbage - Yellow Marsh-marigold Saturated Herbaceous Alliance (Top photo by Steve A. Thomas and bottom photo by Joshua G. Cohen)

Photographs 25 and 26. Tussock Sedge Seasonally Flooded Herbaceous Alliance (non-isolated, free draining) (Top photo by Steve A. Thomas and bottom photo by Joshua G. Cohen)

Photograph 27. Tussock Sedge Seasonally Flooded Herbaceous Alliance (isolated, inundated) (Photo by Steve A. Thomas)

Photograph 28. (Narrowleaf Cattail, Broadleaf Cattail) - (Clubrush species) Semipermanently Flooded Herbaceous Alliance in foreground and Open Water in background (Photo by Steve A. Thomas)

Photograph 29. American White Water-lily - Yellow Pond-lily species Permanently Flooded Temperate Herbaceous Alliance (beyond inundated sedge tussocks) (Photo by Steve A. Thomas)

Photograph 30. Potential plant alliance (Photo by Steve A. Thomas)

Photograph 31. Field (Photo by Steve A. Thomas)