Muscatatuck National Wildlife Refuge Inventory and Monitoring Plan[1]

I. Signatures

Action	*Signature /Printed Name*	*Date*
Prepared By:	Dan Wood (Wildlife Refuge Specialist); Sean Blomquist (R3 IM Zone Biologist); Pat Ward (NRPC IM Ecologist); Brian Loges (R3 IM Zone Biologist)	5-8-13
Submitted By:	Alejandro Galvan (Project Leader)	5/8/13
Reviewed By:	Jason Goldberg (Acting Refuge Supervisor, Area 2)	5/30/13
Reviewed By:	Melinda Knutson (Regional I&M Coordinator)	6/3/13
Reviewed By:	Pat Heglund (Regional Refuge Biologist/RNR Division Chief)	6/3/13
Approved By:	Charlie Blair (Regional Chief, National Wildlife Refuge System)	6/3/13

[1] Version dated 7 May 2013

Table of Contents

I. Signatures....1
II. Plan....3
A. Introduction....3
B. Methods and Rationale Used to Develop the IMP, Prioritize, and Select Surveys....3
C. Narratives of Selected Surveys....3
Table 1. Surveys that can be Conducted with Current Resources....4
Table 2. Surveys to be Conducted with Expected Additional Resources....5
D. List of Future (Unselected) Surveys....5
E. Surveys Not Included in the Prioritization Process....5
III. Summary Tables....6
Table 3. Summary of Prioritized Surveys....7
Table 4. Estimated Annual Budget for Implementing the IMP....14
Table 5. Estimated Annual Work Schedule, January – December....17
Table 6. Estimated Multi-year Work Schedule, 2013-2017....18
IV. Amending and Revising the IMP....19
A. Amending the IMP....19
B. Revising the IMP....19
Figure 1. Inventory and Monitoring Plan Revision Form....20
V. References....21
VI. Appendices....23
Appendix A. Simple Multi-Attribute Rating Technique (SMART tool) and Prioritization Criteria....23
Table A1. Weight Applied to Prioritization Criteria....27
Appendix B. Survey Priority from SMART Tool....28
Appendix C. Survey Profiles for Surveys with Current Status....29
Appendix D. Survey Profiles for Surveys with Expected Status....42

II. Plan

A. Introduction

This plan (IMP) documents the inventory and monitoring surveys that will be conducted at the Muscatatuck National Wildlife Refuge from 2013 through 2028, or until the refuge's Comprehensive Conservation Plan (CCP) and Habitat Management Plan (HMP) are revised. The majority of surveys considered in this plan address resource management objectives identified in the HMP (2012) for this refuge. Other surveys are a continuation of past monitoring conducted for the purpose of understanding long-term trends in specific resources or are part of regional and national survey efforts.

B. Methods and Rationale Used to Develop the IMP, Prioritize, and Select Surveys

Station staff generated a list of extant and anticipated surveys by generating a list of all observational efforts to gather information on refuge resources, including surveys specifically requested by FWS Migratory Birds, Ecological Services, or the State of Indiana. This extensive list was later refined to exclude general observations (reconnaissance) of refuge resources that do not require protocols or data management. The remaining surveys were then assigned a priority score using 16 pre-defined criteria (Appendix A) and rank the surveys in order of priority.

The priority ranking of surveys was determined during a one-day (11 July 2012) meeting at the Muscatatuck NWR office. Project Leader Alejandro Galvan and Wildlife Refuge Specialist Dan Wood met with Region 3 Zone Biologists Sean Blomquist and Brian Loges and Ecologist Pat Ward from the Natural Resources Program Center to prioritize and select the surveys. Background information for each survey was summarized in advance by Dan Wood and briefly discussed prior to prioritizing the surveys. The 16 criteria, assignment rules, weighting and score calculation process followed the *Criteria for Prioritizing Surveys Entered into the PRIMR Database* (Appendix A). The two refuge staff made all decisions required to produce the survey priority scores (Appendix B) and select surveys for implementation. This meeting was among the first of such deliberations conducted in Region 3 and nationally and served as a beta test of the process. Refinements were made to the process based on lessons learned during the meeting; all ranking decisions for Muscatatuck NWR were made based on the criteria in use at the time of the workshop.

C. Narratives of Selected Surveys

The prioritization process identified 16 surveys to be completed for the duration of this Inventory and Monitoring Plan (IMP) (Tables 1 and 2). Narratives justifying each survey selected for implementation are provided in Appendix C and D, Survey Profiles.

Table 1. Surveys that can be Conducted with Current Resources

The surveys in this section are needed to support high priority station HMP objectives, national survey efforts or other high priority plans (e.g. Recovery Plans), to evaluate the effectiveness of major or costly management actions, or to assess and address major threats to the biological integrity, diversity, or environmental health of the refuge. Current surveys are organized and presented in order of perceived importance to refuge staff.

Name	Priority	Rationale
• Weekly Waterfowl Monitoring • Water Level Monitoring • Wetland Vegetation Cover Survey	3, 8, 10	These surveys address the highest priority station CCP and HMP objectives. Together these surveys comprise the Integrated Waterbird Management and Monitoring Initiative (IWMM), a multi-region adaptive management project.
• Invasive Species Surveys: o Refuge-scale Inventory o Grid-scale Monitoring o Grid-scale Treatment Evaluation	1, 2, 4	These surveys address one of the major threats facing the refuge – invasive plants in forested habitats. Together these surveys comprise the Invasives in Forests adaptive management project, a multi-station inventory and adaptive management project that is serving as a national invasive species pilot project.
• Bat Surveys	7	Monitors occupancy by endangered Indiana bats (*Myotis sodalis*) in support of National and regional objectives to monitor the status and trends of bat species.
• Spotlight Deer Survey	16	Supports the station Hunt Plan
• Moss Lake Fish Surveys	18	Supports restoration efforts in the Moss Lake Complex to restore fish and mussel populations by allowing fish passage through the construction of cut in the Moss Lake Dam
• Moss Lake/GTR Tree Regeneration Surveys	14	Supports restoration and tree regeneration efforts within Moss Lake GTR area and within the GTR 1 and GTR 2 units. Results may be used to determine the need for future management actions to ensure reforestation within the dead zones in each unit.
• Midwinter Eagle Survey	19	Supports efforts coordinated by the US Army Corps of Engineers to determine trends in midwinter counts of Bald eagles in the contiguous United States
• FWS Eastern Greater Sandhill Crane Survey	21	Supports National FWS efforts to estimate the size and trend of the eastern population of Greater sandhill crane.

Table 2. Surveys to be Conducted with Expected Additional Resources

Name	Priority	Rationale
• Weekly Shorebird Surveys	9	These surveys address the highest priority station CCP and HMP objectives. Together with those currently performed, these surveys comprise the Integrated Waterbird Management and Monitoring Initiative (IWMM), a multi-region adaptive management project.
• Environmental Health Monitoring	12	Monitoring of several herptile species as indicators of environmental health, water quality, and monitoring for impacts of climate change. Supports HMP Goal 2 Objective 2.1
• Forest Inventory	17	Supports development of a forest management step-down plan.
• Grassland Monitoring	22	Supports development of a grassland management step-down plan and monitoring to support adaptive management of grasslands.

D. List of Future (Unselected) Surveys

Seven other surveys were included in the prioritization process but not selected for implementation. Priority rank is shown in parentheses. Two of the surveys were considered high priority but resources for conducting these surveys were not immediately available and not expected during the life of the IMP (Table 3). Five other surveys were considered to be lower priority and operational costs exceed available resources. All seven surveys should be reevaluated in the future if additional resources become available (listed below).

- Pre-and Post- Regeneration Grassland and Forest Landbird Surveys (5)
- Water Quality Monitoring (6)
- Marshbird Surveys (11)
- Sport Fish Surveys (13)
- Bathymetric Surveys (15)
- Comprehensive Plant Inventory (20)
- Baseline Herpetofaunal Inventory (23)

E. Surveys Not Included in the Prioritization Process

Nineteen other surveys were considered on the preliminary list of surveys, but are not currently being conducted. Eight historical surveys were primarily discontinued due to lack of funding or a change in cooperator interest in the survey. These eight surveys as well as one desired survey were excluded from the survey prioritization process because they were conducted for other purposes than habitat or population management on the refuge. Additionally, nine surveys were conducted primarily for visitor services purposes or had no written protocols, databases, or application to refuge management (i.e., reconnaissance).

Three threatened and endangered species or migratory bird surveys were discontinued. The refuge is outside of the range of the Copperbelly watersnake population that is threatened, but much research has been done on this species with over 500 animals marked and monitored by academic partners. Surveys for bald eagles were conducted formally until delisting, and the presence of one nest is still noted via

reconnaissance or volunteer efforts each year. The Mid-Winter Waterfowl Survey was discontinued because the State of Indiana coordinator does not request the refuge participate in this survey. The FWS Migratory Bird Program requests that Muscatatuck band 650 wood ducks each year. This banding effort was discontinued due to low capture rates and the high resource investment for the low number of captured ducks.

- Historic Surveys
    - Local surveys discontinued due to completion or lack of funding or cooperators
        - Copperbelly Watersnake Monitoring
        - Tubercled Orchid Survey
        - Butterfly Abundance and Diversity Survey
        - Aquatic Invertebrate Inventory
    - National or Regional-scale surveys discontinued due to lack of funding or cooperators
        - North American Amphibian Monitoring Program (States)
        - FWS Abnormal Amphibian Monitoring
        - FWS Mid-Winter Waterfowl Survey
        - FWS Wood Duck Banding
        - Hoosier Riverwatch Stream Water Quality Monitoring
- Historic, Visitor Services and Reconnaissance Surveys
    - Audubon Christmas Bird Count
    - Audubon Mayday Bird Count
    - Waterfowl Brood Survey
    - Great Blue Heron Rookery Count
    - Bald Eagle Nest Production
    - Bald Eagle Nest Search
    - Species List Inventory
    - Constructed Wetland Inventory
    - Cropland/Old Field Inventory
- Desired future survey but not considered further
    - Invertebrate Inventory – exclude due to lack of relationship to refuge management
    - Region 3 Regional Conservation Priority Species Monitoring – specific species identified during resources of concern selection in HMP

III. Summary Tables

Table 3. Summary of Prioritized Surveys. Blue shading indicates surveys selected for implementation during 2012—2028.

Survey Priority [0]	*Survey ID Number[1]*	*Survey Name[2]*	*Survey Type[3]*	*Survey Status[4]*	*Mgmt. Objective Id[5]*	*Survey Area[6]*	*Staff Time (FTE) [7]*	*Annual Cost (OPR) [8]*	*Survey Timing[9]*	*Survey Length[10]*	*Survey Coord. [11]*	*Protocol Citation[12]*	*Protocol Status[13]*
1	FF03RMSC00-019	Invasive Plant Species Grid-scale Treatment Evaluation	M	Current	CCP / Page 56	Multiple management units: At highest priority grid cells as determined by the Invasive Plant Species Refuge-scale Inventory	FWS: 0.02, Other: 0.29	$500.00	Spring, Summer, Fall/ Recurring -- every year	2012-Indefinite	Daniel Wood, Wildlife Refuge Specialist	Blomquist and Wood 2012	Regional; Initial Survey Instructions
2	FF03RMSC00-004	Invasive Plant Species Grid-scale Monitoring	M	Current	CCP / Page 56	Multiple management units: At highest priority grid cells as determined by the Invasive Plant Species Refuge-scale Inventory	FWS: 0.04, Other: 0.32	$500.00	Summer / Recurring -- every year	2012-Indefinite	Daniel Wood, Wildlife Refuge Specialist	Blomquist and Wood 2012	Regional; Initial Survey Instructions

Survey Priority[0]	*Survey ID Number*[1]	*Survey Name*[2]	*Survey Type*[3]	*Survey Status*[4]	*Mgmt. Objective Id*[5]	*Survey Area*[6]	*Staff Time (FTE)*[7]	*Annual Cost (OPR)*[8]	*Survey Timing*[9]	*Survey Length*[10]	*Survey Coord.*[11]	*Protocol Citation*[12]	*Protocol Status*[13]
3	FF03RMSC00-015	Weekly Waterfowl Survey	M	Current	CCP / Page 54, Page 61	Multiple management units: All managed wetland units	FWS: 0.03, Other: 0.02	$250.00	Weekly/ Recurring -- every year	1984-Indefinite	Daniel Wood, Wildlife Refuge Specialist	IWMM Science Team 2012	National; Initial Survey Instructions
4	FF03RMSC00-020	Invasive Plant Species Refuge-scale Inventory	BM	Current	CCP / Page 56	Entire station	FWS: 0.04, Other: 0.69	$1,000.00	Summer / Recurring -- every decade	2011-Indefinite	Daniel Wood, Wildlife Refuge Specialist	Wood and Blomquist 2011	Regional; Initial Survey Instructions
7	FF03RMSC00-022	Bat Survey	BM	Current	CCP / Page 63	National	FWS: 0.01, Other: 0.01	$150.00	Summer / Recurring -- every year	2013-Indefinite	Daniel Wood, Wildlife Refuge Specialist	USFWS Science Team 2012 v4	National; Initial Survey Instructions
8	FF03RMSC00-011	Water Level Monitoring	M	Current	CCP / Page 51, Page 57, Page 54	Multiple management units: All managed wetland units	FWS: 0.03, Other: 0.02	$250.00	Weekly/ Recurring -- every year	1984-Indefinite	Daniel Wood, Wildlife Refuge Specialist	(none)	Site Specific; Initial survey instructions
10	FF03RMSC00-007	Wetland Vegetation Cover Survey	M	Current	CCP / Page 54	Multiple management units: All managed	FWS: 0.0	$50.00	Fall/ Recurring -- every	1984-Indefinite	Daniel Wood, Wildlife Refuge	IWMM Science Team	National; Initial Survey Instructio

Survey Priority [0]	*Survey ID Number[1]*	*Survey Name[2]*	*Survey Type[3]*	*Survey Status[4]*	*Mgmt. Objective Id[5]*	*Survey Area[6]*	*Staff Time (FTE) [7]*	*Annual Cost (OPR) [8]*	*Survey Timing[9]*	*Survey Length[10]*	*Survey Coord. [11]*	*Protocol Citation[1] [2]*	*Protocol Status[13]*
						wetland units			year		Specialist	2012	ns
14	FF03RMSC00-026	Moss Lake/GTR Tree Regeneration Survey	M	Current	CCP / Page 51	Multiple management units: Green Tree Reservoirs - GTR1, GTR2, and the Moss Lake GTR	FWS: 0.01, Other: 0.01	$100.00	Summer / Recurring -- every year	2013- 2023	Daniel Wood, Wildlife Refuge Specialist	(none)	Site Specific; Initial Survey Instructions
16	FF03RMSC00-023	Spotlight Deer Survey	M	Current	CCP / Page 61	Entire station	FWS: 0.01	$400.00	Winter/ Recurring -- every year	2011- Indefinite	Daniel Wood, Wildlife Refuge Specialist	(none)	Site Specific; Initial Survey Instructions
18	FF03RMSC00-024	Moss Lake Fish Survey	M	Current	CCP / Page 61	Multiple management units: Vernon Fork; Mutton, Storm, and Sandy Branch Creeks	FWS: 0.01, Other: 0.08	$100.00	Summer / Recurring -- every year	2011- 2015	Daniel Wood, Wildlife Refuge Specialist	(none)	Site Specific; Initial Survey Instructions

Survey Priority[0]	*Survey ID Number*[1]	*Survey Name*[2]	*Survey Type*[3]	*Survey Status*[4]	*Mgmt. Objective Id*[5]	*Survey Area*[6]	*Staff Time (FTE)*[7]	*Annual Cost (OPR)*[8]	*Survey Timing*[9]	*Survey Length*[10]	*Survey Coord.*[11]	*Protocol Citation*[12]	*Protocol Status*[13]
19	FF03RMSC00-006	Midwinter Eagle Survey	BM	Current	CCP / Page 63	National	FWS: 0.0	$0.00	Winter/ Recurring -- every year	1999-Indefinite	Daniel Wood, Wildlife Refuge Specialist	USGS USACE 2012	National; Approved
21	FF03RMSC00-010	FWS Eastern Greater Sandhill Crane Survey	BM	Current	CCP / Page 63	National	FWS: 0.0	$0.00	Fall/ Recurring -- every year	1979-Indefinite	Daniel Wood, Wildlife Refuge Specialist	Amundson & Johnson 2010	National; Approved
9	FF03RMSC00-021	Weekly Shorebird Survey	M	Expected	CCP / Page 61	Multiple management units: All managed wetland units	FWS: 0.03, Other: 0.02	$250.00	Weekly/ Recurring -- every year	2014-Indefinite	Daniel Wood, Wildlife Refuge Specialist	IWMM Science Team 2012	National; Initial Survey Instructions
12	FF03RMSC00-025	Environmental Health Monitoring	BM	Expected	CCP / Page 61	Entire station	FWS: 0.0, Other: 0.03	$200.00	Summer / Recurring -- every year	2015-Indefinite	Daniel Wood, Wildlife Refuge Specialist	(none)	(none)
17	FF03RMSC00-027	Forest Inventory	BM	Expected	CCP / Page 51, Page 48	Multiple management units: All forested	FWS: 0.08	$4,160.00	Summer / Recurring --	2014-Indefinite	Daniel Wood, Wildlife Refuge	(none)	(none)

Survey Priority [0]	*Survey ID Number [1]*	*Survey Name [2]*	*Survey Type [3]*	*Survey Status [4]*	*Mgmt. Objective Id [5]*	*Survey Area [6]*	*Staff Time (FTE) [7]*	*Annual Cost (OPR) [8]*	*Survey Timing [9]*	*Survey Length [10]*	*Survey Coord. [11]*	*Protocol Citation [12]*	*Protocol Status [13]*
						areas on the Refuge - 69% of refuge (5400 ac)			every decade		Specialist		
22	FF03RMSC00-028	Grassland Monitoring	M	Expected	CCP / Page 53	Multiple management units: All grassland units	FWS: 0.01, Other: 0.01	$250.00	Spring, Summer / Recurring -- every year	2014-Indefinite	Daniel Wood, Wildlife Refuge Specialist	(none)	(none)
5	FF03RMSC00-008	Pre- and Post-Regeneration Landbird Survey	M	Future	CCP / Page 61	Multiple management units: All forested and regenerating forest units on the refuge	N/A	$5,000.00	Spring, Fall/ Recurring -- every two years	Future/TBD-Future/TBD	Daniel Wood, Wildlife Refuge Specialist	(none)	(none)
6	FF03RMSC00-014	Water Quality Monitoring	BM	Future	CCP / Page 61	Multiple management units: null	N/A	$4,500.00	Spring, Summer, Fall/ Recurring -- every year	Future/TBD-Future/TBD	Daniel Wood, Wildlife Refuge Specialist	(none)	(none)

Survey Priority [0]	*Survey ID Number [1]*	*Survey Name [2]*	*Survey Type [3]*	*Survey Status [4]*	*Mgmt. Objective Id [5]*	*Survey Area [6]*	*Staff Time (FTE) [7]*	*Annual Cost (OPR) [8]*	*Survey Timing [9]*	*Survey Length [10]*	*Survey Coord. [11]*	*Protocol Citation [12]*	*Protocol Status [13]*
11	FF03RMSC00-029	Marshbird Survey	M	Future	CCP / Page 61	Multiple management units: All managed wetland units	N/A	$500.00	Twice in Summer / Recurring -- every five years	Future/TBD-Future/TBD	Daniel Wood, Wildlife Refuge Specialist	(none)	Initial Survey Instructions
13	FF03RMSC00-013	Sportfish Survey	M	Future	CCP / Page 61	Multiple management units: All fishable lakes on refuge	N/A	$4,000.00	Spring, Fall/ Recurring -- every year	Future/TBD-Future/TBD	Daniel Wood, Wildlife Refuge Specialist	(none)	(none)
15	FF03RMSC00-003	Bathymetric Survey	I	Future	CCP / Page 51	Multiple management units: All wetland areas on refuge	N/A	$6,000.00	Spring, Summer / Occurs one time only	Future/TBD-Future/TBD	Daniel Wood, Wildlife Refuge Specialist	Wood and Nelson 2009	Site Specific; Initial Survey Instructions
20	FF03RMSC00-002	Comprehensive Plant Inventory	I	Future	N/A	Entire station	N/A	$10,000.00	Spring, Summer / Occurs one time only	Future/TBD-Future/TBD	Daniel Wood, Wildlife Refuge Specialist	(none)	Initial Survey Instructions
23	FF03RMSC0	Baseline Herpetofaun	I	Future	CCP /	Entire	N/A	$10,000.0	Spring, Summer	Future/TBD-	Daniel Wood,	(none)	Initial Survey

Survey Priority [0]	*Survey ID Number[1]*	*Survey Name[2]*	*Survey Type[3]*	*Survey Status[4]*	*Mgmt. Objective Id[5]*	*Survey Area[6]*	*Staff Time (FTE) [7]*	*Annual Cost (OPR) [8]*	*Survey Timing[9]*	*Survey Length[10]*	*Survey Coord. [11]*	*Protocol Citation[1] [2]*	*Protocol Status[13]*
	0-009	al Inventory			Page 61	station		0	/ Occurs one time only	Future/TBD	Wildlife Refuge Specialist		Instructions

0: The rank for each survey listed in order of priority (e.g., numeric).

1: A unique identification number consisting of: [station organization code]-[sequential number].

2: Short titles for the survey name, preferably the same names in station work plans.

3: Type of survey (I=Inventory, CI=Coop Inventory, BM=Baseline Monitoring, CB=Coop Baseline Monitoring, M=Monitoring to Inform Management, CM=Coop Monitoring to Inform Management, R=Research, CR=Coop Research).

4: Surveys planned for the lifespan of this IMP (e.g., Current, Expected, Future).

5: The management plan and objectives that justify the described survey.

6: Station management unit names, entire station, or names of other landscape units included in the survey.

7: Estimates of Service (FWS) and non-Service (Other) staff time needed to complete the survey (1 work year = 2080 hours = 1 FTE).

8: Average annual operations costs for conducting the survey (e.g., equipment, contracts, travel) not including staff time.

9: Timing and frequency of survey field activities.

10: The years during which the survey has been or will be conducted.

11: Name and position of the Survey Coordinator for each survey.

12: Title, author, and version of the survey protocol (if there is no protocol to cite, enter None).

13: Scale of intended use (Local, Regional, or National) and stage of approval (Initial Survey Instructions, In Development, In Review, or Approved) of the survey protocol.

Table 4. Estimated Annual Budget for Implementing the IMP.

To aid in planning, the table is broken into three sections for currently implemented surveys (A), surveys expected to be implemented during the life of the IMP (B), and surveys that will be implemented in the future (C). Costs are divided among FWS permanent staff hours (staff time, FWS), temporary, seasonal, or intern staff hours (staff time, other), and operations costs (fuel, travel, equipment, contracts).

(A) Current surveys

Survey Name	Survey Priority	Average Annual Staff Time, FWS (hours)	FWS Staff Total ($)	Average Annual Staff Time, Other (hours)	Other Staff Total ($)	Average Annual Operations Cost ($)	Total Cost ($)
Invasive Plant Species Grid-scale Treatment Evaluation	1	40	$1,460.00	600	$2,250.00	$500.00	$4,210.00
Invasive Plant Species Grid-scale Monitoring	2	80	$2,920.00	656	$2,460.00	$500.00	$5,880.00
Weekly Waterfowl Survey	3	72	$2,628.00	32	$120.00	$250.00	$2,998.00
Invasive Plant Species Refuge-scale Inventory	4	80	$2,920.00	1,440	$5,400.00	$1,000.00	$9,320.00
Bat Survey	7	16	$584.00	16	$60.00	$150.00	$794.00
Water Level Monitoring	8	72	$2,628.00	32	$120.00	$250.00	$2,998.00
Wetland Vegetation Cover Survey	10	8	$292.00	0	$0.00	$50.00	$342.00
Moss Lake/GTR Tree Regeneration Survey	14	16	$584.00	16	$60.00	$100.00	$744.00
Spotlight Deer Survey	16	16	$584.00	0	$0.00	$400.00	$984.00
Moss Lake Fish Survey	16	16	$584.00	160	$600.00	$100.00	$1,284.00
Midwinter Eagle Survey	19	4	$146.00	0	$0.00	$0.00	$146.00

Survey Name	Survey Priority	Average Annual Staff Time, FWS (hours)	FWS Staff Total ($)	Average Annual Staff Time, Other (hours)	Other Staff Total ($)	Average Annual Operations Cost ($)	Total Cost ($)
FWS Eastern Greater Sandhill Crane Survey	21	4	$146.00	0	$0.00	$0.00	$146.00
Current Totals	**12**	**424**	**$15,476.00**	**2,952**	**$11070.00**	**$3,300.00**	**$29,846.00**

(B) Expected surveys

Survey Name	Survey Priority	Average Annual Staff Time FWS (hours)	FWS Staff Total ($)	Average Annual Staff Time Other (hours)	Other Staff Total ($)	Average Annual Operational Cost ($)	Total Cost ($)
Weekly Shorebird Survey	9	72	$2,628.00	32	$120.00	$250.00	$2,998.00
Environmental Health Monitoring	12	8	$292.00	64	$240.00	$200.00	$732.00
Forest Inventory	17	160	$5,840.00	0	$0.00	$4,160.00	$10,000.00
Grassland Monitoring	22	16	$584.00	24	$90.00	$250.00	$924.00
Expected Totals	**4**	**256**	**$9,344.00**	**120**	**$450.00**	**$4,860.00**	**$14,654.00**

(C) Future surveys. Cost estimates for Future surveys based on total cost of labor and supplies.

Survey Name	Survey Priority	Average Annual Staff Time FWS (hours)	FWS Staff Total ($)	Average Annual Staff Time Other (hours)	Other Staff Total ($)	Average Annual Operational Cost ($)	Total Cost ($)
Pre- and Post-Regeneration Landbird Survey	5	0	$0.00	0	$0.00	$5,000.00	$5,000.00
Water Quality Monitoring	6	0	$0.00	0	$0.00	$4,500.00	$4,500.00
Marshbird Survey	11	0	$0.00	0	$0.00	$500.00	$500.00
Sportfish Survey	13	0	$0.00	0	$0.00	$4,000.00	$4,000.00
Bathymetric Survey	15	0	$0.00	0	$0.00	$6,000.00	$6,000.00
Comprehensive Plant Inventory	20	0	$0.00	0	$0.00	$10,000.00	$10,000.00
Baseline Herpetofaunal Inventory	23	0	$0.00	0	$0.00	$10,000.00	$10,000.00
Future Totals	**7**	**0**	**$0.00**	**0**	**$0.00**	**$40,000.00**	**$40,000.00**

Table 5. Estimated Annual Work Schedule, January – December

Survey Name	Survey Priority	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Current													
Invasive Plant Species Grid-scale Treatment Evaluation	1			FW	FW	T, FW	FW	FW	FW	FW	FW	FW	DE
Invasive Plant Species Grid-scale Monitoring	2					T, FW	FW	FW	FW	FW			
Weekly Waterfowl Survey	3	FW, A,R	FW, A,R	FW	FW	FW	FW	FW	FW	FW	FW	FW	FW, DE
Invasive Plant Species Refuge-scale Inventory*	4					T	FW	FW	FW	FW	DE	A,R	
Bat Survey	7				P	T	FW	FW	DE				
Water Level Monitoring	8	FW, A,R	FW, A,R	FW	FW	FW	FW	FW	FW	FW	FW	FW	FW,DE
Wetland Vegetation Cover Survey	10	A, R									FW	DE	
Moss Lake/GTR Tree Regeneration Survey	14						P,T	FW	FW	DE	A	R	
Spotlight Deer Survey	16	FW	DE, A,R									P,T	FW
Moss Lake Fish Survey	18					P,T	FW	FW	FW, DE	A	R		
Midwinter Eagle Survey	19	FW, R											
FWS Eastern Greater Sandhill Crane Survey	21	FW,R											
Expected													
Weekly Shorebird Survey	9	FW, A,R	FW, A,R	FW	FW	FW	FW	FW	FW	FW	FW	FW	FW,DE
Environmental Health Monitoring	12		P	FW	FW	FW	FW	FW	DE	A	R		
Forest Inventory*	17			P			FW	FW		A	R		
Grassland Monitoring*	22				P	T	FW	FW	DE	A	R		

P=Planning, T=Training, FW=Field Work, DE=Data Entry, A=Analysis, R=Reporting

*Denotes Inventory or Monitoring conducted at 7-20 year intervals (not annual work)

Table 6. Estimated Multi-year Work Schedule, 2013-2017.

Survey Name	Survey Priority	2013	2014	2015	2016	2017
Current						
Invasive Plant Species Grid-scale Treatment Evaluation	1	X	X	X	X	X
Invasive Plant Species Grid-scale Monitoring	2	X	X	X	X	X
Weekly Waterfowl Survey	3	X	X	X	X	X
Invasive Plant Species Refuge-scale Inventory*	4	X	X	X	X	X
Bat Survey	7	X	X	X	X	X
Water Level Monitoring	8	X	X	X	X	X
Wetland Vegetation Cover Survey	10	X	X	X	X	X
Moss Lake/GTR Tree Regeneration Survey	14	X	X	X	X	X
Spotlight Deer Survey	16	X	X	X	X	X
Moss Lake Fish Survey	18	X	X	X	X	X
Midwinter Eagle Survey	19	X	X	X	X	X
FWS Eastern Greater Sandhill Crane Survey	21	X	X	X	X	X
Expected						
Weekly Shorebird Survey	9		X	X	X	X
Environmental Health Monitoring	12		X	X	X	X
Forest Inventory*	17	Not scheduled to occur again until 2018 (seven years after initial inventory completed in 2011)				
Grassland Monitoring*	22		X	Next inventory in 2024 if completed in 2014		

*Denotes Inventory or Monitoring conducted at 7-20 year intervals (not annual work)

IV. Amending and Revising the IMP

The IMP will be revised according to the I&M Policy, summarized below. Revisions will be needed as CCP and HMP plans are modified or following a Wildlife and Habitat Review.

A. Amending the IMP

When new survey protocols or new versions of existing protocols are approved and assigned to a survey, the station and I&M staff need to amend the station's IMP. When amending an IMP, first update the PRIMR database with the following information. Then, export tables that have changed, annotate with the amendment date, and append to the existing IMP.

1. Add new protocol citations to Table 1.
2. Update the estimates of survey cost and staff time in Table 1.
3. Obtain reviews from appropriate I&M staff; no formal signatures are required.

B. Revising the IMP

Selecting a new survey or removing a selected survey from an approved IMP results in a more substantial change because it may require re-evaluating the ranking of surveys in the IMP. When revising an IMP, first update the PRIMR database for all surveys, including revised survey priorities, and then update the IMP accordingly. Use the SMART ranking tool to support the re-ranking process if major changes in priority are anticipated or if the HMP or CCP are revised. A revision requires reviews and signatures from refuge staff, Regional I&M staff, Regional Refuge Biologist/Natural Resources Division Chief on the revision form below, but not the Refuge Supervisor or Regional Chief of Refuges.

1. Reassign survey priorities in Table 1.
2. If a new survey is included, add required information in Table 1.
3. Store the revised IMP in the Service's document catalog.

Figure 1. Inventory and Monitoring Plan Revision Form

Inventory and Monitoring Plan Revision
For: Muscatatuck National Wildlife Refuge

Action	***Signature /Printed Name***	***Date***
Survey list and priority changed:		
Submitted By:	Refuge Manager/Project Leader	
Reviewed By:	Regional I&M Coordinator	
Approved By:	Regional Refuge Biologist/Division Chief	

V. References

Amundson CL, Johnson DH. 2010. Assessment of the eastern population Greater Sandhill Cranes (*Grus canadensis tabida*) fall migration survey, 1979-2009. Report to the US Fish and Wildlife Service, Migratory Bird Management, Region 3, Bloomington, Minnesota.

Blaustein AR, Wake DB, Sousa WP. 1994. Amphibian declines: judging stability, persistence, and susceptibility of populations to local and global extinctions. Conservation Biology 8(1):60-71.

Blomquist SM, Wood D. 2012. Adaptive Management of Invasive Forest Plants: Draft Grid-scale Monitoring Protocol. US Fish and Wildlife Service, National Wildlife Refuge System, Region 3, Bloomington, Minnesota. Draft 13 February 2013.

Dewey SA, Andersen KA. 2004. Strategies for early detection: using the wildfire model. Weed Technology 18 (Invasive Weed Symposium):1396–1399.

Fisher BE. 2007. Results of mussel survey conducted in 2007. Unpublished report from Indiana Department of Natural Resources to Muscatatuck National Wildlife Refuge, Seymour, Indiana.

Harmon JL. 1996. Survey of the freshwater mussels (Bivalvia: Unionidae) of the Muscatatuck National Wildlife Refuge. Unpublished manuscript to the US Fish and Wildlife Service, Muscatatuck National Wildlife Refuge, Seymour, Indiana.

Houlahan JE, Findlay CS, Schmidt BR, Mayer AH, Kuzmin SL. 2000. Quantitative evidence for global amphibian population declines. Nature 404(6779):752-755.

Kruse KL, Dubovsky JA, Cooper TR. 2011. Status and harvests of sandhill cranes: Mid-Continent, Rocky Mountain, Lower Colorado River Valley and Eastern Populations. Report to the US Fish and Wildlife Service, Migratory Bird Management, Region 6, Denver, Colorado.

Land D, Gill S, O'Neal B, Wood D. 2012. Abundance and demographics of white-tailed deer at Muscatatuck National Wildlife Refuge. Spring 2012 Proceedings of the Indiana Chapters of the American Fisheries Society and the Wildlife Society Conference, Indianapolis, Indiana.

Lindsey AA. 1997. Walking in wilderness. Pages 113- 123 in Jackson MT, editor. The Natural Heritage of Indiana. Indiana University Press, Bloomington.

Robinson SK, Thompson III FR, Donovan TM, Whitehead DR, Faaborg J. 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267(5206):1987-1990

Steenhof K, Bond L, Dunn LL. 2008. The midwinter bald eagle survey results and analysis 1986-2005. US Geological Survey, National Biological Information Infrastructure, and Northwest Alliance for Computational Science and Engineering. Available at http://www.nacse.org/nbii/eagles (accessed January 2013).

[USFWS] United States Fish and Wildlife Service. 2004. Integrated Pest Management: Guidance for Preparing and Implementing Integrated Pest Management Plans. Washington, D.C.: Department of Interior. Available at: http://www.fws.gov/contaminants/Documents/GuidanceIPMPlan.pdf (accessed January 2013).

[USFWS] United States Fish and Wildlife Service. 2009. Muscatatuck NWR Comprehensive Conservation Plan. US Fish and Wildlife Service, Muscatatuck National Wildlife Refuge, Seymour, Indiana. Available at: http://www.fws.gov/midwest/planning/muscatatuck/index.html (accessed January 2013)

[USFWS] United States Fish and Wildlife Service. 2011.Muscatatuck NWR Water Management Plan. US Fish and Wildlife Service, Muscatatuck National Wildlife Refuge, Seymour, Indiana

[USFWS] United States Fish and Wildlife Service. 2012. Muscatatuck NWR Habitat Management Plan. US Fish and Wildlife Service, Muscatatuck National Wildlife Refuge, Seymour, Indiana.

Wake DB. 1991. Declining amphibian populations. Science 253(5022):860.

Wood D, Blomquist SM. 2011. Adaptive Management of Invasive Forest Plants: Draft Refuge-scale Inventory Protocol and GIS Process for Calculating Interpolation Score for Prioritization. US Fish and Wildlife Service, National Wildlife Refuge System, Region 3, Bloomington, Minnesota. Draft 13 February 2013.

Wood, D. and F. Nelson. 2009. Muscatatuck National Wildlife Refuge Bathymetric Models and Tutorial. US Fish and Wildlife Service, Seymour, Indiana. 15 August 2009.

IWMM Science Team 2012

USFWS Science Team 2012v4

USGS USACE 2012 Midwinter eagle survey

VI. Appendices

Appendix A. Simple Multi-Attribute Rating Technique (SMART tool) and Prioritization Criteria

The following 16 criteria were weighted by refuge staff at Muscatatuck NWR and used to prioritize surveys through a Simple Multi-Attribute Rating Technique (SMART tool). Please note that these criteria were in draft form at the time of prioritization. The current tool (PRIMR prioritization tool) and criteria (*Criteria for Prioritizing Surveys Entered into the PRIMR Database*) can be downloaded here. If this link is dead, contact Kevin Kilbride (R1) or Sean Blomquist (R3). If you use these current criteria, they do not need to be included as an appendix in the IMP.

1) **Station purpose:** Does the survey provide information to evaluate whether or not the station is achieving one or more Comprehensive Conservation Plan (CCP), Habitat Management Plan (HMP), or other management plan objectives directly related to its purpose(s)?
   Note: A survey addressing wilderness character addresses purpose for a refuge with proposed or designed wilderness.
   1. No
   2. Yes

2) **Other legal mandates**: Does the survey provide information to evaluate whether or not the station is achieving one or more CCP, HMP, or other management plan objectives directly related to legal mandates besides refuge purposes such as Biological Integrity, Diversity and Environmental Health (BIDEH); NWR Resources of Concern (e.g., migratory birds, species listed under the federal Endangered Species Act, anadromous fishes, marine mammals); and maintaining water rights?
   Note: For BIDEH, only consider surveys addressing the highest measure of biological integrity on a refuge which is viewed as those intact and self-sustaining habitats and wildlife populations that existed during historic conditions (see 601 FW 3.10). Example: Because 99% of the wet prairie habitat has been lost throughout the Willamette Valley of western Oregon, remnant prairie on WL Finley NWR represents the highest order of BIDEH on the refuge where habitat monitoring is a priority survey.
   1. No
   2. Yes

3) **High-priority management actions**: Does the survey inform whether or not the station is achieving one or more CCP, HMP, or other management plan objectives involving high-priority management actions conducted by the station staff?
   For example, if conducting wetland management actions requires considerable station staff time and funding annually, then surveys that track response of vegetation and waterfowl to those wetland management actions could be considered a high priority.
   1. No
   2. Yes

4) **Controversy**: Does the survey support decision making to assess a suspected or known controversial refuge management action or refuge use?
   Note: These terms are defined in the appendix. Examples of suspected or known controversial refuge management actions include mammalian predator control and use of pesticides. Examples of suspected

or known controversial refuge uses (recreational and economic) are establishing new close areas from waterfowl hunting, use of genetically modified crops, and livestock grazing.

1. No
2. Yes

5) **Known or suspected threats:** Will the survey provide information to potentially reduce the duration of the threat(s) to the station, cost to the station due to those threat(s), or effect station resources of concern due to those threat(s) during the current or future CCP planning cycles?
Examples of known or suspected threats include the following: proposed water withdrawal within the station's watershed, a new invasive species, impacts of proposed development, and combinations of threats like increased fire cycles promoting invasive species.
    1. The survey does not address threat(s).
    2. Low: The survey potentially informs 1 of 3 factors (duration, cost, or effect on resources).
    3. Medium: The survey potentially informs 2 of 3 factors (duration, cost, or effect on resources).
    4. High: The survey potentially informs all 3 factors (duration, cost, and effect on resources).

6) **Species or vegetation community non-federal listing status**: Is the species or vegetation community (the focus of the survey) state listed (threatened or endangered only), ranked by the state's natural heritage program (S1 or S2 rank only), globally ranked by NatureServe (G1 or G2 rank only) or globally listed on the IUCN Red List of Threatened Species (Critically Endangered, Endangered or Vulnerable only)?
Note: Federally listed species are accounted for under criterion #2 so they should not be considered here. Example: Survey to inventory small mammals on the refuge where one or more of the species likely or suspected to be found is state or globally listed. Surveys of abiotic factors affecting state listed or globally ranked species should be considered under this criterion. Example: Monitoring water in refuge wetlands inhabited by state-listed aquatic birds to assess potential effects to avian species.
    1. Not listed
    2. State listed or ranked by state's natural heritage program
    3. Globally listed

7) **FWS priorities:** Does the survey provide information that directly contributes to evaluating the status and trends of resources that are a priority for the NWRS or other FWS regional or national program (e.g., Migratory Birds, Fisheries, T&E species) or the national I&M initiative (e.g., phenology)?
Examples: North American Breeding Bird Survey, Woodcock Singing Ground Counts, North American Amphibian Monitoring Program, Mid-Winter Waterfowl Survey, and Circumpolar Biodiversity Monitoring Network are surveys which are priorities for regional or national FWS programs.
    1. No
    2. Yes

8) **Survey coverage for species or vegetation community:** What proportion (%) of the species' (sub)population or vegetation communities' geographic range under U.S. jurisdiction will be covered by the survey on the station?
Example 1: 75% of Laysan Albatross population nest on Midway NWR. Conducting a survey to monitor the breeding population size on the refuge would cover >25% of the entire species' population.
Note: Surveys of abiotic factors affecting these species or vegetation communities should also be considered for this criterion. Example 2: 60% of the wintering waterfowl in the Pacific Flyway use wetlands in the Central Valley of California including the San Luis NWRC. Monitoring water levels by reading staff gauges weekly from October to March in managed wetlands is an important abiotic survey

to indicate if there are sufficient acres of suitable foraging habitat to support 60% of the wintering waterfowl.

1. Survey covers <1% of the species' or communities' population/range
2. Survey covers 1-10% of the species' or communities' population/range
3. Survey covers 11-25% of the species' or communities' population/range
4. Survey covers >25% of the species' or communities' population/range

9) **Survey utility**: How many station CCP, HMP, or other management plan objectives can be evaluated by the survey?
Examples: A survey of staff gauge readings for water levels in representative units can be used to evaluate a range of wetland habitat objectives including seasonal, emergent, and permanent types. An Early Detection Rapid Response survey can be used to detect the presence of highly invasive plant species in multiple refuge habitats.
    1. Does not address an objective
    2. Addresses 1 objective
    3. Addresses 2 objectives
    4. Addresses 3 or more objectives

10) **Survey leveraging**: Is the survey conducted (integrated) with one or more other surveys?
Example 1: There are surveys that must be conducted in conjunction with each other in order to fully evaluate the status and trends of the target resource and its habitat. Example: The landbird point count protocol requires habitat parameters to be collected in conjunction with avian data. Example 2: Habitat parameters and avian population counts are collected for the Integrated Waterbird Management and Monitoring project.
    1. Survey is not integrated with other surveys
    2. Survey is integrated with 1 other survey
    3. Survey is integrated with >1 other surveys

11) **FWS Partners**: Does the survey address high or medium priorities of relevant Landscape Conservation Cooperatives (LCC), state agencies, or conservation partners?
    1. Does not address a management priority identified by FWS partners (e.g., LCC, state agency).
    2. Addresses a management priority identified by 1 FWS partner (e.g., LCC, state agency).
    3. Addresses a management priority identified by 2 FWS partners (e.g., LCC, state agency).
    4. Addresses a management priority identified by ≥3 FWS partners (e.g., LCC, state agency).

12) **Survey spatial context**: At what scale does the survey most benefit the information needs required for resource management?
Note: Only surveys with a standard protocol and established systems of data management and analysis are scored higher than a 1.
    1. Small scale: Applicable to only 1 station.
    2. Medium scale: Applicable to a smaller group of stations or single complex.
    3. Large scale: Applicable to multiple stations/complexes across an entire ecoregion, LCC, or region.
    4. Continental scale: Component of a large landscape level survey (e.g., North American Breeding Bird Survey, Woodcock Singing Ground Counts, North American Amphibian Monitoring Program, and Circumpolar Biodiversity Monitoring Network).

13) **Survey duration**: Over what time scale will the objective(s) addressed by the survey need to be evaluated?
Long-term surveys will need to be consistently implemented over multiple generations of the species or successional stages of habitat to evaluate achievement of objective(s).
    1. Short-term: 1-15 years
    2. Long-term: >15 years.

14) **Cost of data collection, analysis, and reporting**: What is the cost (e.g., staff time, contractor cost, equipment, sample analysis/processing, annual funding) for survey design, implementation, data management, data analysis, and reporting?
Note: Surveys that require novel techniques, many repeated visits or large numbers of staff will likely be more expensive to implement. Similarly, surveys that require assistance for the development of protocols and analysis of data will be more costly. Conversely, if a standardized protocol, database, analysis, and/or reporting system are available, then the costs of implementing such a survey may be much lower than if these elements must be designed and tested upfront.
    1. High: >5% of annual funding or staff time for the refuge biological program dedicated for the survey
    2. Medium: 1-5% of annual funding or staff time for the refuge biological program dedicated for the survey
    3. Low: 0.1- 1% of annual funding or staff time for the refuge biological program dedicated for the survey
    4. Very Low: <0.1% of annual funding or staff time dedicated for the refuge biological program dedicated for the survey

15) **Data analysis**: Are the survey data analyzed?
Note: The frequency and intensity of management is dependent upon station objectives. In some cases, surveillance monitoring is appropriate given active management is not anticipated for the foreseeable future. In contrast, targeted monitoring may be needed to maintain certain habitats (e.g., moist-soil wetlands) that require considerable, annual management activities to achieve desired conditions.
    1. Low: Study design does not allow data to be readily analyzed.
    2. Medium: Data can/have been analyzed on infrequent basis.
    3. High: Data can/have been analyzed on regular intervals.

16) **Data use**: Are the survey results reported and used to inform current and future management decisions?
Note: See description from criterion #15.
    1. Low: Study design does not allow results to be readily reported. Therefore, results are not used in resource management decisions.
    2. Medium: Results can/have been reported, but these results have not been used to guide management at the station, regional, or larger landscape levels.
    3. High: Currently reported on regular intervals and used to inform management at the station, regional, or larger landscape levels.

Table A1. Weight Applied to Prioritization Criteria.

Each station is asked the importance weight of the prioritization criteria using a direct weighting technique. Because the weights affect the final score in the SMART tool, they must be reported here.

Criteria #	Criteria description	Station-specific weight
1	Station purpose	0.091
3	High-priority management actions	0.091
14	Cost of data collection, analysis, and reporting	0.086
16	Data use	0.086
2	Other legal mandates	0.082
9	Survey utility	0.073
7	FWS priorities	0.068
4	Controversy	0.066
15	Data analysis	0.066
5	Known or suspected threats	0.064
10	Survey leveraging	0.062
11	FWS partners	0.059
6	Species or vegetation community non-federal listing status	0.057
8	Survey coverage for species or vegetation community	0.035
12	Survey spatial context	0.012
13	Survey duration	0.001

Appendix B. Survey Priority from SMART Tool

Final scores and ranks used to clarify the importance of surveys planned at Muscatatuck National Wildlife Refuge. Final scores were the culmination of evaluation of 16 criteria for each survey (Appendix A) and weighting value for each criteria determined by refuge staff (Table A1). Scores were then ranked by assigning an integer value 1—23. Finally, surveys were assigned a status based on implementation of the survey (definitions found in the PRIMR User Guide, P 7).

Survey	Final Score	Score Rank	Status
Invasive Plant Species Grid-scale Treatment Evaluation	0.905	1	Current
Invasive Plant Species Grid-scale Monitoring	0.839	2	Current
Weekly Waterfowl Survey	0.834	3	Current
Invasive Plant Species Refuge-scale Inventory	0.780	4	Current
Bat Survey	0.670	7	Current
Water Level Monitoring	0.654	8	Current
Wetland Vegetation Cover Survey	0.646	10	Current
Moss Lake/GTR Tree Regeneration Survey	0.527	14	Current
Spotlight Deer Survey	0.497	16	Current
Moss Lake Fish Survey	0.459	18	Current
Midwinter Eagle Survey	0.456	19	Current
FWS Eastern Greater Sandhill Crane Survey	0.409	21	Current
Weekly Shorebird Survey	0.649	9	Expected
Environmental Health Monitoring	0.584	12	Expected
Forest Inventory	0.470	17	Expected
Grassland Monitoring	0.406	22	Expected
Pre-and Post- Regeneration/Regeneration Landbird Surveys	0.735	5	Future
Water Quality Monitoring	0.684	6	Future
Marshbird Surveys	0.585	11	Future
Sportfish Surveys	0.581	13	Future
Bathymetric Surveys	0.501	15	Future
Comprehensive Plant Inventory	0.425	20	Future
Baseline Herpetofaunal Inventory	0.386	23	Future

Appendix C. Survey Profiles for Surveys with Current Status

Survey: Invasive Plant Species Grid-scale Treatment Evaluation *(FF03RMSC00-019)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *1*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 56; Objective 1.5: Invasive Plant Species; Comprehensive Conservation Plan; Survey address CCP: Goal 1 Obj. 1.5 Strat. 4 & 5 and HMP: Obj. 1.11 Justification for Selection: Why was this survey selected over others? Effective and efficient control of invasive plants is a high priority for the Refuge. The majority of the Refuge is forested; >80% of forested habitats on the Refuge had 42 invasive plant species present based on a preliminary forest inventory in 2009-2010. These invasive plants are interfering with the regeneration of a diverse native hardwood forest of different ages and structural classes. Maintaining the hardwood forests' native biodiversity is the primary vehicle for maintaining biological integrity, diversity, and environmental health of the refuge and to monitor the status and trends of invasive plants across the refuge.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

To tie our management actions to pre- and post-management monitoring data, we created a decision model and adaptive management framework that supports learning about the effectiveness of invasive species treatments and predicts the optimal treatments. The treatment monitoring will document a variety of variables that may influence the effectiveness of treatments as well as documenting the specific treatment at a given grid cell. The data will be used in combination with pre and post-treatment monitoring to improve the accuracy of the decision model and support the adaptive management feedback loop.

What is the population or attribute of interest, what will be measured, and when?

A wide array of variables are recorded for each treatment that occurs within each treated grid cell at the Refuge. These variables range from type of treatment, plant morphology, size of infestation, to climatic variables, chemicals used, among many others. Biological Integrity; Invasive Species; Plantae (plants); Fabaceae (peas, legumes); Myristicaceae (No common name); Scrophulariaceae (figworts); Apiaceae (No common name); Celastraceae (bittersweet); Ranunculaceae (buttercups, crowfoot); Polygonaceae (buckwheat, knotweed); Cannabaceae (hemp); Salicaceae (willows); Poaceae (grasses); Brassicaceae (crucifers, mustards); Dioscoreaceae (Yam Family); Simaroubaceae (quassias); Lythraceae (loosestrife); Dipsacaceae (teasel); Oleaceae (olives); Asteraceae (sunflowers); Lamiaceae (mints); Apocynaceae (dogbane); Berberidaceae (bayberries); Rosaceae (roses); Caprifoliaceae (honeysuckle); Elaeagnaceae (oleasters); Recurring -- every year; Spring, Summer, Fall

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Chicago Botanic Garden (Eric Lonsdorf) is helping with database and decision model development. Also, funding &/or labor from USFWS Invasive Species Office, local universities and weed cooperatives

Survey: **Invasive Plant Species Grid-scale Monitoring** *(FF03RMSC00-004)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *2*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 56; Objective 1.5: Invasive Plant Species; Comprehensive Conservation Plan; Survey address CCP: Goal 1 Obj. 1.5 Strategy 4 & 5 and several HMP objectives relating to community specific restoration targets and general invasive species control (Obj. 1.1, 1.2, 1.3, 1.4, 1.9, and 1.11). Justification for Selection: Why was this survey selected over others? Effective and efficient control of invasive plants is a high priority for the Refuge. The majority of the Refuge is forested; >80% of forested habitats on the Refuge had 42 invasive plant species present based on a preliminary forest inventory in 2009-2010. These invasive plants are interfering with the regeneration of a diverse native hardwood forest of different age and structural classes. Maintaining the hardwood forests' native biodiversity is the primary vehicle for maintaining biological integrity, diversity, and environmental health of the refuge and to monitor the status and trends of invasive plants across the refuge.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

Monitoring at the grid scale will assess the effectiveness of the management action in controlling invasive plants. Rapid, transect-based monitoring includes collection of categorical data on level of invasive species, type of invasive species and native species diversity. To tie our management actions to pre- and post-management action monitoring data, we created a decision model that will predict an optimal treatment based on the initial hypotheses about habitat response to treatments and allow managers to learn about effectiveness of those treatments. We have developed a draft protocol for the grid-scale monitoring, and pilot tested it in 2012.

What is the population or attribute of interest, what will be measured, and when?

Categorical occupancy by invasive species monitored via a 0.25-ha grid imposed over forested habitats on the refuge. Biological Integrity; Invasive Species; Plantae (plants); Fabaceae (peas, legumes); Myristicaceae (No common name); Scrophulariaceae (figworts); Apiaceae (No common name); Celastraceae (bittersweet); Ranunculaceae (buttercups, crowfoot); Polygonaceae (buckwheat, knotweed); Cannabaceae (hemp); Salicaceae (willows); Poaceae (grasses); Brassicaceae (crucifers, mustards); Dioscoreaceae (Yam Family); Simaroubaceae (quassias); Lythraceae (loosestrife); Dipsacaceae (teasel); Oleaceae (olives); Asteraceae (sunflowers); Lamiaceae (mints); Apocynaceae (dogbane); Berberidaceae (bayberries); Rosaceae (roses); Caprifoliaceae (honeysuckle); Elaeagnaceae (oleasters); Recurring -- every year; Spring, Summer, Fall

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Chicago Botanic Garden (Eric Lonsdorf) is helping with database and decision model development. Also, funding &/or labor from USFWS Invasive Species Office, local universities and weed cooperatives

Survey: Weekly Waterfowl Survey *(FF03RMSC00-015)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *3*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 54; Objective 1.4: Moist Soil Units and Emergent Marsh Units; Comprehensive Conservation Plan Page 61; Objective 2.1: Monitoring; Comprehensive Conservation Plan Survey address CCP: Goal2 Obj. 2.1 Strategy 2 and HMP: Obj. 1.4 and 1.6 Justification for Selection: Why was this survey selected over others? The Migratory Bird Conservation Commission approved the acquisition of Refuge lands to provide duck breeding and migration habitat. The Refuge purpose is "…for use as an inviolate sanctuary for migratory birds", and the purpose of the Refuge's seasonally flooded impoundments and marshes are for waterbird use. Therefore, the Refuge manages habitat to support waterfowl use. This survey yields data that directly answers whether the Refuge is achieving its purpose. Waterfowl use at Muscatatuck NWR accounts for nearly 10% of the waterfowl use on public lands in Indiana and the data are valued by State partners. The data are used on an annual basis to assess, modify, and recommend wetland management actions.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

Surveying waterfowl is one part of a three-pronged approach the Refuge uses within an adaptive management framework for moist soil and wetland management. Water level manipulations drive vegetation responses and ultimately wildlife responses. Wildlife use, especially waterfowl use, is used to assess the success of wetland management actions. The data, when used in combination with water level and vegetation cover data, can be used to monitor productivity, signal problems, and to refine water level management to optimize conditions. The data are also shared with our partner, Indiana Dept. of Nat. Resources, for various purposes.

What is the population or attribute of interest, what will be measured, and when?

Direct counts or estimates of all waterfowl and certain waterbird species, coots, moorhens, loons, sandhill cranes, and grebes on all managed wetland units on the Refuge. Biological Integrity; Other Biota; Aves (Birds); Anseriformes (Ducks, Waterfowl, Swans, Screamers, Geese); Recurring -- every year; Weekly

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Local universities

Survey: **Invasive Plant Species Refuge-scale Inventory** *(FF03RMSC00-020)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *4*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 56; Objective 1.5: Invasive Plant Species; Comprehensive Conservation Plan; Survey address CCP: Goal 1 Obj. 1.5 and HMP: Obj. 1.1 Strategy 2a., 1.9, 1.11, and 1.12 Strategy 11 Justification for Selection: Why was this survey selected over others? Managers of National Wildlife Refuges, and most other land managers, have an established need for cost-effective informational tools to properly plan, prioritize, manage, and understand non-native invasive plant infestations (i.e., weeds). Often, in the face of temporal, budgetary, and personnel constraints, managers plan their management strategies with little or no a priori information as to the nature of the infestations that they are managing. Effective weed management is dependent upon reliable vegetation monitoring data. Area-wide invasive species inventories should be conducted before prioritizing and adopting specific management strategies (Dewey and Andersen 2004). Department of Interior and Fish and Wildlife Service policies (517 DM1, 30 AM 12, 7 RM 14, and 620 FW1) instruct Refuges to adopt integrated pest management (IPM) as a strategy for managing invasive species. These policies also relate directly to the Biological Integrity Policy (601 FW 3) which mandates the use of IPM strategies. The USFWS Integrated Pest Management guidance (USFWS 2004) for preparing and implementing IPM strategies states that monitoring and mapping are critical components of successful IPM programs and should be completed prior to any pest management action. Weed inventories should be conducted as a “first step” in an integrated pest management strategy with the objective of creating accurate species-distribution maps that will be used in priority setting and management strategy selection.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

Managers of National Wildlife Refuges, and most other land managers, have an established need for cost-effective informational tools to properly plan, prioritize, manage, and understand non-native invasive plant infestations (i.e., weeds). Often, in the face of temporal, budgetary, and personnel constraints, managers plan their management strategies with little or no a priori information as to the nature of the infestations that they are managing. Effective weed management is dependent upon reliable vegetation monitoring data. Area-wide invasive species inventories should be conducted before prioritizing and adopting specific management strategies (Dewey and Andersen 2004). Department of Interior and Fish and Wildlife Service policies (517 DM1, 30 AM 12, 7 RM 14, and 620 FW1) instruct Refuges to adopt integrated pest management (IPM) as a strategy for managing invasive species. These policies also relate directly to the Biological Integrity Policy (601 FW 3) which mandates the use of IPM strategies. The USFWS Integrated Pest Management guidance (USFWS 2004) for preparing and implementing IPM strategies states that monitoring and mapping are critical components of successful IPM programs and should be completed prior to any pest management action. Weed inventories should be conducted as a “first step” in an integrated pest management strategy with the objective of creating accurate species-distribution maps that will be used in priority setting and management strategy selection.

What is the population or attribute of interest, what will be measured, and when?

The project incorporates a multi-step approach of refuge-scale inventory, followed by prioritization, pre-treatment monitoring, treatment, and effectiveness (follow-up) monitoring. The first phase, the refuge-scale inventory, will guide prioritization and management decisions by providing highly detailed maps of the spatial extent and severity of approximately 40 invasive plant species as well as provide maps of non-invaded areas across refuge habitats. The refuge-scale inventory is a rapid assessment of grid cells across the entire refuge based on five major metrics that will affect prioritization. The information is input into a decision support tool developed to give priority scores to each grid cell for determining where limited resources should be spent to get the most “bang for the buck”. This inventory coupled with the decision support provides a transparent means to increase efficiency of invasive management actions taken at the Refuge. Biological Integrity; Invasive Species; Plantae (plants); Fabaceae (peas, legumes); Myristicaceae (No common name); Scrophulariaceae (figworts); Apiaceae (No common name); Celastraceae (bittersweet); Ranunculaceae (buttercups, crowfoot); Polygonaceae (buckwheat, knotweed); Cannabaceae (hemp); Salicaceae (willows); Poaceae (grasses); Brassicaceae (crucifers, mustards); Dioscoreaceae (Yam Family); Simaroubaceae (quassias); Lythraceae (loosestrife); Dipsacaceae (teasel); Oleaceae (olives); Asteraceae (sunflowers); Lamiaceae (mints); Apocynaceae (dogbane); Berberidaceae (bayberries); Rosaceae (roses); Caprifoliaceae (honeysuckle); Elaeagnaceae (oleasters); Recurring -- every year; Spring, Summer, Fall

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Chicago Botanic Garden (Eric Lonsdorf) is helping with database and prioritization model development. Also, funding &/or labor from USFWS Invasive Species Office, local universities and weed cooperatives

Survey: Bat Survey *(FF03RMSC00-022)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *7*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 61; Objective 2.2: Federal T&E Species; Comprehensive Conservation Plan; Survey address CCP: Goal 2 Obj. 2.2 Strategy 2 and HMP: Obj. 1.16 Justification for Selection: Why was this survey selected over others? Indiana bats are known to exist at the Refuge and several other species are thought to be present at various times, however, data are lacking. This survey will give the Refuge more insight into what bat species occur, where, their abundance, and potentially help to identify important bat habitats/locations on the Refuge. The survey will provide baseline data that can be used to indicate trends in bat use and trends in the local populations over time. The survey will also lend data to larger datasets that will be analyzed for larger scale analyses of populations and their trends. The survey has minimal costs considering the Refuge has the software and hardware to complete the survey. Minimal time is involved, and state, regional, and national partners will likely find interest in and use the datasets.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

This survey is part of a large-scale, multi-regional, multi-refuge, grassroots project to determine bat presence and abundance on National Wildlife Refuges. The data will be used in many ways at different scales. At the largest scale it is hoped that this data can be used to determine the status of bat populations in the wake of white-nose syndrome and monitor changes in those populations. At the Refuge, data will be analyzed to determine species' presence, potentially confirming suspected species such as the gray bat. Data may provide for calculations of abundance, or at least as an index to abundance of the various bat species at Muscatatuck NWR and also to determine which habitats are used.

What is the population or attribute of interest, what will be measured, and when?

Occupancy and abundance of bat species will be measured using a roof mounted Anabat call logger along a 26 mile route on and adjacent to the refuge.

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Local universities, other refuges

Survey: **Water Level Monitoring** *(FF03RMSC00-011)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *8*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 57; Objective 1.6: Seep Springs Research Natural Area; Comprehensive Conservation Plan Page 51; Objective 1.2: Bottomland Hardwood Forest; Comprehensive Conservation Plan Page 54; Objective 1.4: Moist Soil Units and Emergent Marsh Units; Comprehensive Conservation Plan Survey address CCP: Goal 1 Obj. 1.2, 1.4, and 1.6 Strategy 7 and HMP: Obj. 1.2, 1.4, 1.5, 1.6, and 1.7 Justification for Selection: Why was this survey selected over others? The CCP lists water level monitoring as the most important of all monitoring or surveys. Wetland, waterfowl, and even forest management relies on properly managed water levels. Without this data it would be very difficult to ensure adequate management of the Refuge's resources. Past problems such as forest mortality, loss of productivity, among others are directly contributable to the lack of hydrologic understanding. It is the Refuge's intent to learn from past mistakes and prevent their repetition. Some of the most important successes in wetland management from 2007-2012 were achieved through careful analysis of water level data from 1982 to 2007; the data were used to determine why forest mortality occurred, to protect critical areas such as the Seep Springs Research Natural Area, and to restore productivity and increase waterfowl use within the Refuge's impoundments. The water level data will continue to provide useful insights into the future.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

Water level monitoring is one part of a three-pronged approach the Refuge uses within an adaptive management framework for moist soil and wetland management. Water level manipulations drive vegetation responses and wildlife responses. Water levels must be monitored to ensure optimum depths are achieved for waterfowl feeding, especially during peak migration. Data are used during drawdowns to inform management as the drawdown progresses. Analysis of water level, vegetation, and waterfowl data supports the adaptive management cycle. Beaver are abundant at the Refuge and they have the potential to dramatically impact forest resources. Monitoring of water levels is an efficient means for remote sensing of impediments to hydrologic flows that could have negative impacts to the forested systems and the wildlife species they support. Water level monitoring can also alert management to potential infrastructure issues such as leaking water control structures or dike breaches.

What is the population or attribute of interest, what will be measured, and when?

Water elevations are measured in feet mean sea level at each managed wetland unit and Mutton and Storm Creek ditches at each of the four bridges on CR400 and CR500. Water; Hydrology; Recurring -- every year; Weekly

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Local universities

Survey: **Wetland Vegetation Cover Survey** *(FF03RMSC00-007)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *10*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 54; Objective 1.4: Moist Soil Units and Emergent Marsh Units; Comprehensive Conservation Plan; Survey address CCP: Goal 1 Obj. 1.4 Strategy 12 and HMP: Obj. 1.4-1.11.c Justification for Selection: Why was this survey selected over others? Management of seasonally flooded impoundments primarily occurs to provide adequate supplies of annual plants as food resources for migratory waterbirds. The effectiveness of management is assessed through a three pronged approach, using water level, waterfowl, and vegetation data. The data are used to create the annual water management plan and in making recommendations for management actions. The data are used to ensure that management actions are justifiable and support adaptive management of refuge impoundments. Finally, the survey was selected due to the importance of the data, the temporal and budgetary expenditures being extremely low, and the high ranking it received in the ranking process.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

Surveying wetland vegetation is one part of a three-pronged approach the Refuge uses within an adaptive management framework for moist soil and wetland management. Water level manipulations drive vegetation responses and ultimately wildlife responses. Wildlife use, especially waterfowl use, is used to assess the success of wetland management actions. The data, when used in combination with water level and waterfowl data, can be used to monitor productivity, signal problems, and to recommend management actions such as disking, mowing, or burning to optimize conditions. The data are also used to recommend treatments of invasive species within the wetland units.

What is the population or attribute of interest, what will be measured, and when?

A rapid survey is conducted to characterize dominant vegetation and structure within seasonally flooded impoundments and marshes at the Refuge; Biological Integrity; Other Biota; Plantae (plants); Cyperaceae (sedges); Poaceae (grasses); Recurring -- every year; Fall

Is this a cooperative survey? If so, what partners are involved in the survey?

NO

Survey: **Moss Lake/GTR Tree Regeneration Survey** *(FF03RMSC00-026)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *14*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Survey address CCP: Goal 1 Obj. 1.2 Strategy BH2 and HMP: Obj. 1.2 Strategy 2b., 1.8, 1.9 Strategies 1,2, and 3. Justification for Selection: Why was this survey selected over others? Substantial changes to the hydrology of Moss Lake and GTR 1 & 2 have been made between 2007 and 2012. These changes have resulted in the dominance of more natural hydrologic regimes within the units. Tree regeneration is expected over the coming decades and that regeneration may need to be supplemented with additional seedings and/or plantings. This survey will yield valuable information for recommending such actions. The survey protocol, although yet to be developed, should allow for quick, low cost data collection that will directly influence decision making.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

The purpose of this survey is to assess the degree to which tree regeneration is occurring within the Refuge's Green Tree Reservoirs, including GTR1, GTR2, and the Moss Lake GTR. During the period of 1992-2007 these areas experienced dramatic declines in forest health, largely due to excessive flooding and active impoundment when trees were actively growing. An estimated 750 acres were impacted within the Moss lake unit, nearly 50 acres within GTR1, and 10-20 acres within GTR2. This survey will improve management by documenting the extent of regeneration within these units and the regenerating tree species abundance and composition, allowing for future management recommendations to be made.

What is the population or attribute of interest, what will be measured, and when?

This survey measures the abundance and the species composition of regeneration within Moss Lake, GTR1, and GTR2.; Recurring -- every year; Summer

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, local universities.

Survey: Spotlight Deer Survey *(FF03RMSC00-023)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *16*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 61; Objective 2.1: Monitoring; Comprehensive Conservation Plan; Survey address CCP: Goal 2 Obj. 2.1 Strategy 13 Justification for Selection: Why was this survey selected over others? Other than beaver, white-tail deer are the species that have the greatest potential to affect habitats, forest regeneration and other plant community assemblages on the refuge. It is the Refuge's desire to maintain adequate herd size for consumptive users while preventing overpopulation and the associated negative impacts to vegetative communities. Over time, this survey will provide the Refuge the information necessary to ensure such objectives are met. This survey was selected over others due to the extremely high public interest in the species for recreational purposes, the potential the species has for altering native habitats, and due to the relatively low costs made possible by the contributions made by the Refuge's partner, Franklin College.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

White-tail deer (Odocoileus virginianus) are a critical component of the Midwestern landscape where they serve as keystone herbivores, disease vectors, and an important source of recreation. Over the last couple decades, the size and demographics of herds present on Indiana natural areas have changed substantially as a result of new management strategies and infectious diseases (i.e., Epizootic Hemorrhagic Disease). Managers and members of the public are eager to understand how local sub-populations have responded to past pressures and how they will change as new ones emerge. To help meet this need, we established a long-term survey of deer numbers and demographics at Muscatatuck National Wildlife Refuge (taken from Land et. al 2012). The data will be used to make annual recommendations for the Refuge's deer hunting program.

What is the population or attribute of interest, what will be measured, and when?

Biological Integrity; Other Biota; Odocoileus virginianus (white-tailed deer); Recurring -- every year; Winter

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Franklin College

Survey: Moss Lake Fish Survey *(FF03RMSC00-024)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *18*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 61; Objective 2.1: Monitoring; Comprehensive Conservation Plan; Survey address CCP: Goal 2 Obj. 2.1 Strategy 12 Justification for Selection: Why was this survey selected over others? A total of 85 species of fish, have been documented on the Refuge and include several state listed species including the bigeye chub, northern studfish, and the eastern sand darter. The eastern sand darter is a Region 3 priority species and is imperiled through much of its historic range. Fishery surveys from 2007 documented only 54 species and survey work in 2011 only 37 species. The loss of many species may be attributable to the Moss Lake dam as it was a barrier to upstream movement of fish. At least 24 species of mollusks have been documented as occurring on the Refuge (Harmon 1996, Fisher 2007); however, only 6 species have been found north of the Moss Lake dam. It is hypothesized that restoring the Vernon Fork's connectivity to the Mutton Creek Ditch will result in restoration of some fish species throughout the ditch system and in turn result in restoration of some mussel species. This survey was selected to monitor for and document those population restorations.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

The Moss Lake dam was modified in 2012 by cutting a 300 ft. span from the western edge to allow sheetflow of flood waters (previously impounded on nearly 1,000 acres of bottomland forest), increase the discharge capacity of the nearly 67 sq. mi. watershed, to restore connectivity of the Vernon Fork to the creek systems and to restore fish and mussel populations within Mutton, Storm, and Sandy Branch Creeks. This survey was established to determine if the dam modification results in restoration of fish species within those systems.

What is the population or attribute of interest, what will be measured, and when?

Biological Integrity; Other Biota; Osteichthyes (bony fishes); Siluriformes (catfishes); Cypriniformes (suckers, minnows); Perciformes (perch-like fishes); Recurring -- every year; Summer

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Missouri Department of Conservation (Jackson, Missouri LRTM Office) and local universities.

Survey: Midwinter Eagle Survey *(FF03RMSC00-006)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *19*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 63; Objective 2.3: State T&E Species and Species of Concern; Comprehensive Conservation Plan; Survey address CCP: Goal 2 Obj. 2.3 and Goal 3 Obj. 3.6 Strategy 1 and HMP: Obj. 1.17. Justification for Selection: Why was this survey selected over others? This survey requires minimal additional effort and costs. The survey is conducted during the Refuge's weekly waterfowl survey. The survey is completed at the request of our state partner, the Indiana Dept. of Nat. Resources, and federal partner, the US Army Corps of Engineers, who coordinates the survey; the survey fulfills the requirement within the CCP to maintain existing partnerships. Also, the survey aids in the conservation and protection of State listed species.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

Data obtained from survey will not improve management at the Refuge; however, it is used to assess eagle populations at the State, Regional, and National levels. This information is used to develop and inform decisions regarding policy and management at these larger scales. The purpose of Refuge participation is to fulfill our obligations to assist our partners.

What is the population or attribute of interest, what will be measured, and when?

Direct counts of any and all eagle species within the Refuge Boundary; Biological Integrity; Other Biota; Haliaeetus leucocephalus (Bald Eagle); Recurring -- every year; Winter

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Indiana DNR and the US Army Corps of Engineers

Survey: **FWS Eastern Greater Sandhill Crane Survey** *(FF03RMSC00-010)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *21*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 63; Objective 2.3: State T&E Species and Species of Concern; Comprehensive Conservation Plan; Survey address CCP: Goal 2 Obj. 2.3 Strategy 1 and Goal 3 Obj. 3.6 Strategy 1 and HMP: Obj. 1.16 and 1.17. Justification for Selection: Why was this survey selected over others? This survey requires minimal additional effort and costs. The survey is conducted during the Refuge's weekly waterfowl survey. The survey is completed at the request of our state partner, the Indiana Dept. of Nat. Resources, and the FWS Region 3 Migratory Bird Office who coordinates the survey; the survey fulfills the requirement within the CCP to maintain existing partnerships. Also, the survey aids in the conservation and protection of a State species of special concern.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

This survey will not be used to improve management at the Refuge. It is used at the State, Regional, flyway, and National scales to analyze population trends and for establishing harvest recommendations.

What is the population or attribute of interest, what will be measured, and when?

Direct counts of Sandhill Cranes within the Refuge Boundary (Amundson and Johnson 2010); Biological Integrity; Other Biota; Grus canadensis (Sandhill Crane); Recurring -- every year; Winter

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, USFWS Migratory Bird Office and Indiana DNR

Appendix D. Survey Profiles for Surveys with Expected Status

Survey: Weekly Shorebird Survey *(FF03RMSC00-021)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *9*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 61; Objective 2.1: Monitoring; Comprehensive Conservation Plan Survey address CCP: Goal 2 Obj. 2.1 Strategy 8 Justification for Selection: Why was this survey selected over others? Each year one or more managed impoundments are manipulated for the benefit of shorebirds with minimal monitoring of shorebird use. The Refuge purpose is "…for use as an inviolate sanctuary for migratory birds", and the purpose of the Refuge's seasonally flooded impoundments and marshes are for waterbird use. The CCP mandates management for shorebirds; therefore, the Refuge should manage habitat to support shorebird use. This survey will yield data that directly answers whether the Refuge is achieving its purpose and the objectives and strategies within the CCP. The data will be used on an annual basis to assess, modify, and recommend wetland management actions.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

The Refuge impoundments are managed for three waterbird guilds, waterfowl, wading birds, and shorebirds. Effective management relies on water level and vegetation data, and manipulations of those two variables largely determine the potential for shorebird use on a given wetland unit. Shorebird surveys measure the success of management actions and also support the adaptive management feedback loop. Very little quantitative or anecdotal evidence exists for Muscatatuck NWR with regard to shorebird use and management. Data acquired through this survey will help to shape management for this guild.

What is the population or attribute of interest, what will be measured, and when?

Direct counts of all shorebird species at each managed wetland unit on the Refuge Biological Integrity; Other Biota; Aves (Birds); shorebirds; Recurring -- every year; Weekly

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Local universities

Survey: **Environmental Health Monitoring** *(FF03RMSC00-025)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *12*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 61; Objective 2.1: Monitoring; Comprehensive Conservation Plan; Survey address CCP: Goal2 Obj. 2.1 Strategy 10 Justification for Selection: Why was this survey selected over others? Species diversity is relatively high at the Refuge and with limited staff and funding it would be impossible to monitor all species to determine downward trends in their populations. Amphibians are especially sensitive to changes in their environment and their populations are declining worldwide (Houlahan et al. 2000; Wake 1991; Blaustein et al. 1994). Monitoring the health of reptile and amphibian populations at Muscatatuck NWR may help detect other environmental problems such as contaminants or impacts due to global climate change and they can be used as indicators to overall environmental health. The Refuge, as outlined in the CCP, sees environmental health monitoring as a priority means for assessing overall health of habitats and for determining impacts that may be realized from climate change.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

This survey serves the purpose of providing a means for assessing the Refuge's overall environmental health, monitoring for contaminants, and assessing impacts of global climate change. Data acquired will be used to alert Refuge staff to negative impacts from the aforementioned variables. Management decisions can be made to increase monitoring based on declines in indicator species and seek additional assistance to alleviate issues as they arise, before impacts escalate.

What is the population or attribute of interest, what will be measured, and when?

Biological Integrity; Other Biota; Reptilia (Reptiles); Amphibia (Amphibians); Caudata (Salamanders); Squamata (Amphisbaenians, Snakes, Lizards); Anura (Toads, Frogs); Testudines (terrapins, tortoises, Turtles); Recurring -- every year; Summer The protocol for this monitoring has yet to be determined, however, one or more herpetile species will be chosen as indicator species and monitored at strategic locations (also yet to be determined) on Refuge lands.

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, local universities

Survey: **Forest Inventory** *(FF03RMSC00-027)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *17*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Survey address CCP: Goal 1 Obj. 1 Strategy 3 and HMP: Obj. 1.1, 1.2 Strategy 9, and 1.9. Justification for Selection: Why was this survey selected over others? Historically, the Refuge was a part of the expansive, contiguous deciduous hardwood forest that covered most of the central and southern part of the state. Lindsey (1997) listed oak-hickory and beech-maple as the dominant pre-settlement forest types. Approximately 69 percent (about 5,400 acres) of the Refuge is covered by forests. Of this, about half of the Refuge, or approximately 78 percent of the forested area (about 4,180 acres), is classified as one of several types of bottomland hardwood forest. The remaining 15 percent of the forested area (approximately 1,210 acres) of the Refuge is classified as upland hardwood forest. The Refuge has made forest management a high priority considering the dominance of forested habitats. It has been 25 years since a forest inventory was conducted; it is imperative that management of such habitats be based on current, sound science and data. The forest inventory would allow the Refuge to make informed management recommendations to ensure its CCP and HMP goals and objectives are met with regard to forest habitats and the species that depend on them.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

Land use practices, invasive plant introduction, and modifications to the hydrology of the landscape over the past century have drastically altered the vegetative communities on the Refuge and led to increased fragmentation of the habitat. Studies have shown that forest fragmentation reduces nesting success of migratory birds because of increased nest predation and parasitism. Area sensitive forest bird species generally require large, contiguous blocks of forested habitat and are also negatively affected when fragmentation results in smaller contiguous acreages (Robinson et al. 1995). We anticipate allowing natural regeneration of upland hardwoods and supplementing tree diversity with plantings of species that were historically present. Certain species such as oak and hickory species may not regenerate on their own and thus supplemental plantings of these hard mast species may be necessary to progress more quickly toward the forest community desired. The CCP and HMP both called for the completion of a Forest Inventory to determine the current state of forest health and make recommendations in a step down Forest Management Plan.

What is the population or attribute of interest, what will be measured, and when?

Tree species composition, abundance/dominance, diversity, size and age class demographics will be measured across all forested habitats at the Refuge; Recurring -- every decade; Summer

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, USFWS Region 4 Foresters, Chicago Botanical Society, local universities and Indiana DNR

Survey: **Grassland Monitoring** *(FF03RMSC00-028)*
Refuge: *MUSCATATUCK NATIONAL WILDLIFE REFUGE*
Priority: *22*

Which station management objective does the survey support? Is the objective derived from the CCP, interim objectives, HMP, or other?

Page 53; Objective 1.3: Grassland; Comprehensive Conservation Plan Survey address CCP: Goal 1 Obj 1.3 Strategy 3 and HMP: Obj. 1.3 Strategy 4 and Obj. 1.8. Justification for Selection: Why was this survey selected over others? Effective management of grasslands is a priority for the Refuge and is highly dependent on understanding community dynamics. Recommendations for management actions such as mowing, burning, and/or haying will rely heavily on pre- and post-treatment monitoring to make smart decisions. Data acquired from this monitoring will be used in an adaptive management framework to adjust and modify future management.

Why is it important to conduct the survey? Describe how survey results will be used to make better informed refuge management decisions. If survey results are used to trigger a management response, identify the management response and threshold value for comparison to survey results.

The Refuge's CCP and HMP call for managing high quality diverse grasslands on approximately 470 acres. Little information is available with regard to current conditions of these grasslands, and much of the acreage was retired from the farming program in 2012. The Refuge plans to assess the current state of these grassland acres and use that information to develop a step-down Grassland Management Plan to provide habitat for Sandhill and Whooping Cranes, as well as provide limited nesting, quality resting, and high quality forage habitat for other grassland bird species. Continued monitoring will be used to make management recommendations that will ensure provision of high-quality feeding habitat for listed species (e.g., Henslow's Sparrow), waterbirds (e.g. Blue-winged teal) and other migratory birds (e.g. , Bobolink, Dickcissel, Loggerhead Shrike, Grasshopper Sparrow and Sandhill Crane), and contribute to the native biological diversity of the Refuge.

What is the population or attribute of interest, what will be measured, and when?

Biological Integrity; Other Biota; Plantae (plants); Poaceae (grasses); Recurring -- every year; Spring, Summer Although the protocol has yet to be written, a whole host of variables may be measured within the five grassland management units. These may include species composition, stem densities, percent cover, percent grasses vs. percent forbs, presence/absence, percent cover of woody vegetation, interspersion, diversity, and litter, etc.

Is this a cooperative survey? If so, what partners are involved in the survey?

YES, Local universities