



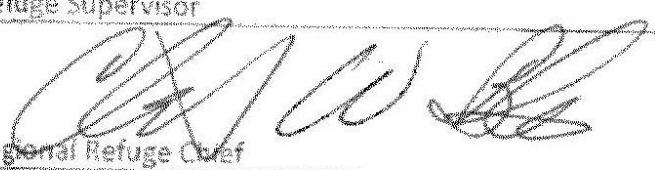


## **HABITAT MANAGEMENT PLAN FOR KIRTLAND'S WARBLER WILDLIFE MANAGEMENT AREA (MICHIGAN, 2013)**



The natural range of variation in the compositional and structural patterns of vegetation that result from wildfire in jack pine (*Pinus banksiana*) ecosystems (as shown above) should provide the “desired future condition” for Kirtland’s Warbler (*Setophaga kirtlandii*) habitat management at Kirtland’s Warbler WMA.

Habitat Management Plan  
for  
Kirtland's Warbler Wildlife Management Area

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## Synopsis

1. This planning document attempts to justify current and future management actions based on our contemporary (and incomplete) understanding of the natural world. We do this by using geographically-relevant literature and other data to support statements and proposed management actions. Much of the literature used comes directly from studies conducted at Kirtland's Warbler Wildlife Management Area (WMA) and are the products of the long history of Seney NWR functioning as a *de facto* Land Management and Research Demonstration Area.
2. The Kirtland's Warbler WMA Comprehensive Conservation Plan (CCP, 2009) took a disturbance ecology-based perspective on habitat management that considered the range of conditions encountered across jack pine seral states or age classes: from mature, closed-canopy forests to openland-dominated pine barrens.
3. Based on the CCP and other studies (see Literature Cited), habitat management as outlined in this document focuses on promoting the "natural range of variability" (NRV, Landres *et al.* 1999) within the context of the *Refuge Improvement Act* and the *Biological Integrity Policy* (Schroeder *et al.* 2004; Scott *et al.* 2004; Meretsky *et al.* 2006). Studies led by refuge staff are currently underway to fill in many existing knowledge gaps re: NRV.
4. Approaches to management are a combination of "meso-filtered" and "fine-filtered" (Hunter 2005). Although jack pine (*Pinus banksiana*) plantation management will still be an important consideration of the Kirtland's Warbler WMA, this HMP deemphasizes (but does not abandon) the management of this anthropogenic habitat and provide the framework for a better balance between the approaches of restoration ecology and conservation biology (Young 2000).
5. Because fire, as the main ecological process, has been severely altered in northern Lower Michigan, research and management is focused on understanding and promoting wildfire patterns, while working with others to promote prescribed fire use.
6. Applied research and graduate student education is an integral part of adaptive management and fulfills to an imperfect degree some aspects of inventory and monitoring.

**Note:** Many terms used in this document were defined in the Seney NWR CCP and readers can view that document for more definitions. The term “ecological integrity” is used with the definition being: “A natural community has ecological integrity if: 1) ecological processes are intact and within their natural range of variation; 2) species distribution, composition, and relative abundance are within their natural range of variation; 3) the community is resilient, or able to recover from severe disturbance events.” The term “restoration” is used to describe the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. “Conservation” is defined as active management to maintain existing conditions, more or less. “Preservation” is defined as passive management that allows patterns to develop without intervention. “Benchmark” or “reference” refers to sites or conditions that have not been altered since pre-European times. “Natural range of variation” (NRV) means the range of values explaining patterns/processes expected in natural (unaltered) systems. Understanding the NRV of jack pine ecosystems and related processes forms the foundation of proposed habitat (ecosystem) management.

**Acknowledgments:** The authors appreciate the support of colleagues at Seney NWR and elsewhere in the National Wildlife Refuge System, including those who previously worked on the CCP from the Regional Office. Special thanks to Charles Goebel (The Ohio State University), Dan Kashian (Wayne State University), and Nancy Seefelt (Central Michigan University). We would also like to thank the Applied Sciences Program interns (including Cary Fado) and the numerous graduate students who assisted with data collection, analysis, and reporting.

## I. Introduction

### A. Legal mandates.

*"Kirtland's Warbler Wildlife Management Area was established in 1980 ..... to conserve (A) fish or wildlife which are listed as endangered species or threatened species.... or (B) plants ...16 U.S.C.1534 (Endangered Species Act of 1973)." This Habitat Management Plan (HMP) also rests upon the legal mandate of the National Wildlife Refuge System Improvement Act of 1997, 16 U.S.C. 668dd and the Biological Integrity, Diversity, and Environmental Health Policy of 2001, 601 FW3. Considered the "Organic Act of the National Wildlife Refuge System," the Improvement Act defines the mission of the System, designates priority wildlife-dependent public uses, and calls for comprehensive refuge planning. The Biological Integrity, Diversity, and Environmental Health Policy is an additional directive for refuge managers to follow while achieving refuge purpose(s) and the System mission. It provides for the consideration and protection of the broad spectrum of fish, wildlife, and habitat resources found on refuges and associated ecosystems. Further, it provides refuge managers with an evaluation process to analyze their refuge and recommend the best management direction to prevent further degradation of environmental conditions; and where appropriate and in concert with refuge purposes and System mission, restore lost or severely degraded components.*

**Mission statements** — The mission of the U. S. Fish and Wildlife Service (Service) is: *"Working with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefits of the American people."*

The mission of the National Wildlife Refuge System is: *"To administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans."*

The Vision Statement of the 2009 CCP was: *"The Kirtland's Warbler Wildlife Management Area will be managed to promote jack pine ecosystems that contributes to a sustainable population of Kirtland's Warblers and associated wildlife species. Lands will be actively managed to mimic historic disturbance regimes and resulting structural and compositional attributes, such as dense stands of jack*



*pine with barren-like openings, snags and coarse woody debris. Research will be encouraged and the public will be invited to learn about the jack pine ecosystem and the wildlife it supports."*

**B. Relationship to other plans.** This HMP is a step-down plan to the *Kirtland's WMA Comprehensive Conservation Plan* (CCP, 2009) and the *Kirtland's Warbler WMA Fire Management Plan* (2005). As much as is possible, this HMP takes information directly from the CCP and provides more site-specific information regarding ecosystem (habitat) management.

**II. Background** Kirtland's Warbler WMA was established in 1980 in response to the need for more land dedicated to the recovery of Kirtland's Warbler (*Setophaga kirtlandii*). The U.S. Fish and Wildlife Service established the WMA due to recommendations of the *Kirtland's Warbler Recovery Team*.

**A. Inventory and description of habitat.**

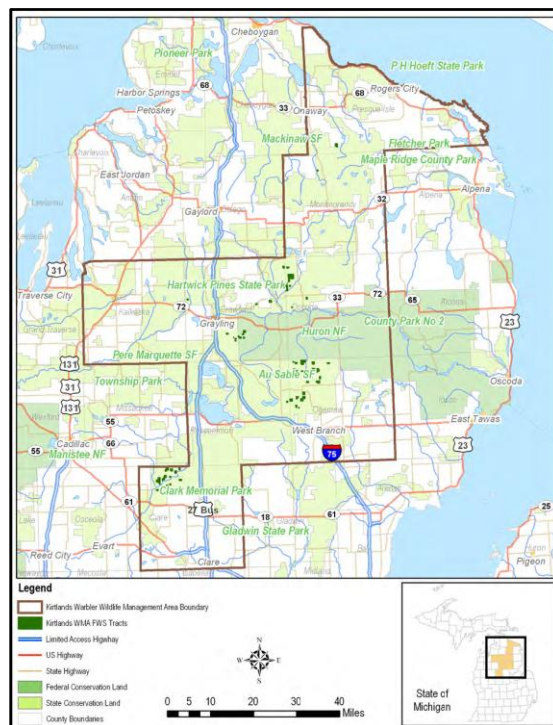
**(1) Location and Management Units** — Because Kirtland's Warbler WMA consists of separate parcels of land over 8 counties of northern Lower Michigan that were purchased over approximately 20 years, the accuracy and precision of the geographic information system (GIS) ownership layer has always been a concern. In 2004 Seney NWR began working on corrections to this layer, but as more information becomes available updates occur (Figure 1, Table 1, below). Currently, there are 125 separate GIS records (often mistakenly called "tracts", as was done in the CCP). In reality, it is perhaps more accurate to state that there are 119 tracts (as defined by realty, etc.). Tracts and ownership polygons (GIS records) are not necessarily the same thing. Some GIS records, for instance, repeat tract numbers signifying lands that are spatially disconnected, but likely came from the same owner or were included in the same deed transaction (purchase): Crawford County has 24 ownership polygons, but only 22 tract identifiers; Ogemaw County has 48 ownership polygons, but only 46 tract identifiers; Oscoda County has 23 polygons and 21 tract identifiers. **For consistency between this document and the CCP, we will use the term "tract" to signify the 125 GIS records.** Tract size varies from <10 acres to >700 acres; average tract size is 56 acres, the median size is 39 acres. The original acquisition goal was to acquire 7,500 acres of land on which habitat would be managed for the benefit of Kirtland's Warbler. At present, the area contains approximately 6,869 acres (a slight deviation from the number reported in the CCP). Most of these tracts are located within or adjacent to state forest lands also managed for the Kirtland's Warbler. **An exchange of these lands with other agencies is a major**



objective outlined in the CCP, but is not covered here. Achieving this objective should be the priority of future managers and is more important than inventory and monitoring on these relatively small and disjunct tracts.

**Table 1. Kirtland's Warbler WMA management history, ranked by county with the most acres (as of August 2012). The 54 tracts that have not yet been managed average 40 acres (median = 17 acres).**

County	Number of GIS Records (Ownership Polygons)	Number (%) Ownership Polygons Already Managed	Ownership Acres (Not Treatment Acres)
Ogemaw	49	23 (47%)	2,911
Clare	26	19 (73%)	1,401
Oscoda	22	17 (74%)	1,410
Crawford	24	9 (38%)	788
Presque Isle	1	1 (100%)	199
Kalkaska	1	1 (100%)	80
Roscommon	1	0 (0%)	40
Montmorency	1	1 (100%)	40
<b>Total</b>	<b>125</b>	<b>71 (57%)</b>	<b>6,869</b>



**Figure 1. Kirtland's Warbler WMA tracts (small, dark green polygons).**

## **(2) Physical or Geographic Setting**

**a. Climate** — Due to its inland location, northern latitude, and relatively high elevation, the Kirtland's Warbler WMA is characterized by a relatively severe climate. The growing season ranges from 70 to 130 days, with spring freezes common. Extreme temperatures range from -50 degrees Fahrenheit to over 105 degrees Fahrenheit. Snowfall is heavy, with up to 140 inches recorded annually in some localities. Average annual precipitation is relatively uniform across the area, between 28 and 32 inches (Albert 1995).

**b. Landscape Ecosystems and Glaciation** — Most (94%) of the tracts are found in the Highplains Subsection (VII.2) of the Northern Lacustrine-Influenced Lower Michigan Section (VII) as described by Albert (1995) (Goebel *et al.* 2007). The Highplains Subsection is a high plateau and has the most severe climate of Lower Michigan due to its inland location, high elevation, and northern latitude. The Subsection consists mainly of broad outwash plains with soil that is excessively drained sand or sand mixed with gravel. The physical characteristics of the Kirtland's Warbler WMA are consistent with most of the northern half of Lower Michigan. Topographically, the land is flat to gently rolling and landforms are glacially derived. The vegetation of the area is primarily jack pine, with some northern pin oak (*Quercus ellipsoidalis*), red pine (*P. resinosa*), and aspen (*Populus* spp.).

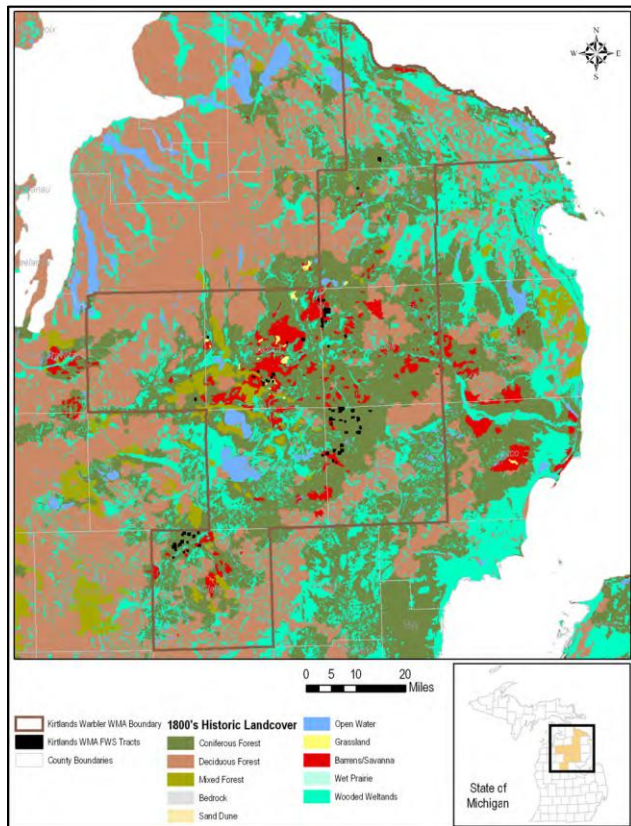
**c. Soils** — Three soil associations dominate the tracts: Grayling – Graycalm - Au Gres (35%), Rubicon – Grayling - Croswell (34%), and Grayling – Rubicon - Au Gres (21%). All of the soil series in the three soil associations are xeric sands (Goebel *et al.* 2007).

**d. Surface Hydrology** — The vast majority (98%) of the tracts do not have any surface water. Exceptions are a few tracts in northwest Clare County and the largest tract in Oscoda County.

**(3) Historic condition** — Historic evidence indicates that prior to European settlement both pine forests and pine barrens were dominant features of northern Lower Michigan (Figure 2, below). Barrens were large, relatively open tracts with clusters of jack pine and red pine of varying density scattered throughout. Common shrubs and herbaceous plants included cherry (*Prunus* spp.), sweet fern (*Comptonia peregrina*), and big bluestem (*Andropogon gerardii*). Fire, both anthropogenic and other, and biotic factors like native insect defoliation acted as the primary disturbance mechanisms that maintained these ecosystems and created the diverse pattern of thickly forested pine stands scattered among openings across a landscape.

**A research project co-authored and led by staff at Seney NWR and colleagues from Wayne State University (D. Kashian) and The Ohio State University (C. Goebel) is investigating pre-European patterns of these land covers on the landscape and patterns of vegetation resulting from wildfire.**

Fire is an important disturbance factor in jack pine ecosystems. The young jack pines under which Kirtland's Warbler nest are established after fire forces open cones and exposes mineral soil for the germination of the seeds.



**Figure 2. Pre-European land covers in northern Lower Michigan (Comer *et al.* 1995). Kirtland's Warbler WMA tracts are shown by small black polygons.**

**(5) Current habitat types** — According to Goebel *et al.* (2007), the majority of the WMA consists of jack pine ecosystems. Approximately 41% of the tracts (2,695 acres) are between 5-23 years old (the age for Kirtland's Warbler occupancy), while 14% (959 acres) are <5 years old and 45% (2,298 acres) are >23 years old. [Note: these values have changed since this 2007 work as more habitat treatments to produce the younger stands have occurred, thus decreasing the percentage of stands in the oldest age class and increasing the percentage in the younger two age classes, see Table 1.] It is important to note

**(4) Changes from historic condition** — Like many parts of northern Lower Michigan and elsewhere, changes to ecological processes, such as the frequency, intensity, severity, and rotation period of wildfire, have altered vegetation composition and structure relative to historic conditions (Schulte *et al.* 2007). Kirtland's Warbler WMA is no different (Corace *et al.* 2012), with fire now playing a less significant role in shaping the vegetation communities than it once did. However, this "mesophication" (Nowacki and Abrams 2008) is likely less pronounced on xeric soils growing jack pine than on more productive sites, suggesting a novel opportunity for conservation and restoration within the NRV at Kirtland's Warbler WMA.

that many of the tracts have multiple cohorts; to determine the age of each the most extensive cohort was considered indicative of the overall stand age. See Goebel *et al.* (2007) for a complete list of species encountered and more detailed tract-scale descriptors.

### III. Resources of Concern

**A. Identification of refuge resources of concern.** Few inventory efforts other than that of Goebel *et al.* (2007) have been conducted at Kirtland's Warbler WMA. However, recent and ongoing applied research has and should supplement the dearth of inventory information and provide a baseline for monitoring. Corace *et al.* (2010a) documented 59 bird species, besides Kirtland's Warbler, in 37 jack pine-dominated tracts. Kirtland's Warbler was observed in 90% (27 of 30) of the KW habitat patches sampled, indicating the general success of efforts to increase the population of Kirtland's Warbler and manage habitat for this species. Five bird species of *Regional Conservation Priority* were found among the habitat types: Black-billed Cuckoo (*Coccyzus erythrophthalmus*), Field Sparrow (*Spizella pusilla*), Kirtland's Warbler, Northern Flicker (*Colaptes auratus*), and Upland Sandpiper (*Bartramia longicauda*). All these species, other than Kirtland's Warbler, were most common in the openland-dominated (pine barren-like), young habitat (jack pine <5 years old). Five indicator species associated with this habitat type and the Kirtland's Warbler habitat (jack pine 5-23 years old) were observed, while nine species were associated with the jack pine habitat >23 years old (Table 2, below). A functional group analysis indicated that stand structure influenced the presence and abundance of breeding species across habitat types.

**Table 2. Bird species associated with each of three age classes of jack pine at Kirtland's Warbler WMA (Corace *et al.* 2010a). \* $P < 0.05$ ; \*\*  $P < 0.01$ ; \*\*\*  $P < 0.001$ .**

Young (<5 years old)	KW (5-23 years old)	Old (>23 years old)
Indigo Bunting ( <i>Passerina cyanea</i> )***	Kirtland's Warbler***	Eastern Wood-Pewee ( <i>Contopus virens</i> )***
Eastern Bluebird ( <i>Sialia sialis</i> )***	Nashville Warbler ( <i>Oreothlypis ruficapilla</i> )***	Hermit Thrush ( <i>Contopus virens</i> )***
Field Sparrow***	Eastern Towhee ( <i>Pipilo erythrophthalmus</i> )***	Ovenbird ( <i>Seiurus aurocapilla</i> )***
Lincoln's Sparrow ( <i>Melospiza lincolnii</i> )***	Brown Thrasher ( <i>Toxostoma rufum</i> )**	Rose-breasted Grosbeak ( <i>Pheucticus ludovicianus</i> )***
Black-billed Cuckoo*	Alder Flycatcher ( <i>Empidonax alnorum</i> )**	Red-breasted Nuthatch ( <i>Sitta canadensis</i> )***
		Red-eyed Vireo ( <i>Vireo olivaceus</i> )***
		Black-capped Chickadee ( <i>Poecile atricapillus</i> )**
		Chipping Sparrow ( <i>Spizella passerina</i> )**
		Mourning Dove ( <i>Zenaida macroura</i> )*

**B. Potential refuge contribution to the habitat needs of the resources of concern.** No other refuge in the National Wildlife Refuge System is known to have breeding Kirtland's Warbler. However, due to relatively small tract size, Kirtland's Warbler WMA by itself offers relatively little contribution to the long-term sustainability of any wildlife population. These tracts are most valuable when managed in conjunction with the neighboring Michigan Department of Natural Resources (DNR) lands, especially when management at Kirtland's Warbler WMA can occur within larger patches, enhances landscape structure, and emulates natural patterns not common on adjacent lands (Corace *et al.* 2010b; Corace *et al.* 2010c; Kashian *et al.* 2012).

**C. Reconciling conflicting habitat needs for resources of concern.** As outlined in the CCP, Kirtland's Warbler WMA was established when the population of Kirtland's Warbler was well below the recovery objective of 1,000 singing males. Intensive management of jack pine plantations on these lands and the much more substantial U.S. Forest Service and DNR land holdings have resulted in an increase in the number of individuals and the extension of the species' breeding range (Probst *et al.* 2003). Now, **with recovery thresholds met for nearly a decade**, the opportunity exists to manage Kirtland's Warbler



WMA tracts more holistically and based upon natural patterns resulting from natural disturbances across jack pine (and other forest) habitat types (Corace and Goebel 2010c).

Previous plantation management at Kirtland's Warbler WMA has yielded patterns not indicative of wildfire (Goebel *et al.* 2007; Corace *et al.* 2010a), but applied research has recently been conducted that examines structural patterns of wildfire (Kashian *et al.* 2012) and methods for snag creation (Corace *et al.* 2010b). Moreover, the opportunity exists to manage jack pine across age classes, and not focus **solely** on the age class important for Kirtland's Warbler. Such management would fall in line with the *Refuge Improvement Act* and the *Biological Integrity Policy* and be an integral facet of Seney NWR's *de facto* Land Management and Research Demonstration Area (LMRD). If a significant population decline is noted, traditional "opposing wave" plantations can be relatively easily and quickly produced on lands managed as barrens, for instance. All management would still occur in consultation with the Michigan DNR and look to produce more natural stand and landscape patterns.

#### **IV. Habitat Goals, Objectives, and Strategies (Desired Future Condition)**

The preferred alternative, *Ecological Management and Land Ownership Consolidation*, formed the basis for the Kirtland's Warbler WMA CCP and the goals, objectives, and strategies presented below.

**Goal—Manage habitat to support Kirtland's Warblers and associated wildlife species by providing the natural range of variation of conditions across all seral stages of the jack pine ecosystem. Employ sound management practices that emulate patterns of structure and composition resulting from wildfire and other natural disturbances (Figure 3).**



**Objective—Continue to manage jack pine tracts (stands) in conjunction with the Michigan DNR, but place greater emphasis on promoting ecological integrity within managed stands.**

**Figure 3. Resulting structural patterns from prescribed fire (left center) and plantation management (surrounding area). Patterns from fire should provide the "desired future condition" for managed tracts.**

*Rationale*—Because many plantations at Kirtland's Warbler WMA are ecologically simplified and lack the structural and compositional diversity of stands produced by wildfire, future management should consider all seral stages of jack pine ecosystem development, from barrens to mature forest, and strive to emulate natural conditions in each stage that result under a natural fire regime.

*Strategies:*

1. Work with Federal, State and local fire officials to employ prescribed fire as a management tool.
2. Develop research demonstration sites that exemplify ecologically-based jack pine management and illustrate how emulating natural conditions can provide multiple species benefits. [**Completed via the Lake States Fire Science Consortium Demonstration Area portfolio.**]
3. Manage parcels that contain habitats other than jack pine to emulate patterns resulting from natural disturbances. Sites not well suited for jack pine should be managed for other (often, mixed) forest types/ecosystems. For instance, many of the unmanaged tracts in Clare County are better suited for a mixed-aspen community and should be managed as such to provide habitat for species like the Golden-winged Warbler (*Vermivora chrysoptera*).
4. Elsewhere, attempt to emulate the compositional and structural patterns of jack pine stands resulting from wildfire via mechanical treatments (timber sales) with consideration of the following (**note: applied research funded by Joint Fire Science Program to Seney NWR, Wayne State Univ., and Ohio State Univ. is underway to document the variability in stand composition, structure, and spatial patterns that follows a wildfire**):

**A. Age classes.** Management should retain the range of age classes that now exist among all the tracts at Kirtland's Warbler WMA. Tracts should be managed to produce patches of at least 40 acres among each age classes (smaller tracts can be aggregated to do this). Where this is not possible, small patches may be left as residual structure (biological legacy patches) if the surrounding area is managed as a plantation or a barrens. Tracts >300 acres, including the largest tract in Oscoda County, should be managed to retain the mix of age classes presently found on this parcel and the diversity of structure and composition it now has (i.e., this large tract should not be managed for Kirtland's Warbler).

**B. Composition.** Management should retain the natural range of diversity found on each parcel.

**C. Structure.** Management should mitigate for stand homogenization due to plantation management by:



- a. leaving and/or creating biological legacy patches (stringers) per Kashian *et al.* (2012). These linear strips of live and dead trees are the biological legacies retained after wildfire. They should represent 5-10% of the treated parcel, range from 1-7 acres in size, and be oriented along the long axis of the harvest unit;
- b. conserving and creating snags (Corace *et al.* 2010b). According to Spaulding (2008), the abundance of snags in jack pine stands regenerated by wildfire is on the order of 300 stems per acre. Although it is unlikely that this is possible in treated stands, 30 stems per acre (10% of this value), may be possible. Snags should be clumped so as to reduce mortality (snapping, etc.) by wind;
- c. retaining large stems (>20 inches dbh) of more fire resistant tree species (e.g., red pine, oak, and eastern white pine, *P. strobus*) distributed over the stand. Large individuals of these species often survive wildfire and add to the pool of biological legacies.

**D. Spatial patterns.** Results from the ongoing studies should, among other things, provide knowledge for making plantations with more natural spatial patterns and possibly provide information for treatment of abandoned plantations in a manner that is more natural as well. In the interim, plantations will follow the “opposing wave pattern” being currently applied by the Michigan DNR.

## **V. Management Strategy Constraints**

**A. Staffing.** This is an unstaffed refuge. All habitat management, inventorying and monitoring, and applied research is done under the leadership of Seney NWR staff; **the closest tract is 3 hours from Seney NWR.** Severe limitations therefore exist in what can practically be done on these lands. Time and money does not allow for intensive monitoring, for instance.

**B. Invasive species.** At present, management is not constrained by invasive species. However, species such as the *Sirex* woodwasp need to be considered in the future. This and other management limitations are discussed at Recovery Team meetings conducted twice per year. (**Note:** one parcel in northwest Clare County has a significant wetland on it that is being invaded by purple loosestrife (*Lythrum salicaria*). Management to reduce purple loosestrife has occurred and should continue (see *Integrated Pest Management Plan*).

**C. Climate change.** The future of the Kirtland's Warbler is, in a large part, tied to the extent and availability of suitable jack pine forests on its breeding grounds. These forests will likely change in extent over time due to global climate change. The U.S. Forest Service, Northern Research Center modeled and mapped 134 tree species from the eastern United States for potential response to several scenarios of climate change. The scenarios, built upon three independent climate models, were predicted for both low and high intensity CO<sub>2</sub> emissions through the year 2100. The model only depicted suitable habitats of species and not actual changes in ranges of the species. Results indicated a shift northward in jack pine.

**D. Stand size and timber markets.** Across ownerships involved in habitat management, >90% of the actions undertaken to produce Kirtland's Warbler habitat involve timber management activities (mechanical treatments followed by planting seedlings). The small size of Kirtland's Warbler WMA tracts and the instability of local economies together could pose difficulties in future years as it could become more difficult to sell wood products (or even give them away with proper constraints and restrictions). Currently, the 54 tracts that have not been managed are relatively small (40 acres on average, median is 17 acres) and many of these may not have the timber volume to entice loggers who are necessary for the first step in treatments (i.e., harvesting the existing stand). Financial gain is in no way a goal or objective of habitat management, but the appropriate economic conditions must exist for mechanical treatments to occur.

**D. Regeneration.** All regeneration (planting following timber harvesting) is done by the Michigan DNR at their cost. This means that a partner is bound to do work on NWRS lands; if the partner is financially limited in the future there does not seem to exist a mechanism to fund regeneration on these lands. It costs nothing (for the most part) to manage older stands and to produce barrens.

## **VI. Management Strategy Impacts, Prescriptions, etc.**

**A. Impacts to the resources of concern associated with the implementation of the proposed habitat management strategies.** An increased emphasis on biological legacies within managed stands may reduce overall area devoted to plantations by 10-20% (maximum). It is not known what effects this enhanced structure has on breeding Kirtland's Warbler, but studies are underway to characterize bird communities within biological legacy patches (N. Seefelt, Central Michigan Univ.).

**B. Management strategy prescriptions (timing, frequency, severity, etc.).** Habitat management is the application of disturbance ecology principles, and because Kirtland's Warbler WMA is primarily comprised of jack pine ecosystems, it is perhaps the most fire-dependent (disturbance-dependent), forest-dominated refuge in the Midwest (Corace *et al.* 2012a). Depending on the type of jack pine ecosystem (barrens or mature forests), fire consisted of frequent (<25 year) mixed-severity fires in barrens or stand-replacing, crown fire at a fire return interval (FRI) of 35-55 years. Insect outbreaks also contributed to maintaining jack pine ecosystems. Jack pine stands are susceptible to outbreaks of the jack pine budworm (*Choristoneura pinus pinus*) at 6-10 year intervals. The caterpillar defoliates the jack pines by consuming the needles and dropping the dead dry needles to the ground leading to some tree mortality, especially in mature stands. The excessive dry needles on the ground contribute to fueling surface fires, which may become crown fires if the stand is dense (Frelich 2002). Thus, fire and herbivory together produce the structure and composition of these ecosystems.

Future management should consider the above in both the use of prescribed fire and mechanical treatments, especially the NRV of the main disturbance (fire). Knowing when the last fire occurred would function as the "trigger." For instance, if a given tract (stand) will be managed as a spatially static openland-dominated barren, then treatments (preferably fire) should occur at an FRI of <25 years to maintain the site in a relatively open condition. If, however, the stand is to be managed as Kirtland's Warbler habitat and then mature forest, then management should occur within the range of stand-replacing fire (35-55 years). Some mature stands should be left as is, especially when the overall condition is a naturally heterogeneous mix of tree species and, as such, represents a more unique condition at Kirtland's Warbler WMA (e.g., the largest parcel located in Oscoda Co.).

### **C. Management strategy documents.**

**(1) Necessary resources** — Besides some applied research, this refuge lacks in most every way due to the lack of staff. The best thing that can be done is to exchange these lands as discussed in the CCP and obtain similar lands (fewer and larger tracts) closer to Seney NWR. Other than regeneration that is necessary for producing Kirtland's Warbler habitat and fire management, the other habitat management discussed in this document can be achieved by existing refuge funds. For instance, forest management operations, other than regeneration and prescribed fire, tend to pay for themselves, but to conduct more monitoring or assessments of forest stands is unlikely with existing staffing levels.

**(2) Documentation of special uses** — Compatibility Determinations (CDs) were done for the CCP.

**(3) Documentation of compliance** — This document is a step-down to the Kirtland's Warbler CCP and its associated regulatory documents (e.g., NEPA).

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