Federal Assistance

Endangered Species Traditional Section 6 Grant

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May 1, 2008 – April 30, 2011

Relationship between Forest Management and Summering Indiana Bats

Missouri Department of Conservation

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WORK PLAN

I. PLANNED ACTIVITIES
Year 1: May 1, 2008-April 30, 2009

1) Determine whether Indiana bats are present on Charlie Heath Memorial CA and Fox Valley Lake CA – if not documented in an area then priority will be shifted away from that area.
    a. Hire and coordinate temporary employees for project
    b. Acquire radio transmitters for attachment to pregnant or lactating Indiana bats
    c. Conduct trapping activities using mist nets and harp traps on CHCA and FVCA
    d. Attach radio transmitters to pregnant or lactating Indiana bats
    e. Monitor activities until transmitters fail or are groomed off
2) Determine probability of patch occupancy and probability of detection for Indiana bats on Charlie Heath Memorial CA (1st priority), Fox Valley Lake CA (2nd priority), and Deer Ridge CA (3rd priority) and develop predictive occupancy and habitat use models based on roost, site and landscape covariates.
    a. Hire and coordinate temporary employees for project
    b. Acquire AnabatII detection systems
    c. Place acoustic detection equipment for 2 successful nights of passive recording of bat activity on each area (CHCA, FVCA, DRCA) according to spatial and temporal schedule
    d. Collect vegetative (prism plot) and environmental (temperature, rel. humidity, barometric pressure, etc.) at each sample point
    e. Analyze data collected
3) Map roost trees, associated flight corridors, and foraging areas for Indiana bat colonies (using triangulated positions of active bats) at Charlie Heath Memorial CA (1st priority) and Deer Ridge CA (2nd priority).
    a. Hire and coordinate temporary employees for project
    b. Conduct trapping activities using mist nets and harp traps on CHCA and DRCA and attach radio transmitters to pregnant or lactating Indiana bats
    c. Monitor foraging activities using simultaneous telemetry readings and triangulation for each bat tagged with transmitter for each of the areas
    d. Survey triangulated foraging locations via helicopter and/or aerial photography to determine associated vegetative use patterns
    e. Using GIS, determine landscape vegetative characteristics of used and non-used areas
    f. Analyze data collected
4) Attempt to identify primary roost locations at Charlie Heath Memorial CA (1st priority), Fox Valley Lake CA (2nd priority), and Deer Ridge CA (3rd priority). If found, track the activity/fate of individual maternity colonies through time by conducting aerial and primary-roost-site searches and estimate use of identified sites. Track use and suitability of identified trees over time.
    a. Hire and coordinate temporary employees for project

b. Locate roost trees by tracking tagged bats or helicopter surveys at CHCA, FVCA, and DRCA
c. Collect prism plots to document vegetative conditions of roost tree and surrounding area for each roost located
d. Using GIS, determine landscape vegetative characteristics of used roosting locations and non-used potential roosts
e. Summarize data collected

Year 2: May 1, 2009-April 30, 2010

1) Determine whether Indiana bats are present on Charlie Heath Memorial CA and Fox Valley Lake CA – if not documented in an area then priority will be shifted away from that area.
    a. NA – Objective addressed in Year 1
2) Determine probability of patch occupancy and probability of detection for Indiana bats on Charlie Heath Memorial CA (1st priority), Fox Valley Lake CA (2nd priority), and Deer Ridge CA (3rd priority) and develop predictive occupancy and habitat use models based on roost, site and landscape covariates.
    a. Hire and coordinate temporary employees for project
    b. Place acoustic detection equipment for 2 successful nights of passive recording of bat activity on each area (CHCA, FVCA, DRCA) according to spatial and temporal schedule
    c. Collect vegetative (prism plot) and environmental (temperature, rel. humidity, barometric pressure, etc.) at each sample point
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    a. Hire and coordinate temporary employees for project
    b. Acquire radio transmitters for attachment to pregnant or lactating Indiana bats
    c. Conduct trapping activities using mist nets and harp traps on CHCA and DRCA and attach radio transmitters to pregnant or lactating Indiana bats
    d. Monitor foraging activities using simultaneous telemetry readings and triangulation for each bat tagged with transmitter for each of the areas
    e. Survey triangulated foraging locations via helicopter and/or aerial photography to determine associated vegetative use patterns
    f. Using GIS, determine landscape vegetative characteristics of used and non-used areas
    g. Analyze data collected
4) Attempt to identify primary roost locations at Charlie Heath Memorial CA (1st priority), Fox Valley Lake CA (2nd priority), and Deer Ridge CA (3rd priority). If found, track the activity/fate of individual maternity colonies through time by conducting aerial and primary-roost-site searches and estimate use of identified sites. Track use and suitability of identified trees over time.
    a. Hire and coordinate temporary employees for project
    b. Conduct trapping activities including attaching radio transmitters at FVCA

c. Locate roost trees by tracking tagged bats or helicopter surveys at CHCA, FVCA, and DRCA
d. Collect prism plots to document vegetative conditions of tree and surrounding area for each roost located
e. Using GIS, determine landscape vegetative characteristics of used and non-used areas
f. Summarize data collected

Year 3: May 1, 2010-April 30, 2011

1) Determine whether Indiana bats are present on Charlie Heath Memorial CA and Fox Valley Lake CA – if not documented in an area then priority will be shifted away from that area.
    a. NA – Objective addressed in Year 1
2) Determine probability of patch occupancy and probability of detection for Indiana bats on Charlie Heath Memorial CA (1st priority), Fox Valley Lake CA (2nd priority), and Deer Ridge CA (3rd priority) and develop predictive occupancy and habitat use models based on roost, site and landscape covariates.
    a. Hire and coordinate temporary employees for project
    b. Place acoustic detection equipment for 2 successful nights of passive recording of bat activity on each area (CHCA, FVCA, DRCA) according to spatial and temporal schedule
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    a. Hire and coordinate temporary employees for project
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    a. Hire and coordinate temporary employees for project
    b. Conduct trapping activities including attaching radio transmitters at FVCA
    c. Locate roost trees by tracking tagged bats or helicopter surveys at CHCA, FVCA, and DRCA

d. Collect prism plots to document vegetative conditions of tree and surrounding area for each roost located
e. Using GIS, determine landscape vegetative characteristics of used and non-used areas
f. Summarize data collected

II. SCHEDULE

Work Schedule (Three Years):

Year 1 Schedule: May 1, 2008 through April 30, 2009

Tasks	M	J	J	A	S	O	N	D	J	F	M	A
Hire and coordinate temporary employees for project	X											
Acquire radio transmitters for attachment to pregnant or lactating Indiana bats	X											X
Conduct trapping activities using mist nets and harp traps on CHCA and FVCA to confirm presence of Indiana bats	X	X										
Attach radio transmitters to pregnant or lactating Indiana bats	X	X										
Monitor activities until transmitters fail or are groomed off	X	X	X									
Acquire AnabatII detection systems	X											
Place acoustic detection equipment for 2 successful nights of passive recording of bat activity on each area (CHCA, FVCA, DRCA) according to spatial and temporal schedule	X	X	X	X								
Collect vegetative (prism plot) and environmental (temperature, rel. humidity, barometric pressure, etc.) at each sample point		X	X	X								
Conduct trapping activities using mist nets and harp traps on CHCA and DRCA and attach radio transmitters to pregnant or lactating Indiana bats		X	X	X								
Monitor foraging activities using simultaneous telemetry readings and triangulation for each bat tagged with transmitter for each of the areas		X	X	X								
Survey triangulated foraging locations via helicopter and/or aerial photography to determine associated vegetative use patterns			X	X								
Using GIS, determine landscape vegetative				X	X	X	X	X				

characteristics of used and non-used areas												
Locate roost trees by tracking tagged bats or helicopter surveys at CHCA, FVCA, and DRCA	X	X	X	X								
Collect prism plots to document vegetative conditions of roost tree and surrounding area for each roost located		X	X	X								
Using GIS, determine landscape vegetative characteristics of used roosting locations and non-used potential roosts				X	X	X	X	X				
Data analysis					X	X	X	X	X	X		
Status report											X	X

Year 2 Schedule: May 1, 2009 through April 30, 2010

Tasks	M	J	J	A	S	O	N	D	J	F	M	A
Hire and coordinate temporary employees for project	X											
Acquire radio transmitters for attachment to pregnant or lactating Indiana bats												X
Place acoustic detection equipment for 2 successful nights of passive recording of bat activity on each area (CHCA, FVCA, DRCA) according to spatial and temporal schedule	X	X	X	X								
Collect vegetative (prism plot) and environmental (temperature, rel. humidity, barometric pressure, etc.) at each sample point		X	X	X								
Conduct trapping activities using mist nets and harp traps on CHCA and DRCA and attach radio transmitters to pregnant or lactating Indiana bats		X	X	X								
Monitor foraging activities using simultaneous telemetry readings and triangulation for each bat tagged with transmitter for each of the areas		X	X	X								
Survey triangulated foraging locations via helicopter and/or aerial photography to determine associated vegetative use patterns			X	X								
Using GIS, determine landscape vegetative characteristics of used and non-used areas				X	X	X	X	X				
Conduct trapping activities including attaching radio transmitters at FVCA	X	X	X									
Locate roost trees by tracking tagged bats or helicopter surveys at CHCA, FVCA, and	X	X	X	X								

DRCA												
Collect prism plots to document vegetative conditions of roost tree and surrounding area for each roost located		X	X	X								
Using GIS, determine landscape vegetative characteristics of used roosting locations and non-used potential roosts				X	X	X	X	X				
Data analysis					X	X	X	X	X	X		
Status report											X	X

Year 3 Schedule: May 1, 2010 through April 30, 2011

Tasks	M	J	J	A	S	O	N	D	J	F	M	A
Hire and coordinate temporary employees for project	X											
Place acoustic detection equipment for 2 successful nights of passive recording of bat activity on each area (CHCA, FVCA, DRCA) according to spatial and temporal schedule	X	X	X	X								
Collect vegetative (prism plot) and environmental (temperature, rel. humidity, barometric pressure, etc.) at each sample point		X	X	X								
Conduct trapping activities using mist nets and harp traps on CHCA and DRCA and attach radio transmitters to pregnant or lactating Indiana bats		X	X	X								
Monitor foraging activities using simultaneous telemetry readings and triangulation for each bat tagged with transmitter for each of the areas		X	X	X								
Survey triangulated foraging locations via helicopter and/or aerial photography to determine associated vegetative use patterns			X	X								
Using GIS, determine landscape vegetative characteristics of used and non-used areas				X	X	X	X	X				
Conduct trapping activities including attaching radio transmitters at FVCA	X	X	X									
Locate roost trees by tracking tagged bats or helicopter surveys at CHCA, FVCA, and DRCA	X	X	X	X								
Collect prism plots to document vegetative conditions of roost tree and surrounding area for each roost located		X	X	X								
Using GIS, determine landscape vegetative				X	X	X	X	X				

characteristics of used roosting locations and non-used potential roosts												
Data analysis					X	X	X	X	X	X		
Final report preparation										X	X	X

III. ESTIMATED COSTS

REQUESTED FUNDING	May 1, 2008 - April 30, 2009	May 1, 2009 - April 30, 2010	May 1, 2010- April 30, 2011	Total
Expense:				
Univ of MO contract	$38,290	$38,290	$38,290	$114,870
MDC Supplies	$39,600	$12,800	2,000	$54,400
Sub Total	$77,890	$51,090	40,290	$169,270
Indirect Cost (MDC expense only: 33.25%)	$13,167	$4,256	$665	$18,088
Total	**$91,057**	**$55,346**	**$40,955**	**$187,358**
***FWS share (50%)**	**$45,528**	**$27,673**	**$20,478**	**$93,679**
MDC share (50%)	**$45,529**	**$27,673**	**$20,479**	**$93,679**

*We will obligate $33,624.50 in federal 2008 ES funds now to get the project started and to take us to at least October 1, 2008. The remaining federal share will be obligated in federal years 2009 and 2010, SAF.

University of MO Contract will include labor. MDC Supplies will include radio transmitters, Anabat Ultrasonic Detectors, and field sampling supplies (head lamps, gloves, waders, etc.). Section 6 funds will reimburse MDC for research and monitoring activities. The forest management is part of ongoing, regularly scheduled forest management undertaken on conservation areas by MDC and will not be reimbursed from Section 6.

IV. ESTIMATED COSTS BY FAIMS CATEGORY

FAIMS Category: 3440 (Endangered Species Research/Habitat)

PROJECT STATEMENT

I. NEED

The Indiana bat (*Myotis sodalis*) is listed as endangered under the Endangered Species Act and despite aggressive protection of bats at their winter cave hibernacula sites, the abundance of the species has continued to decline (Clawson 2002). Habitat loss or modification from development or timber harvest at their summer forested roost sites is often cited as contributing to the decline. Worries about summer habitat quality have resulted in dramatic modification or restriction of active timber management on many public forests where Indiana bats are known to summer.

While responsible forest management is considered suited for maintaining Indiana bat summer habitat, information on the effects of forest management on bat populations is limited (USFWS 2007). Current timber management recommendations to benefit Indiana bat summer habitat focus on creating or retaining snags for roost trees and creating canopy gaps as foraging areas. Proper spatial arrangement of these habitat components is usually inferred from distances moved from capture location to roost tree and between roost trees.

Additionally, even if responsible forest management in areas inhabited by summering Indiana bats is considered acceptable (possibly beneficial) to the population, direct effects ("take") of management on individual bats is a contentious issue. Three cases have been documented in which a roost occupied by Indiana bats was felled (USFWS 2007). In all cases some bats were injured or killed, but other bats were seen exiting the felled tree and in one case adult females that survived apparently returned and retrieved non-volant young. Timpone (2004) documented Indiana bats appearing to abandon a primary roost in response to removal of selected trees within 100m of the roost tree. However, this abandonment occurred during the last summer of study so it is unknown whether bats utilized the roost in subsequent years and this was only one instance. Because of the possibility of direct harm to bats, seasonal restrictions on management activity (i.e., cutting while bats are hibernating) are often suggested (USFWS 2007).

Current work on estimating relative abundance or density is based on capture rates, detections/unit effort, or capture/recapture. Acoustic monitoring is often presented as detections per unit effort, but realistically only relays presence or non-detection information; until recently the probability of a bat being present but undetected was not included in studies (Amelon 2007).

Studies in 2001 and 2002 at Deer Ridge Conservation Area (DRCA, Figures 1 and 2), owned by MDC, used radio telemetry and ANABAT detectors to document the largest summer aggregation of Indiana bats known in Missouri (Miller 2003, Timpone 2004). In 2003, with input from Rick Clawson (Team Leader of the Federal Recovery Team), a forest management program was begun on the area. Small clear cuts, uneven aged management with small group openings, and retention of snag trees were the dominant practices. This management was designed to maintain or improve 2001-2002 levels of

Indiana bat use and habitat availability while achieving traditional forest and other wildlife objectives. Limited pilot work in summer 2007 indicated that a significant population of Indiana bats still uses DRCA, but increased use of the most recently managed areas was not documented, though bats did roost in trees that were girdled in 1997 or 1998. An evaluation of the relationship between forest management and Indiana bat summer roosts, foraging activity, or population would provide key pieces of information to assess the effect of treatments. Unfortunately, differences in methods and area coverage between the previous studies and our proposal reduce the utility of considering the previous work as pre-treatment data. Any work at DRCA would be documenting Indiana bat population trends and area use in the presence of managed forests, without being able to infer any changes from pre-management conditions.

There are two other Conservation Areas in northeastern Missouri (Clark County, Figure 1) that are excellent potential study sites for examining relationships between forest management and summering Indiana bats. Charlie Heath Memorial (CHCA, Figure 3) and Fox Valley Lake (FVCA, Figure 4) CA's both include bottomland and upland forest and appear to be very good Indiana bat summer habitat. However, while there is high potential for Indiana bats to use these sites, presence has not been confirmed. MDC has not conducted forest management on these areas since acquisition. Timber inventory has been completed on FVCA and cutting is scheduled to begin in September, 2008. This presents the opportunity to conduct work at FVCA during the summer of 2008 to determine whether and how Indiana bats are using the area. While the one year will not provide range of variation of pretreatment data, planned management may provide the opportunity to investigate direct impacts of logging on individuals or specific maternity colonies. Forest inventory and subsequent management is scheduled to begin at CHCA in 2011. This provides an opportunity to conduct 3 years pretreatment data collection (this project proposal, which address Phase 1 of the overall planned project); with the intention that post treatment studies will be completed after the harvest (Phase 2, under a separate proposal). Comparisons between pre- and post- treatment use by Indiana bats will allow strong inferences between forest management treatments and effects on use by Indiana bats on one study area.

II. OBJECTIVES

1) Determine whether Indiana bats are present on Charlie Heath Memorial CA and Fox Valley Lake CA – if not documented in an area then priority will be shifted away from that area.
2) Determine probability of patch occupancy and probability of detection for Indiana bats on Charlie Heath Memorial CA, Fox Valley Lake CA, and Deer Ridge CA and develop predictive occupancy and habitat use models based on roost, site and landscape covariates.
3) Map roost trees, associated flight corridors, and foraging areas for Indiana bat colonies (using triangulated positions of active bats) at Charlie Heath Memorial CA and Deer Ridge CA.
4) Attempt to identify primary roost locations at Charlie Heath Memorial CA, Fox Valley Lake CA, and Deer Ridge CA. If found, track the activity/fate of

individual maternity colonies through time by conducting aerial and primary-roost-site searches and estimate use of identified sites. Track use and suitability of identified trees over time.

III. EXPECTED RESULTS AND BENEFITS

The objectives outlined in this project will benefit Indiana bats by evaluating the effects of forest management on the quality of habitat and relative amount of use associated with common forest management activities. Information from this project will assist forest management decisions on both public and private land in Missouri, potentially contributing to best management practices for forest management in the presence of summering Indiana bats. Timing, spatial arrangement, and type of forest management are all important considerations in managing for Indiana bats.

To date, in the absence of credible information on the relationship between Indiana bats and forest management, the presence of Indiana bats has been used as a reason to restrict active forest management. Active forest management is proceeding in northeastern Missouri and information from this project will be useful in informing and potentially defending that management. Producing useful data from these few locations in northeastern Missouri could encourage other agencies (USFWS, other state wildlife agencies, etc.) to conduct similar research throughout the Indiana bats range.

This first phase of the larger project will produce important information regarding Indiana bat use of areas with and without recent forest management. Additionally, in conjunction with Phase 2 of the project this work will track a population of bats on an unmanaged area to provide baseline information through the active management and immediate post-harvest timeframe.

IV. PROJECT APPROACH

This will be a long-term, two phase project designed to evaluate habitat use by Indiana bat both spatially and temporally as affected by forest management. Phase 1 will be conducted from May 2008 through April 2011 (this grant) and Phase 2 will cover years 2012 through 2015. Project activities outlined in this proposal will require temporary staff to be contracted through the University of Missouri to collect data during the maternity period (May through August). Activities will be coordinated by permanent staff members of Forest Service and MDC.

Study Design

MATRIX: SITE by YEAR by TREATMENT SCHEDULE

Phase 1 – this proposal

SITE ↓	**2008**	**2009**	**2010**	**2011**
Deer Ridge (DRCA)	POST	POST	POST	Phase 1 final report and proposal of Phase 2
Fox Valley Lake (FVCA)	PRET	DURT?	POST	Phase 1 final report and proposal of Phase 2

Charlie Heath (CHCA)	PRET	PRET	PRET	Phase 1 final report and proposal of Phase 2

POST = post treatment, PRET = pre-treatment, DURT = during treatment

Phase 2 – will be proposed in 2010/2011

SITE ↓	**2011**	**2012**	**2013**	**2014**	**2015**
Deer Ridge (DRCA)	POST	POST	POST	POST	Final report
Fox Valley Lake (FVCA)	POST	POST	POST	POST	Final report
Charlie Heath (CHCA)	PRET/DURT?	DURT	POST	POST	Final report

POST = post treatment, PRET = pre-treatment, DURT = during treatment

General Description of Forest Management at Each Conservation Area

Deer Ridge Conservation Area

Forest management on areas owned by MDC is conducted on a schedule with a goal in northeast Missouri of compartment re-entry every 15-20 years. According to that schedule, forest management in 3 of 7 forest compartments was initiated on DRCA in 2003 and completed during 2008. DRCA is 6,955 acres in size. Approximately 5,400 acres are forested. Between 2003 and 2008 2,700 forested acres were impacted by forest management. A limited amount of forest management had occurred on the area prior to 2003 in association with the Riparian Ecosystem Assessment and Management (REAM) project and a private timber sale (clearcut) that took place just prior to MDC acquiring an area addition. Figure 5 shows the type and geographical arrangement of forest management that has been completed on DRCA. These prescriptions were based on the recommendations developed for the Missouri Bat Plan (Appendix 1; Clawson et al. 2006).

Fox Valley Conservation Area

FVCA is 2,159 acres in size. Approximately 1,300 acres are forested. Forest management activities on FVCA (Figure 6; this management entry will only be in the 781 acres of forest land in Compartment 1) began in winter 2007/08, including thinning of small size class trees. Commercial harvest and post-harvest slashing will begin in September 2008 with plans to complete management by April 2009. In the event of bad weather or other logistic delays, harvest activity could extend into the Indiana bat maternity period of 2009. Emphasis is given to retention and creation of snags and creation of small forest openings which is line with recommendations on managing for Indiana bats (Appendix 1; Clawson et al. 2006).

Charlie Heath Conservation Area

CHCA is 1,635 acres in size. Approximately 1,350 acres are forested. CHCA will not receive any forest management during the period covered by this proposal. Management at CHCA will occur during or after 2011 and phase 2 of this project, under a different proposal, will be conducted during that time. A description of specific forest management that will occur at CHCA will be included in the phase 2 proposal.

Specific Forest Management at Fox Valley Conservation Area in 2008 and 2009

The various forest management strategies to be implemented at FVCA are (J. Jacobson, MDC Resource Forester, pers. comm.):

Clearcuts - All woody stems in the stand are deadened (merchantable stock is commercially harvested, then left trees are felled or girdled) with the exception of retained cavity trees. Trees not taken during commercial harvest and > 6 inches diameter at breast height (DBH) are girdled and left standing, contributing to snag creation. A current emphasis in northeastern region forestry is identifying, prior to commercial harvest, trees with potential to become roosts, marking them to retain, and girdling them after harvest. Two stands of 8 and 6 acres will be clearcut.

Shelterwood - Harvests are two stage evenaged management with widely spaced overstory trees retained during the initial harvest, then harvested in during the next inventory entry, as long as advanced regeneration is well established. Remaining basal area after the initial harvest will be 15-20 ft^2 per acre. One stand of 13 acres will be managed with shelterwood harvest.

Timber Stand Improvement(TSI) - Stands to be treated are over stocked but the trees are not merchantable in size. Thin small size class trees to create a "fully stocked" stand improving forest health. ("Fully stocked" is a term from the timber production industry referring to a forest stand where trees receive plenty of light, but also have enough competition to encourage tall, straight growth to reach full timber production potential. Foresters can manipulate the combination of average tree diameter and basal area to maintain fully stocked stands. For example, if a stand with an average DBH of 7 inches and basal area of 105 ft^2 per acre is considered overstocked, thinning to average DBH of 8 inches and basal area of 90 ft^2 per acre could create a fully stocked stand.) The amount of thinning is based on conditions of each stand at the time of entry. Seven stands of 27, 20, 19, 13, 12, 11, and 10 acres will receive TSI.

Intermediate Harvest followed by TSI - Stands are over stocked with some merchantable timber and need to be thinned (by commercial harvest) to promote forest health. After harvest, thin stands down to approximately 60-70 ft^2 of basal area per acre. Five stands of 23, 16, 8, 8, and 6 acres will be managed with intermediate followed by TSI.

Unevenaged Management - Same objective as an intermediate harvest with an addition of establishing regeneration on approximately 15-20% of an area using various sized group openings. The intention on these stands for each 15 year harvest entry is to create an uneven aged forest through the group openings and do intermediate harvests to maintain

fully stocked stands. The focus of group openings will be to encourage oak regeneration in locations lacking oak advanced regeneration. Size of group openings will vary depending on aspect and size of area with signs of declining health in oaks. Radius of openings on south facing slopes will be approximately 70' (.3 acre), on east or west facing slopes 105' (.8 acres), and on north facing slopes 140' (1.4 acres). Twenty-four stands of 22, 18, 18, 18, 18, 18, 18, 17, 15, 15, 14, 13, 11, 11, 10, 10, 10, 9, 9, 7, 7, 7, 7, and 6 will receive unevenaged management.

PineThinning - Thin commercially and then conduct TSI. To protect against wind throw, thinning will be heavier in the interior of the stands. The interior of red pine stands will be thinned to approximately 140-155 ft^2 per acre of basal area. The interior of white pine stands will be thinned to approximately 135-145 ft^2 acre basal area. Four stands of 27, 24, 9, and 8 acres will be managed with pine thinning.

Woodland/Savannah Units - Stands will be thinned to 40-70 ft^2 basal area per acre, retaining mature, widely spaced trees. After harvest is complete prescribed fire will be introduced with a fire return interval of 2-5 years. Prescribed fires are carried out before leaf on, usually late March through April potentially as late as the first week of May. Three stands of 44, 28, and 21 acres will be managed as woodland/savannah.

All forest management activities will be conducted with MDC funding according to MDC guidelines (See appendix 1 for MDC guidelines for Indiana bat). Emphasis is given to retention and creation of snags, including the general guidance to retain all snags that are not a safety hazard. Occasionally, recently deceased trees with timber value are harvested, but that practice is being phased out.

Bat Captures and Handling and Radio telemetry

Beginning in May, 2008 work will begin at CHCA and FVCA in order to document whether Indiana bats are using these areas. This initial work will involve mist netting and deploying ANABAT detectors at locations that should be used by any bats that are present. Assuming that bats are found using these CA's then the more intensive study involving site occupancy and radio telemetry will begin.

Radio tracking of actively moving bats is difficult for several reasons including, limited range of radios, speed of movement, complication of getting triangulated positions, etc (Amelon et al. (In Press)). Dr. Sybill Amelon (USFS) has developed and used a tracking system utilizing stationary towers and multiple mobile units to track active bats. In past work triangulated positions have been narrowed to 2 acre polygons. Tracking of active bats will allow the linking of roost and foraging locations, better delineation of individual maternity colonies, timing of foraging bouts, etc.

Good mist netting locations will be found throughout the CA's being studied (CHCA and FVCA and possibly DRCA depending on budget). Bats will be netted, marked with bands or PIT tags and transmitters attached to female Indiana bats with a goal of having 4 to 5 active transmitters per period, hopefully with at least 5 bats marked and tracked per

area per summer. Transmittered bats will then be tracked for the attachment life (usually 10 to 14 days) both during the day to locate roost trees and at night to find forage locations, travel corridors, etc. Synchronized readings of bats are taken by all the active receivers utilizing atomic clocks and electronic compasses. After transmitters have become detached or inactive, work will move to the next CA for a trapping and tracking period. Resource selection models will be developed based on telemetry locations.

Roost Tree Mapping and Identification

Primary roost trees and maternity colonies will be identified by tracking transmittered bats to their roosts during the day. Additionally, in an effort to fully cover our study areas when identifying maternal-colony, primary-roost trees we plan to investigate whether potential roost trees can be identified with aerial surveys. We plan to conduct aerial transect surveys using MDC's helicopter to identify potential roost trees. An initial flight was conducted during fall 2007 and this method for identifying potential roosts appears high. Subsequent flights should be conducted during spring when tree leave buds are beginning to open so green leaves are evident but not obstructing the view from above (mid-April?). Transects will be defined across survey areas using GIS and loaded into a handheld GPS, these transects will be followed by the helicopter while one observer on each side searches for potential roost sites. Potential sites searched for will follow literature descriptions of "typical" primary roost trees (i.e., large DBH snags with exfoliating bark either projecting above the canopy or located at a canopy gap or edge to provide adequate solar exposure). Potential sites will be marked in a handheld GPS. Initially, flight transects will be spaced 500 m apart. At potential roost locations we will then conduct evening exit counts and ANABAT surveys to determine presence and identity of bats. We hope to be able to compare characteristics of used vs. available roost trees using trees identified in this survey. We also see potential for this survey to produce a separate index of abundance for summering Indiana bats so any trends detected by this method can be compared to those detected by the site occupancy method discussed below.

Population Modeling Utilizing Bioacoustic Monitoring

Dr. Amelon has been working to develop patch occupancy models for bats incorporating detection probabilities using ANABAT detectors. She was unable to record enough detections of Indiana bats at her Ozark study sites to model this species, but is confident that during summer 2007 pilot work in northeastern Missouri detected enough for model development. With completion of the model she would be able to monitor Indiana bat occupancy with ANABAT surveys at areas subjected to different types of forest management.

ANABAT locations will be defined by overlaying a grid on the CAs being studied. Cells will be classified as suitable or unsuitable summer habitat for Indiana bats (forest and woodland cover types will be classified as suitable while open habitats will be classified as unsuitable). Grid cells to be sampled will be randomly selected and ANABAT surveys will be conducted at appropriate locations within each grid cell. Detectors will be

calibrated to record equal detection area (Livengood 2003). A detector will record at a location for two consecutive nights then moved to the next location in a random rotation, this pattern will continue throughout the period when trapping and radio tracking are being conducted on the area. An estimated fifty grid cells will be sampled per CA per year.

Analysis

We will use maximum likelihood to simultaneously estimate both probability of detection and probability of site occupancy based on *a priori* hypotheses of factors influencing each. Occupancy estimation will be evaluated from both acoustic and capture data. Additionally, we will use resource selection functions to evaluate habitat selection by Indiana bats based on locations determined by radio-telemetry. We will determine resource selection by individual animals tagged from the population.

V. LOCATION

This project will be conducted on 3 conservation areas (land owned and managed by the Missouri Department of Conservation) in northeastern Missouri (Figure 1). Deer Ridge Conservation Area (Figure 2) consists of 3 land parcels covering 7,057 acres located in Lewis County. Charlie Heath Memorial Conservation Area (Figure 3) is 1 land parcel covering 1648 acres in Clark County. Fox Valley Lake Conservation Area (Figure 4), also located in Clark County, covers 2143 acres in 3 land parcels.

VI. PROJECT PARTICIPANTS

This work will be in coordination with MDC Wildlife and Resource Science Division; USDA Forest Service, Northern Research Station and private landowners.

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Appendix I

The Indiana Bat: How to Manage Missouri Forests for an Endangered Species

Need

The Indiana Bat is a federally listed Endangered Species found throughout much of the eastern U.S. Range wide, Indiana Bat populations have declined about 60% since surveys began in the 1960s. In Missouri, Indiana Bat populations have declined more than 80% since 1983. Known causes of decline include disturbance and vandalism during hibernation, as well as harmful alterations of hibernation caves (improper gates and microclimate changes). Many of the caves in which Indiana Bats hibernate have been protected, but populations have continued to decline despite these efforts. Other, suspected causes of decline include chemical contamination, conversion of large expanses of native vegetation to agriculture, and forest fragmentation. Studies are underway to better understand Indiana Bat ecology and the reasons for the drastic population declines. While we may not yet have all the answers to our questions, the information we have learned about roosting and foraging habitat can be applied and well may enhance the survival of the Indiana Bat during the non-hibernation seasons of the year.

In Missouri, Indiana Bats hibernate in caves in the Ozarks. Evidence suggests that most females migrate north for the spring and summer, where they form maternity colonies of up to 100 bats. Male Indiana Bats may roost singly or in small groups during summer; some males may be found with females in maternity colony areas, although others remain near their hibernation caves. Indiana Bats consistently return to their colony areas and individual roosts each year.

During summer, Indiana Bats can be found in a wide range of habitats. Although summer needs are not yet fully understood, some forest is necessary. Forest cover can vary from 5% to 100%; ideal may be 30-60% in the maternity range. In reality, most of Missouri may be potential summer habitat for Indiana Bats, with north Missouri regarded as core maternity range and south Missouri occupied by male bats, although density of maternity colonies may occur there, as well.

A recovery plan is being drafted for the USFWS. This plan contains information and recommendations that can be used by land managers to protect and enhance Indiana Bat habitat on public and private land. An understanding of elements of this plan can also help staff avoid inadvertently becoming involved with the “takings” regulations of the Endangered Species Act. (Takings under the Act may occur when someone kills, harms, or harasses an endangered species.)

Groups that oppose forest management have used the Indiana Bat as a lever to alter and even halt some forest management activities on National Forest lands in Illinois, Kentucky, Indiana, and Missouri. Despite the controversy surrounding this species, with

proper awareness and planning, forest managers can avoid harming Indiana Bat populations and even enhance Indiana Bat habitat on public and private land.

The information provided below is excerpted from the recovery plan and provided here in synopsis form. For additional information or a copy of the recovery plan (after it is finalized), please contact Peggy Horner, Endangered Species Coordinator or Rick Clawson, Resource Scientist.

Some Specifics about Habitat

Roost Trees

- Indiana Bats, whether in maternity colonies or roosting singly, primarily roost under the loose bark of dead trees (see Figures 24-27 for examples.) Crevices and cavities also are used, but to a much lesser extent. Some live trees (almost always shagbark hickory) also may be used as roosts, but in far fewer numbers than dead trees.
- The physical structure (dead tree/loose bark) is more important than the species of tree.
- Large trees (>20" dbh) are used preferentially as roost trees, especially by maternity colonies, but smaller trees, even some <10" dbh, may be used by individuals and small groups of bats.
- Indiana Bats roost in standing trees; none have been found in down trees.
- In north Missouri, Indiana Bats roost throughout the landscape, from the riparian corridor all the way up the slope to the uplands.
- In the Ozarks, Indiana Bats probably tend to roost in snags on upper slopes and ridge tops.
- Indiana Bats use multiple roosts (up to 17 roost trees have been found for one colony) throughout a summer season. A maternity colony will have at least one primary roost (dead tree, large [>20” dbh,] in the open) and a number of secondary roosts (dead tree or live hickory, usually large, in the open or surrounded by canopy).
- For most roosts, sunlight striking the bark where the bats are roosting is important. As a result, most roosts are found in the open, at forest edges, or high in a tree. During periods of rain or high temperatures, however, Indiana Bats may roost in trees surrounded by canopy, or in living, shaggy-barked hickories.
- Roost trees are ephemeral (the bark sloughs off or they rot and fall down); therefore, a continuing supply is needed.
- Indiana Bats commonly move from roost to roost of their own volition, as well as in response to environmental factors (rain and high temperatures) and loss of a roost site.
- Disturbance (timber harvest, red-cockaded woodpecker management [including fire,] high grading, even hog lots) has been shown to create roost trees.

Food Habits and Foraging Habitat

- Indiana Bats forage on flying insects. They tend to forage among and adjacent to tree canopies. The insects that they eat will reflect what is available where they

forage, i.e., in riparian areas both aquatic and terrestrial prey will be taken; in uplands, terrestrial insects, especially moths, will predominate.

- In north Missouri, Indiana Bats forage preferentially in riparian and floodplain forest, but also may use upland forest, edges, old fields, and ponds.
- In south Missouri, Indiana Bats primarily forage in upland and ridge top forest.

Management Recommendations:

Statewide Forest Management

The following recommendations are designed to provide Indiana Bat roosting and foraging habitat on state-managed forest lands throughout Missouri:

Either even-aged management (EAM) or uneven-aged management (UAM) may be used to manage the forest; both may be used to create Indiana Bat habitat. Within a management compartment, manage to preserve or create a diversity of age and size classes, with mature and over-mature trees well represented. These latter trees, as they die and become snags, will provide a continuing supply of potential roost sites for Indiana bats.

Manage forested acres for optimum numbers of snags using the following chart. Favor oaks, hickories, and ashes for retention or snag creation where choices are possible. (Cavity trees may be used only to a limited extent for roosting by Indiana Bats, but are often used by other species. Snags are emphasized in these guidelines, but cavity trees should be included in the leave tree component of a stand: one cavity tree per acre, if available.) During harvest, leave snags wherever found except where a safety hazard or in a salvage harvest; retain some in groups with live trees to prevent wind-throw.

	Number of Snags per Acre		
Forest Type	**>19” dbh**	**10”-19” dbh**	**<10” dbh**
Heavily Forested	0.5	4	2
Open/Semi-Open	1	4	2
Riparian Corridor	1	7	4
Bottomland Hardwood	1	4	2

Woodland: Manage woodlands on appropriate sites to perpetuate hardwoods or a mixture of hardwoods and pine. The openness of the canopy (20-80%,) low amount of understory, and herbaceous composition of the ground flora should be a highly beneficial for most of the bats of Missouri, including the Indiana Bat.

Bottomland forest: Manage to perpetuate hardwoods with a diversity of tree species and age classes. Use small clear cuts or UAM (group or single tree selection) to create a mixture of mature and over-mature trees in groups within stands, as well as small

openings in the canopy. The goal is to develop patchiness, vertical height diversity, and dead/dying trees and snags to provide roosts and foraging habitat for bats.

Riparian Corridors: Manage to perpetuate a diversity of tree species and age classes. Maintain a forested buffer strip on each side of perennial streams; 100 ft has been adopted as a minimum width, but wider is better if the topography and hydrology are suitable. Reforestation should occur on lands lacking minimum forest corridors. Maintain a minimum of 10 contiguous acres of old growth surrounding caves and springs.

Salvage Cuts: If the bark is still tight, salvaging dead and dying trees due to decline or disease is not a threat to the Indiana bat. Trees that have fallen to the ground may be salvaged regardless of bark conditions.

Additional Forest Management Considerations South of the Missouri River

In regions with large areas of contiguous, mature canopy, forest management practices that open the canopy and reduce understory may enhance Indiana bat roosting and foraging habitat. Reducing the canopy from a solid, 100% coverage into the range of <80% but >30% would create openings and edges where snags would receive sunlight, thus improving them for roosting. Reduced canopy also would create foraging habitat, because Indiana bats preferentially forage around and adjacent to tree crowns. Reducing the understory would make snags more accessible by removing obstacles to flight, allow sunlight to strike the trunks of the snags, and allow the bats to forage beneath the tree canopy. Savanna and woodland management may supply some or all of these conditions and should be applied on appropriate sites within the landscape.

Provide water sources (ponds, ephemeral pools, seasonal depressions, road ruts) to enhance Indiana bat habitat. Site them along ridge tops, approximately $^{1}/_{2}$ mile apart.

Target upper slopes and ridge tops for snag retention and development.

Designate old growth around Indiana Bat hibernation caves. Twenty acres is recommended, but incorporate topography, watershed, etc. considerations into the old growth design, size, and configuration to protect the integrity of the cave system. In addition, manage the site to provide corridors of tree canopy from the cave to foraging areas.

Within 5 miles of known Priority 1 and Priority 2 hibernation caves (see Table 4):
1) Designate a minimum of 10% of forest in each comparatment as old growth.
2) Inventory forest conditions, including number of snags and cavities, every 15 or fewer years. Attempt to inventory at near uniform intervals around a given cave (e. g., if there were 5 forested compartments around a cave, inventory and treat one every three years rather than doing all during a single year).

3) Maintain or create a balanced age-size class distribution through EAM or UAM methods.
4) Retain or create the recommended number of snags in any treated stand: In a clear cut, TSI, or intermediate cut, retain or create the recommended number of snags per acre. Do not treat leave stands or old growth; these will provide snags in the future.
5) In seed tree or shelterwood cuts, defer harvest of residual trees for one or more extra entry periods to provide foraging habitat.
6) Protect the integrity of cave recharge areas and sinkholes (see Karst Land Management, page 26).

Campgrounds and River Accesses - Small Scale Projects

The open canopy, savanna-type forest structure in and around many MDC campgrounds and access areas may be prime habitat for Indiana Bats in both north and south Missouri. Given our policy of removing dead trees for safety purposes, special consideration should be given to the possibility of encountering Indiana bats, especially maternal roost sites in North Missouri. The best way to make sure that Indiana bats are not roosting in a tree when it is removed is to cut trees during the winter months when Indiana bats are hibernating in caves, between 1 October and 31 March. If tree removal becomes necessary outside the above time frame, potential roost trees should be examined carefully to ensure that no Indiana bats are using a tree as a roost when it is cut. For specific guidance, contact Rick Clawson or Peggy Horner.