Appendix J

MONITORING AND ADAPTIVE MANAGEMENT

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Monitoring and Adaptive Management Appendix J

1. Introduction

The 1985 Supplemental Appropriations Act (Public Law 99-88) and Section 1103 of the Water Resources Development Act of 1986 (Public Law 99-662) authorized implementation of ecosystem restoration projects to ensure the coordinated development and improvement of the Upper Mississippi River System. Section 2039 of WRDA 2007 requires that when conducting a feasibility study for ecosystem restoration, the proposed project includes a plan for monitoring the success of the ecosystem restoration. Additionally, paragraph (3)(d) of Section 2039 states that "an adaptive management plan will be developed for ecosystem restoration projects…appropriately scoped to the scale of the project." The implementation guidance for Section 2039, in the form of a CECW-PB Memo dated 31 August 2009, also requires that an adaptive management plan be developed for all ecosystem restoration projects. Adaptive management "prescribes a process wherein management actions can be changed in response to monitored system response, so as to maximize restoration efficacy or achieve a desired ecological state" (Fischenich et al. 2012).

At the programmatic level, knowledge gained from monitoring one project can be applied to other projects. Opportunities for this type of adaptive management are common within the UMRR-EMP. Using an adaptive management approach during project planning enabled better selection of appropriate design and operating scenarios to meet the CCNWR HREP project objectives. Lessons learned in designing, constructing, and operating similar restoration projects within the UMRS have been incorporated into the planning and design of this HREP to ensure that the proposed plan represents the most effective design and operation to achieve project goals and objectives.

The adaptive management for the Clarence Cannon National Wildlife Refuge HREP describes and justifies whether adaptive management is needed in relation to the proposed project management alternatives identified in the project feasibility study. This appendix outlines how the results of the project-specific monitoring plan would be used to adaptively manage the project, including monitoring targets which demonstrate project success in meeting project objectives. The District's intent was to develop monitoring and adaptive management actions appropriate for the project's goal and objectives.

Adaptive management provides a process for making decisions in the face of uncertainty. The primary incentive for implementing an adaptive management plan is to increase the likelihood of achieving desired project outcomes given the identified uncertainties, which can include incomplete description and understanding of relevant ecosystem structure and function; imprecise relationships among project management actions and corresponding outcomes; engineering challenges in implementing project alternatives; and ambiguous management and decision-making processes. Additional uncertainties (i.e., scientific and technological) relating to the proposed project were identified by the project team which included:

- Mississippi River hydrology
- Presence and introduction of invasive species
- Measurable fish movement between the Riverside Unit and the Mississippi River habitats
- Future climate change projections (e.g., flood events, growing season lengths, ice cover, migration patterns)

2. Goals and Objectives

The primary goal of the Clarence Cannon National Wildlife Refuge (CCNWR) HREP is to restore and improve the quality and diversity of wetland ecosystem resources in the project area. Implementation of the proposed project would increase the quality and quantity of ecosystem resources and meet the life requisites for a diverse suite of native floodplain species. Degrading interior berms to establish larger management units will reduce habitat fragmentation. Constructing a setback will increase floodplain connectivity and provide spawning and rearing opportunities for a wide variety of aquatic life. Improving water level management capability would provide more wetland habitat, greater vegetation diversity, a reliable food supply to resident and migratory wetland species, and provide a better means to manage for invasive plant species. Reforestation would increase wetland habitat diversity. Restoring the historic meanders would increase aquatic habitat and improve floodplain topographic diversity. The following objectives and proposed restoration features were considered in detail to achieve the project goal:

1) *Restore native wetland plant communities (forest and non-emergent wetlands)* - Decrease habitat fragmentation between the management units to better follow historic vegetation patterns.
    a. Setback with exterior berm degrade
    b. Notch or fully degrade or partially degrade interior berms to establish larger connected management units
    c. Reforestation and wetland herbaceous plantings
2) *Improve aquatic ecosystem resources* – Increase aquatic habitat diversity and floodplain topographic diversity. Restore seasonal connectivity to the Mississippi River.
    a. Restore historic meanders
    b. Setback with exterior berm degrade
3) *Improve water drainage and delivery* – Deliver water to achieve target surface water levels in < 7 days within the management units. This would provide the project partner improved water conveyance management capability on the management unit(s) which will increase wetland plant diversity, increase invasive species management capabilities, and improve overall ecosystem resources. In addition, during large, overtopping flood events, drain the interior project area to target water levels in < 40 days which is needed to prevent ponding of floodwaters which is detrimental to wetland structure and function.
    a. Construct new larger management units and water control structures
    b. Construct new pump station

3. Performance Indicators

This monitoring and adaptive management plan was developed with input from state and federal resource agencies, as well as incorporating monitoring protocols that are provided in the *Great Rivers and Clarence Cannon National Wildlife Refuges Inventory and Monitoring Plan* (May 2013). Performance indicators to the above objectives were developed with the best available knowledge. They were developed to be specific, measurable, attainable, realistic, and timely. Current performance indicators are summarized in Table 1. The conceptual monitoring schedule and estimated costs are provided in Table 2.

Each project objective was assessed by at least one performance indicator. For each performance indicator, the rationale behind the indicator and the methodology used are discussed. In addition, the monitoring targets (also referred to as desired outcomes) and action criteria (also referred to as adaptive management triggers) are listed. The action criteria are used to determine if and when adaptive management actions should be implemented.

Table 1. Project objectives, indicators, and time before the effects of the Clarence Cannon National Wildlife Refuge HREP become apparent

Objective	Performance Indicator	Monitoring Target (Desired Outcome)	Action Criteria (AM triggers)	Time of Effect[1]	Responsible Party
Restore native wetland communities (forested and non-forested)	Species composition and quality of annual and perennial herbaceous vegetation (relative cover and frequency)	Diversity threshold = 30:70 ratio of annuals and perennials per management subunit Species Richness Threshold = ≥ 8 species per management unit Quality Threshold = importance value score of ≥ 3.5 % invasive species = maintain below 5% relative cover and frequency per management subunit	Apply adaptive management actions if any of the monitoring targets fall outside the desired thresholds	4- years post-construction	Project partner
	Survival and growth of existing and planted forest in the Riverside Unit	[a]Initial and [b]long-term survival of planted trees of at least 70%. Increased basal diameter & positive relative growth rate over time[b]	<50% survivability	[a]1 year post-planting [b]10 year post-planting	USACE
	Bird Use Days	Increasing trend over time for use of wetland habitats by migratory and resident wildlife	Lack of increasing trend	4-years post-construction	Project partner
Improve aquatic ecosystem resources	Duration & frequency of inundation of land affected by setback	Increase duration and frequency of inundated land above existing conditions in the Riverside Unit	None identified	Construction completion	Project partner
	Native fish assemblage	When Riverside Unit is inundated, an increase by ≥ 20% of native fish species	<20% native fish species	5-years post - construction	USACE
	Aquatic habitat complexity	An increase of more than 20% habitat complexity	Average depth < 2.5 feet	Construction completion	USACE
Improve water level management	Water delivery and drainage	For water delivery, management subunits should reach target water levels[2] in < 7 days After large overtopping flood event, drainage of project area < 40 days	Further identified during plans and specifications	Construction completion	Project partner
	Species diversity and quality of annual and perennial herbaceous vegetation	See above			Project partner
	Bird Use Days	See above			Project partner

[1]Full realization of results is highly dependent upon river levels in the project area post-construction; several high water events may be necessary before benefits are realized and a state of relative equilibrium is reached. Therefore, should river levels be unusually low subsequent to project construction, more time may be needed in order to fully realize anticipated results.

[2]See Table 3 for estimated annual target water gauge levels for each management subunit

Table 2. CCNWR HREP conceptual monitoring schedule and estimated monitoring costs. Construction completion is set at year 0.

Performance Indicator	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10
Plant Species Diversity*	X	Construction	X	X	X	X	X	X	X	X	X	X
Forest	x		X				X					X
Bird Use*	X		X	X	X	X	X	X	X	X	X	X
Setback			X									
Fish	X				X				X			
Habitat Complexity	X				X				X			
Water Conveyance[1]	x		X									
Performance Evaluation Report							X					X
Est. Cost ($)	$18,000		$12,000	$0	$12,000	$0	$20,000	$0	$12,000	$0	$0	$20,000
SUBTOTAL	**$94,000**											
Contingencies (15%)	**$14,100**											
TOTAL	**$108,100**											

*These data will be collected annually by the project partner as part of standard refuge management. These data are appropriate for use in assessing the success of the HREP and will be used at no additional cost to the HREP.

[1]Water drainage target contingent on large overtopping flood event

Vegetation Monitoring

1) **Objectives supported:** 1 and 3
2) **Performance Indicators:** Species composition and quality of annual and perennial herbaceous vegetation.
3) **Rationale:** This survey will be conducted to evaluate effectiveness of restoration features to reduce invasive species, specifically reed canary grass; and evaluate effectiveness of improved water level management and vegetative plantings in improving/maintaining early successional wetland habitats within the new subunits.
4) **Methodology:** As outlined in the *Great Rivers and Clarence Cannon National Wildlife Refuges Inventory and Monitoring Plan* (May 2013) and following design and methodology from Vacek et al. (2011), plant species composition and structure (relative cover and frequency) will be assessed by USFWS annually following construction. A stratified random design will be followed with sample locations being stratified according to Nelson (2005) communities. Sample units are random transects (25-m long) stratified within a management area of interest (with a minimum of 5 transects per management subunit; or at most for larger subunits a target of 1 transect per 10 acres). Each transect will have 5 quadrats (1.0 m^2), located at every 5.0 meters (0, 5, 10, 15, and 20-m). Foliar cover values will be estimated for the top 4 species (based on cover) using the modified Daubenmire (1959) cover values on a 7-point scale (0-1%; 1-5%; 5-10%; 10-25%; 25-50%; 50-75%; and 75-100% cover). Of the combined annual and perennial vegetation, an importance value (based on preferred wildlife food resource) will be calculated using the categories (none =0, low =1, medium=2, high=3) as provided in the *Integrated Waterbird Management and Monitoring Initiative (IWMM) of the Atlantic and Mississippi Flyways Monitoring Program* (http://iwmmprogram.ning.com/group/protocols.). Pre-construction data and post-construction data will be collected by site staff. Analysis will likely be limited to non-parametric techniques for comparing the means in structural parameter of interest (percent cover, frequency, and importance values). Analysis will determine the effectiveness of the restoration features.
5) **Monitoring Targets (Desired Outcomes):** With the improved water level management and restoration of native wetland communities, the targets for species composition and quality include the following:
    - **a.** Diversity Threshold = A ratio of 30:70 annuals to perennials per management subunit
    - **b.** Species Richness Threshold = Greater than 8 species per management subunit
    - **c.** Quality Threshold = Combined importance of value of top 4 dominant species greater than or equal to 3.5
    - **d.** Percent invasive species below 5% relative cover and frequency per management subunit
6) **Action Criteria (Adaptive Management triggers):** Adaptive management actions should be implemented if any of the below action criteria are triggered. Adaptive management could include, but not limited to, physical disturbance (e.g., mowing, disking, rolling, prescribed fire), chemical control, or drawdown. The exact management action implemented will be decided by the site manager.
    - **a.** Diversity Threshold outside the desired 30:70 annuals to perennials ratio
    - **b.** Species Richness Threshold: < 8 species per management subunit
    - **c.** Quality Threshold = combined importance value of top 4 dominant species less than 3.5
    - **d.** Percent invasive species above 5%

Integrated Waterbird Management and Monitoring

1) **Objectives supported:** 1 and 3

2) **Performance Indicator:** Bird Use Days
3) **Rationale:** This survey will be conducted to evaluate the effectiveness of restoration features (e.g., interior berm degrades to reduce habitat fragmentation and improved water level management) in providing suitable habitat for resident and migratory wildlife species, primarily waterbirds.
4) **Methodology:** Bird Use Days will be assessed by site staff for each management subunit during non-breeding periods. Weekly to biweekly from August-June. Bird count methods follow the excepted monitoring protocol as outlined in the *Integrated Waterbird Management and Monitoring Initiative of the Atlantic and Mississippi Flyways Monitoring Manual.*
5) **Monitoring Target (Desired Outcomes):** With the improved water level management, restoration of native wetland communities, and reduced habitat fragmentation, the target for Bird Use Days is an increasing trend over time.
6) **Action Criteria (Adaptive Management trigger):** If bird use does not have an increasing trend over time (by year 4 post-construction), coupled with not meeting thresholds listed under the vegetation monitoring indicator, then adaptive management actions should be implemented (e.g., physical disturbance, drawdown, chemical control).

Reforestation Monitoring

1) **Objectives supported:** 1
2) **Performance Indicator:** Survival and growth of existing and planted forest within the Riverside Unit
3) **Rationale:** Floodplain forest, including bottomland hardwoods, have been reduced within the project area due to historic clearing for agriculture and impacts of overtopping flood events and resulting prolonged inundation from ponding due to the exterior berm. Project features of reforestation and the setback are expected to increase quantity and quality of floodplain forest within Clarence Cannon National Wildlife Refuge.
4) **Methodology:** Forest monitoring will follow the sampling design as outlined in the *UMRR-EMP HREP Monitoring Design Handbook Section 1: Vegetation* (McCain, *In Review*). The nested fix plot design (Figure 1) will be used to establish 3 plots randomly in the existing forest of the Riverside Unit. The 0.1-acre large plot sampling method will be used to establish 3 plots randomly within the reforestation area.

   Success of planted trees will be monitored 1 year post-planting to determine basal diameter (dbh) and % seedling survivorship (tree count). To determine long-term success, periodic monitoring (every 5 years, with possible monitoring after large disturbance events) of trees planted as well as the trees in the existing forest plots will include basal diameter measurements. Differences in percent diameter increases will be used to monitor trees through time. In addition, based on Henderson et al. (2009) relative growth rate (RGR) will also be calculated to determine success/survivorship (where RGR > 0 equals positive level of production and survivorship, while RGR < 0 equals loss of production and mortality) using the following equation:

$$r = \frac{\ln(D_2) - \ln(D_1)}{t_2 - t_1}$$

   D_1 and D_2 refer to growth measurements (height or diameter) at times t_1 and t_2.

5) **Monitoring Target (Desired Outcome):** The amount of floodplain forest would increase by a total of approximately 300 acres within the Riverside Unit. Reforestation will be one of the last features completed. The monitoring target for initial and long-term monitoring is 70% survivorship of

planted trees. Additionally, a target of increasing basal diameter (positive growth rate) of tagged trees will be used as in indicator of forest health.

6) **Action Criteria (Adaptive Management triggers):** Full realization of desired outcomes is highly dependent upon flood events, deer browsing, and possible seedling competition with reed canary grass or other invasive species in the project area after construction. If the initial monitoring target of 50% survivability is not met then USACE and the project partner will re-evaluate the necessity to replant these trees. Adaptive management actions that could be taken to reduce deer browsing or competition may include, but not limited to, fencing, herbicide application, or mowing.

Riverside Unit Aquatic Monitoring

1) **Objective supported:** 2
2) **Performance Indicators:** fish species assemblage within Riverside Unit; duration and frequency of inundation; aquatic habitat complexity
3) **Rationale:** Connectivity between the floodplain and the river is vital for ecosystem processes (e.g., nutrient cycling) and for providing essential resources for fish and wildlife (e.g., spawning, rearing, and food). Disconnection eliminates the transfer of nutrients between the river and its floodplain leading to reduced resources for fish and wildlife. Project features are designed to setback the exterior berm along the Mississippi River and restore historic meanders within the Riverside Unit in order to re-connect the river to areas previously disconnected.
4) **Methodology:**
    - **a.** The fish assemblage within the historic meanders will be assessed using daytime electrofishing protocols of the Upper Mississippi River Restoration - Long Term Resource Monitoring Program. Sampling should occur when the Riverside Unit is inundated to ensure adequate depth to access these areas via boat and to document fish use of the flooded areas.
    - **b.** Duration and frequency of inundation of the reconnected floodplain area will be recorded by site staff to determine how often this area is subject to flooding from the Mississippi River and/or Bryants Creek.
    - **c.** Habitat complexity (i.e., bathymetry) of the historic meanders will be used to assess the aquatic habitat depth diversity. Depth data via the depth finder mounted on a boat will be recorded in randomized transects within each area and will occur on the same day as the fish sampling. Sampling should occur when the Riverside Unit is inundated to ensure adequate depth to access these areas via boat.
5) **Monitoring Targets (Desired Outcomes):** For each of the above indicators, the desired outcomes include:
    - **a.** Native Fish Assemblage: An increase by more than 20% of native species should be realized within 5 years of construction completion.
    - **b.** Duration and frequency of inundation: Increase in number of days the Riverside Unit is connected to the Mississippi River and/or Bryants Creek. This success criterion is highly dependent on the river hydrology and climate (i.e., drought).
    - **c.** Habitat Complexity: An increase by more than 20% of aquatic depth diversity of Riverside Unit should be realized upon construction completion.
6) **Action Criteria (Adaptive Management triggers):**
    - **a.** Native Fish Assemblage: Less than 20% of the fish assemblage comprised of native fish. Adaptive management actions would include considering altering fish sampling methods (i.e., timing, frequency, gear type) to try to better capture the fish community being able to access the project area.

b. Duration and frequency of inundation: No Adaptive Management trigger identified since this indicator is dependent on river hydrology.

c. Habitat complexity: Constructed average depth is 5 feet. If depth is lost (<2.5 feet average depth) in these channels then re-excavation should be evaluated by USACE and the project partner. Re-excavation was assumed to be needed once during the 50-year period of analysis and the cost is captured in the OMRR&R cost for the project.

Water Level Management

1) **Objective supported:** 3
2) **Performance Indicator:** Water delivery and drainage
3) **Rationale:** Currently, the water level management at CCNWR is operating at an inadequate water conveyance capacity. The existing system results in the interior of CCNWR being flooded longer than exterior surrounding areas. Floodwaters have repeatedly overtopped the exterior berm inundating the interior for extended periods resulting in expansion of invasive species, (specifically reed canary grass), forest mortality, and loss of wetland diversity. Project features are designed to improve water delivery and drainage. Hydrologic and hydraulic modeling was conducted for the proposed plan.
4) **Methodology:** Pre- and post-construction dewatering and filling times will be recorded by site staff to determine the change in water drainage and delivery efficiencies.
5) **Monitoring Target (Desired Outcome):** With the improved water delivery capacity, the management subunits should flood up to target water levels (Table 3) in < 7 days. After large flood events (i.e., 0.5% chance of exceedance), the interior of the project area should drain to target water levels in < 40 days (See Appendix D, *Hydrology and Hydraulics*). Results should be realized in the first year after construction completion.
6) **Action Criteria (Adaptive Management trigger):** Table 3 provides estimated water levels for the proposed new management units. However, more specific decision criteria would be developed during the pre-construction engineering and design phase of the project since additional topographic data may become available to further refine the target water levels. Water level management is a primary tool used by USFWS to generate the desired vegetative response. Vegetation monitoring would be a principal driver in determining what water level management the USFWS would implement for any given year.

Table 3. Estimated Annual Target Water Gauge Levels for Management Subunits. Elevation in mean sea level (MSL).

		North Unit		South Unit				
		MSU7	Northern	Southwest	Central	Eastern	Supply Pond	Big Pond
Time Frame	Early Sept	439.50	NA	439.80	439.90	NA	438.60	437.10
	Early Oct	440.00	NA	440.10	440.30	440.30	438.60	437.10
	Late Oct	440.50	NA	440.25	440.40	440.60	439.00	437.70
	Early Nov	440.60	440.70	440.35	440.65	440.85	439.60	438.00
	Late Nov	440.80	441.00	440.80	441.00	441.00	439.80	438.20
	Early Feb	441.00	441.10	441.00	441.20	441.20	440.00	438.40
	Early Mar	440.80	440.90	440.80	441.00	441.00	440.10	438.20
	Early Apr	440.60	440.55	440.25	440.65	440.75	439.80	438.00
	Late Apr	440.40	440.35	440.20	440.30	440.45	439.40	437.70
	May	439.50	439.55	439.45	439.05	438.75	438.80	437.10

4. Data Management Plan

The data management plan has been developed to support the monitoring and adaptive management plan. Data management includes the collation, storage/retrieval, analysis, summarization, and communication of monitoring results and related information used in support of adaptive management. The St. Louis District and USFWS would archive the data collected. All data collected by either party would be shared amongst parties and incorporated and summarized in the Performance Evaluation Report prepared by the Corps in years 5 and 10 post-construction. The Performance Evaluation Reports will document the status of meeting project objectives and ultimately determining project success. Additionally, forest data collected will be added to the USACE Forest Inventory, and any other appropriate final project material will be submitted to the UMRR-EMP HREP database once that database is operational.

5. References

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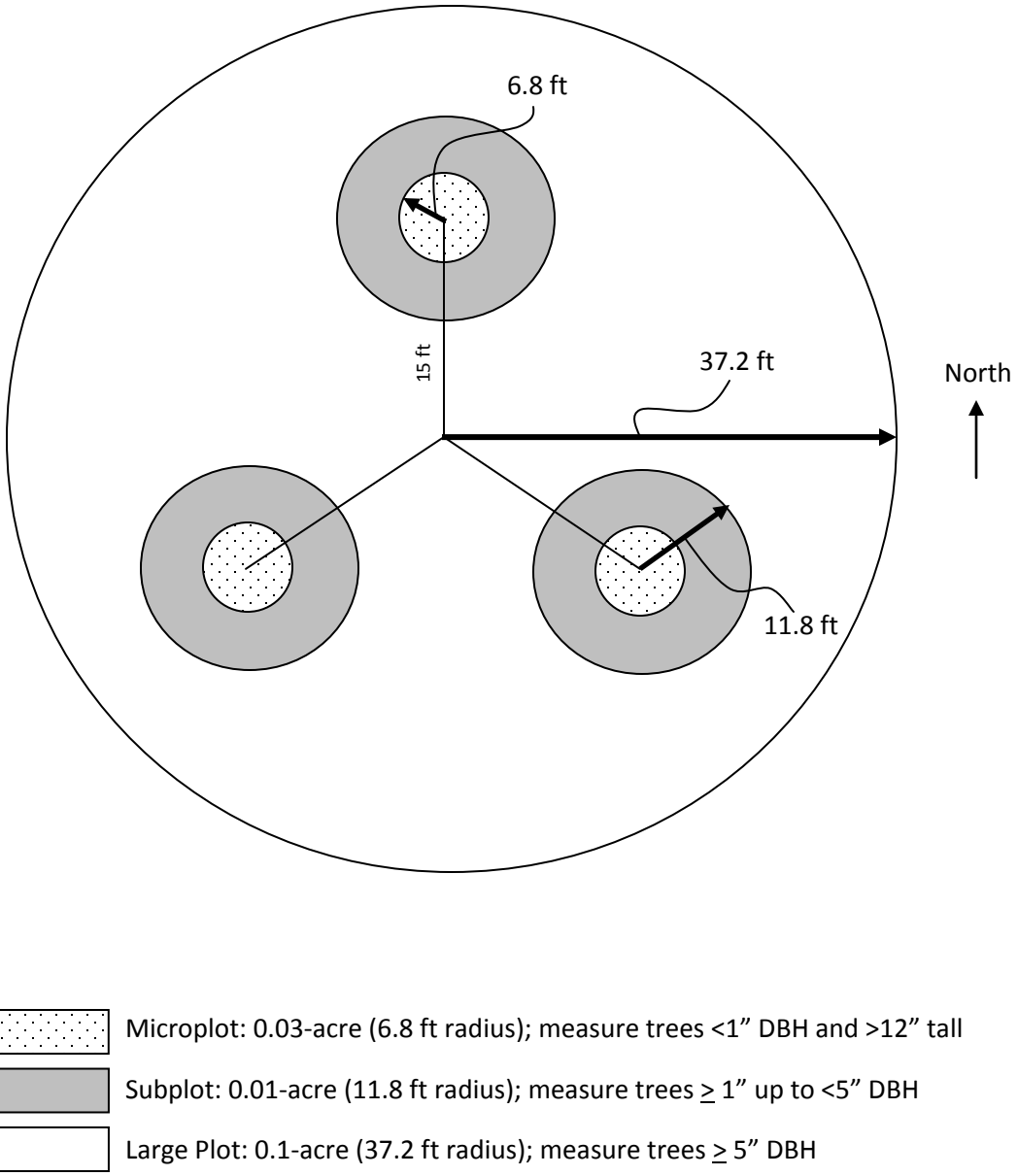
Nelson, P.W. 2005. *Terrestrial Natural Communities of Missouri*, revised edition. Missouri Natural Areas Committee. Published by Missouri Department of Natural Resources, Jefferson City, MO.

Vacek, S.M., D. Cornett, and M. Ahlerin. 2011. Grassland Monitoring Team Standardized Monitoring Protocol Version 6. USFWS. 10 May 2011.

Figure 1. Nested fixed radius design. The center of the subplots and microplots are 15 feet from the large plot center. This full monitoring protocol is applicable for the existing forested areas within the Riverside Unit. For the reforestation area, all planted trees within the 0.1-acre sampling large plot will be tagged and data recorded (species, dbh, and height).



See *UMRR-EMP HREP Monitoring Design Handbook Section 1: Vegetation* (McCain, *In Review*) for details on field data collection