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**Determining Mitigation Needs for NiSource Natural Gas
Transmission Facilities - Implementation of the Multi-Species
Habitat Conservation Plan (MSHCP)**

Final Report

**Section 6 Cooperative Endangered Species Conservation Fund Grant
(IDFW Tasks 1 & 2)**

**Prepared by The Conservation Fund
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FINAL REPORT

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EXECUTIVE SUMMARY

MSHCP and Section 6 Project Overview

NiSource Inc. (NiSource), a Fortune 500 natural gas transmission and storage company, operates a 15,414 linear mile network of natural gas pipelines covering over 6.4 million acres through 14 states. NiSource pipelines extend from the Gulf of Mexico to New York and from the Atlantic coast to the Great Lakes (see map). The company annually delivers nearly a trillion cubic feet of gas to nearly four million customers.



In compliance with Federal law, NiSource has traditionally conducted numerous biological consultations annually on federally listed threatened or endangered species that might be affected by routine pipeline construction, operations and maintenance. This permit-by-permit, year-by-year approach, in addition to being costly and time-consuming for the company and the US Fish and Wildlife Service (USFWS), is also ineffective at addressing the habitat protection needs of the affected species.

In an effort to enhance this process and generate better conservation outcomes, NiSource and USFWS embarked upon a multiple species habitat conservation plan (MSHCP) that, when completed, would allow NiSource to operate under a single, consolidated permit for the next 50 years covering 44 federally listed threatened and endangered species, and under the plan, NiSource would fund mitigation projects that satisfy its compensatory mitigation requirements.

As a complementary effort to the MSHCP, the 14 affected states received an Endangered Species Act Section 6 Cooperative Grant to design a consistent and effective mitigation approach across the NiSource system. The states enlisted the assistance of The Conservation Fund (the Fund) to develop a decision support framework that helped find the best locations for mitigation that meet the requirements of the MSHCP. In partnership with the states, NiSource, and USFWS, the Fund has mapped a green infrastructure network, identified potential mitigation opportunities, and designed decision support tools that will ensure implementation of strategic mitigation for the MSHCP.

Why Green Infrastructure?

Green Infrastructure is technically defined as “a strategically planned and managed network of natural lands, working landscapes, and other open spaces that conserve ecosystem values and functions and provide associated benefits to human populations” (Benedict, McMahon 2006). Green Infrastructure is a well established planning method that recognizes that limited resources are available to identify and protect the lands most suitable for conservation, and that competing interests, needs and opportunities must be evaluated to develop the most efficient and effective land conservation strategies. The green infrastructure approach has been utilized by numerous states and local communities within the NiSource service area (Weber, Wolf & Sloan, 2006; The Conservation Fund 2010).

Green Infrastructure offers a conceptual approach for identifying mitigation opportunities at an ecosystem level. The Fund’s green infrastructure network prepared for this particular project extends well beyond NiSource’s 15,414 mile network to encompass the adjacent counties, ecoregions, and watershed units within the 14-state area. Utilizing a green infrastructure approach provides NiSource, USFWS and the states a robust planning method to integrate species habitat mitigation within the context of an interconnected network of lands and waters, providing multiple benefits across the entire range of NiSource’s natural gas pipeline transmission activities. Such an approach will also ensure that a consistent methodology is used to determine selection of mitigation. The methodology employed in this process was accepted by the 14 participating states. The green infrastructure network was not used to determine how much mitigation should occur in response to a take, but rather, will be used to guide the types and locations for such mitigation opportunities at an ecosystem level.

What is Green Infrastructure?

Green Infrastructure is based on the well-established principles of landscape ecology and conservation biology (Forman and Godron, 1986; Ehrlich and Mooney, 1983). The network consists of core areas, corridors, and hubs that provide essential habitat to endangered and threatened species and that link to broader natural functions and processes at the ecosystem scale.

Core areas contain well-functioning natural ecosystems, and provide high-quality habitat for native plants and animals that meet a minimum size threshold based on landscape conditions (see diagram). These are the nucleus of the green infrastructure network.



Corridors are linear features that link core areas in order to allow animal and plant propagule movement between them with the goal of creating viable and persistent metapopulations. The landscape between core areas is assessed for its linkage potential, and conduits and barriers to wildlife and seed movement are identified.

Corridor umbrella species can include reptiles, amphibians, fish, and mammals, depending on the type of linkage.

Hubs are aggregations of core areas, other habitat, and other natural land, divided by major roads or gaps that meet a minimum size threshold based on landscape conditions. Hubs are intended to be large enough to support populations of native species, serve as sources for emigration into the surrounding landscape, and link to areas outside the extent of the analysis area for a particular project.

Umbrella and keystone species native to an area are used to determine size, connectivity, and other thresholds in the green infrastructure network design. Umbrella species are a species or group of species, such as forest interior dwelling birds, whose habitat needs overlap those of other animals and plants. Keystone species are those with an important role in ecosystem function, such as pollinators and top carnivores. Habitat preferences of umbrella and keystone species help identify core areas and hubs. Connectivity requirements of less vagile (i.e. mobile) species (e.g., amphibians and small mammals) are used to model corridors. When sufficient habitat is protected to sustain umbrella and keystone species,

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other important components and microhabitats will be encompassed and are more likely to be protected as well.

The Fund collaborated with the states to identify umbrella and keystone species as well as establish appropriate criteria and thresholds for the green infrastructure network. The resulting network design protocol was used to guide the Geographic Information System (GIS) network design modeling.

Green Infrastructure Network Design Elements

The Fund collaborated with the states on the selection of core habitats for the 14-state area. For this project, forests, wetlands, and aquatic systems were selected given the landscape characteristics of the area. Cave and karst systems also were analyzed, but mostly were addressed through species modeling work completed for the Indiana Bat (*Myotis sodalis*) and Madison Cave Isopod (*Antrouana lira*). Mapping these core habitats helped visualize an interconnected network of forests, wetlands, and aquatic systems where mitigation projects could be strategically implemented to meet the requirements of the MSHCP while simultaneously advancing other conservation objectives.

Core Forests are contiguous areas of relatively undisturbed, mature forest with a minimum size threshold based on landscape conditions. For a current green infrastructure project ongoing in Maryland, core forest areas had to include forest blocks with at least 100 hectares of mature interior deciduous or mixed forest habitat that provided habitat for a majority of forest interior dwelling birds in the study area.

Core Wetlands are contiguous natural areas with relatively undisturbed wetlands that meet a minimum size threshold based on landscape conditions. For a recent green infrastructure project in Delaware, core wetland areas had to be at least 10 hectares in size and include habitat for umbrella species dependent upon riparian forest (Louisiana waterthrush, wood turtle), forested wetlands (Prothonotary warbler), wetland-forest complexes (amphibians, turtles), and/or marsh (Least bittern).

Core Aquatic Systems contain a threshold amount of relatively unimpaired streams based on landscape conditions plus associated riparian forest and wetlands. Umbrella species for aquatic systems often include fish, mussels, and benthic macroinvertebrates. For a recent green infrastructure project in Delaware, core aquatic systems had to contain at least a kilometer of streams with minimal impacts from channelization, dams, and road culverts.

These core areas were combined with corridor and hub areas to create a characterized green infrastructure network map that shows the overlap of the core habitats. Core areas are not mutually exclusive. In fact, the overlap of core areas demonstrates locations where protection of natural systems will likely benefit numerous species that may be dependent on multiple landscape types throughout their life cycle.

Identifying Potential Mitigation Opportunities

Each take species has a set of project selection criteria used to help evaluate and rank potential mitigation projects. At the beginning of the project, over 75 species were reviewed for possible inclusion within the MSHCP. In consultation with USFWS, the number of take species covered by the

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MSHCP was narrowed down to 9 species, with many covered species being taken off the take list as a result of avoidance and minimization measures outlined in the MSHCP.

The Fund generated a list of mitigation project selection criteria for each take species (known as a ‘decision tree’) based upon analysis within the MSHCP. Potential mitigation projects meeting specific requirements will need to be identified over the 50-year timeframe of the MSHCP’s Incidental Take Permit.

Each decision tree evaluates to what extent a potential mitigation project meets the particular take species habitat mitigation requirements (including habitat quality, location, likely protection in perpetuity, and protection of other listed species) as well as how it supports the green infrastructure network design, advances state and regional planning goals, and leverages other financial and partnership resources.

<u>NiSource MSHCP Take Species Requiring Mitigation</u>
Bog Turtle
Clubshell
Fanshell
Indiana Bat
James Spiny mussel
Madison Cave Isopod
Nashville Crayfish
Northern Riffleshell
Sheepnose

Each criterion spans a range of characteristics from most to least suitable in terms of meeting species mitigation requirements. Where each project falls within this range is represented numerically on a standard scale from 0-100 that represents how well it satisfies that particular criteria (100 being the highest). In addition to the value for each criterion, weights are assigned relative to other criteria within its ‘branch of the tree’, since some factors are more important than others in evaluating a potential project. In addition, criteria have a ‘logic structure’ that designates them as mandatory, sufficient, or desired based on their contribution to species protection. The criterion values, weights, and logic structure have been assigned through scientifically rigorous techniques in consultation with species and decision support experts from USFWS, the states, and the Fund.

These decision trees were designed using a state-of-the-art method known as ‘logic scoring of preference’ (LSP) to ensure that all criteria and weightings are designed to reflect fundamental properties of human reasoning and ensure that the benefits calculated accurately reflect the desired intent of decision makers (Dujmović, 2007).

To help make the mitigation program as efficient as possible, the Fund included an optimization tool to help decision makers evaluate both conservation benefits and financial costs of mitigation projects. Optimization is a branch of economics and operations research studies that in recent years has shown land conservation managers how to get more land conserved under their budgets or achieve the same level of environmental benefits from land conservation projects with a smaller budget (Amundsen, Allen and Messer, 2009; Kaiser and Messer, 2010).

Decision Tools

In order for NiSource and USFWS to implement the MSHCP over time, the Fund developed a series of decision support tools that facilitate the ranking and evaluation of potential mitigation projects.

- GIS Map Document: A customized ESRI ArcGIS™ map document (.mxd) that includes key GIS layers for decision support for desktop use.
- Decision Tree Software: A desktop and web-based application for the development and modification of species decision trees and associated mitigation projects.

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- Optimization Software: An Excel™ based application that allows users to identify an optimal set of mitigation projects within a fixed budget and/or to explore the relative cost effectiveness of potential projects.

Next Steps

Because the Federal Register notice and potential issuance of an Incidental Take Permit will take place outside the contract period for the Section 6 grant, the Fund has provided a set of tools that anticipates that elements of the MSHCP will be adjusted over time. In the short term, the Fund will host a webinar for USFWS and state agencies on the green infrastructure network and to provide an orientation to participants on the material covered within mitigation site reports in 2011. The Fund may be requested by NiSource, USFWS or state agencies to provide additional training and/or modify the decision support tools over time. These adjustments to decision support tools fit naturally within the course of a planning cycle.

DETAILED TASK SUMMARY

Task 1: Development of a Process to Identify Potential Mitigation Sites

In 2005, NiSource, a natural gas distribution company, approached the U.S. Fish and Wildlife Service (USFWS) to explore the feasibility of developing a multi-species, multi-state habitat conservation plan. NiSource operates a 15,414 mile pipeline network that passes through 14 states. Each year in the course of routine pipeline and gas field operation and maintenance, NiSource undertakes over 90 consultations with USFWS regarding potential impacts to 75 rare and endangered species. Both NiSource and USFWS were interested in streamlining the Endangered Species Act (ESA) consultation procedures as well as securing a more holistic approach to conservation of listed species and protection of their habitat.

To encourage the proactive protection of listed species and their habitat, Congress adopted Section 10 of the ESA in 1983 that authorizes states, local governments and private landowners to apply for an Incidental Take Permit for activities that may harm listed species. As a first step, applicants must submit a Habitat Conservation Plan (HCP) that addresses how they will minimize the impact upon listed species, as well as an approach to mitigation for the impact on the listed species. A HCP can be focused on one species or multiple species (MSHCP), and can vary in the scale of a study area from an acre to more than 9.3 million acres in the case of the West Mojave Plan in California. USFWS has approved over 430 HCPs with many more in the planning stages.

Starting in late 2006, NiSource contacted the affected states about the proposed MSHCP initiative and held in-person meetings with state agency staff from April 2007 to July 2007. During multi-state calls between the state agencies, USFWS and NiSource, it became clear that a system-wide approach to mitigation was needed as part of the MSHCP.

USFWS, NiSource, and the participating states asked The Conservation Fund (the Fund) to support the MSHCP by developing a green infrastructure network as a decision tool to identify potential mitigation sites. Green infrastructure offers a conceptual approach for identifying mitigation opportunities at an ecosystem level. Specifically, green infrastructure is technically defined as, “Strategically planned and managed networks of natural lands, working landscapes, and other open spaces that conserve ecosystem values and functions and provide associated benefits to human populations.” In early discussions, the Fund proposed that the green infrastructure network extend beyond NiSource’s pipeline network to encompass the adjacent counties, ecoregions and watershed units within the 14-state area. By using a green infrastructure approach, NiSource and state agencies can integrate species habitat mitigation within the context of an interconnected network of lands and waters, providing multiple benefits across the entire range of NiSource’s natural gas pipeline transmission activities. In addition, this approach will also ensure that a consistent methodology is used to determine the selection of mitigation sites across the 14-state region encompassing in many cases the species full range. This was the first application of a green infrastructure network approach as part of a MSHCP.

To support this innovative approach to mitigation, eight states joined together on behalf of 14 partner states and applied for a Section 6 Endangered Species Act grant from USFWS. In March 2008, USFWS

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announced that \$3,007,270 would be awarded to the States of Indiana, Kentucky, Louisiana, New Jersey, Ohio, Tennessee and Virginia for some or all of the following tasks: (1) review of the draft MSHCP, (2) review of the draft EIS, (3) coordination of and participation in focus group sessions, and (4) coordination of and participation in mitigation site report meetings. The Indiana Department of Natural Resources administered the grant with the Fund as a subcontractor coordinating the efforts of the states and designing the green infrastructure network. The other states covered by the NiSource MSHCP – Mississippi, New York, Maryland, Delaware, West Virginia, North Carolina, and Pennsylvania – chose not to participate in the Section 6 grant process for several reasons but did commit to participate in the NiSource MSHCP. Funding, however, was budgeted to support all 14 states and/or contractors on an as-needed basis to complete ecological field assessments and surveys, validate the green infrastructure network design and assist in the identification, evaluation, and ranking of potential mitigation sites. Over time it became clear that the amount of pipeline in North Carolina was minimal and the list of species covered by the MSHCP did not warrant a green infrastructure approach. The formal study area for the green infrastructure network was reduced to 13 states, with North Carolina involved on a consultation basis.

As a first step in the planning process, the Fund hosted a three-day briefing in late March 2008 for state agencies' officials, federal agencies and The Nature Conservancy staff on the overall NiSource project. Over 60 stakeholders were invited and 35 representatives were able to attend the sessions. Participants received an overview of the MSHCP planning process. Presentations were made by key NiSource and USFWS officials with time for questions to be addressed. As part of the briefing, participants designed a hypothetical green infrastructure network for Frederick County, Maryland. This interactive training format allowed state officials to gain experience with the design process of a green infrastructure network, and based on that experience, anticipate additional information and data needs for the network analysis, ask questions based on their experience and to get familiar with the project team. The insight gained by state officials during this training period helped facilitate a smooth, informed and interactive planning process.

The effective start date of the Section 6 grant-funded portion of NiSource MSHCP project was June 1, 2008. The activities to prepare the states and USFWS staff to this point were funded by NiSource.

Subtask 1.1 – Data Inventory and Quality Assessment

Data Discovery

At the commencement of the project, the Fund requested available information previously compiled by ENSR and AMEC, as part of the development of the MSHCP. Any data not subjected to a license agreement restricting its secondary distribution (e.g. state natural heritage element occurrence data) was provided to the Fund via an external hard drive or via a password-protected FTP site. The Fund was required to undertake a separate data request to the state heritage programs for information on rare and endangered species due to the license agreements that prohibited secondary distribution. The requests to the state heritage program by the Fund had several advantages such as: (1) ensuring the Fund had the latest version of the data, (2) requesting data for areas outside the NiSource covered lands, and (3) requesting a broader list of species that the Fund needed to complete the green infrastructure network design. For the most part, the states complied with the Fund's data requests. The

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species data was initially used to prepare species range maps for the state focus group sessions and was used in the design and characterization of the green infrastructure network.

After gathering GIS layers from the state natural resource management agencies, ENSR, AMEC, The Nature Conservancy, and other conservation organizations, a Data Inventory and Quality Assessment (DIQA) report was compiled. The purpose of this assessment was to document the availability and applicability of mapping data and related information to complete the green infrastructure network design. The report described the Fund's approach to obtaining this GIS information and summarized the attributes of the GIS data layers including availability of metadata, project system, source, scale, resolution, data collection date, geographic extent and format. Another section was the 'Data Gap' summary that highlighted completeness issues with some of data layers provided by ENSR. This file helped target future collection of data over the course of the project. Finally, the 'Protected Lands by State' summarized available GIS data for different types of managed lands. Each state was summarized and one spreadsheet of nationwide data was created.

To supplement the State Natural Heritage data, the Fund downloaded the species summaries available on the NatureServe website. These were helpful summaries, particularly before the draft sections of MSHCP Conservation Frameworks were available for review.

Focus Groups

In July 2008, the Fund contacted state agency staff to confirm the designation of an official state point of contact for the project and to organize focus group meetings for the fall of 2008. The purpose of this first round of focus groups with states was to introduce states to green infrastructure, and more importantly, to obtain targeted information to assist with establishing criteria and threshold parameters for the network designs. As several states would be combined to hold a joint meeting, a total of 12 focus group meetings were proposed. The expectations of the roles and responsibilities between the state points of contact and the Fund were outlined in a contact letter. States were provided with three alternative dates for hosting the focus group meetings. The state points of contact were responsible for the logistics of selecting the meeting locations and making sure that appropriate state staff and other stakeholders such as the local chapter of The Nature Conservancy were invited. Clear, proactive communication with state officials was seen as a high priority to ensure that the focus group meetings would be well attended by appropriate staff and produce the highest quality feedback for the project team.

To make the focus group meetings as productive as possible, the Fund prepared an extensive information packet for participants that included: an agenda, frequently asked questions, a fact sheet on the Habitat Conservation Plan, background information on NiSource and green infrastructure planning method, and a species matrix. By providing as much information as possible, the Fund hoped to encourage rigorous participation and optimize the use of the limited meeting time to focus on substantive issues and questions raised by stakeholders. The state point of contact was responsible for distributing the information packets to appropriate staff and stakeholders.

Between October and December 2008, the Fund completed 12 focus group meetings (WV Oct 9, OH Oct 15, VA Oct 22, IN Oct 22, KY Oct 23, MS Oct 24, LA Oct 29, PA Nov 3, TN Nov 6, NY Nov 7, NJ Nov 13, MD/DE Nov 15). Over 116 state agency staff and other stakeholders participated in the focus group meetings providing valuable information. As participants had received an extensive information packet

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prior to the meeting, many attendees were well prepared with comments. To make sure that participants had their basic questions addressed, the focus group sessions began with an overview of the NiSource MSHCP and the purpose of the meeting.

Following a short presentation on the green infrastructure design method, the Fund staff distributed a six-page feedback form to solicit information on current species distribution, current research and fieldwork, and species that were no longer present within the state. Participants were also asked for comments on focal species, criteria and thresholds for core areas for forest, wetlands, aquatics, and karst landscape types. Similar questions were listed for feedback on assumptions for the delineation of wildlife corridors. Participants were asked to comment on the extent of the proposed study area for the green infrastructure network. The feedback forms were designed to obtain precise information that would be delivered in a useful manner to the Fund design team and reduce the possibilities of misunderstandings. Facilitators carefully guided participants through each section of the feedback forms to make sure that terms were understood and the concepts were well illustrated and to pause for any questions. Participants made extensive comments on all aspects of the green infrastructure effort.

Next, participants were asked to review a GIS data quality assessment report and a bibliography of state planning documents. Participants were asked to add missing GIS layers or planning documents that were in development so that these products could be incorporated into the NiSource planning effort.

The final part of the focus group meetings involved an exercise in which participants provided locations of potential mitigation opportunities and restoration projects. To help participants, hard copy maps were provided displaying the regional species distribution of NiSource affected species. Participants used sticky dots on a state map to approximate the location of potential mitigation opportunities. The Fund staff digitized the hard copy dot maps from each of the 12 focus group meetings. As a result of the dot exercise, 345 opportunity areas were highlighted with dots on the maps in 13 states (nothing in NC). Of this total, 190 opportunity areas were located within the NiSource covered lands counties and 16 were within the NiSource covered lands. A total of 155 opportunities fell outside the NiSource covered lands counties.

The significance of the opportunities located outside of the NiSource covered lands is that these points demonstrate the underlying logic of the statewide scale green infrastructure network. One of the central goals of the green infrastructure network for the NiSource MSHCP is to help decision makers identify the best locations for mitigation for affected species, regardless of the proximity to the impact area. The opportunity point exercise was a quick method to engage state officials in conversation about their priorities and translating those priorities into a visual format where broad patterns within a state and at a multi-state scale could be observed for the take species. States were asked if they would potentially support mitigation projects that crossed states' lines from both a biological perspective and a political perspective.

The Fund transcribed and analyzed the input provided at the state focus group meetings. During this period, the Fund staff continued to contact individual focus group participants to obtain additional GIS layers, scientific literature, or clarification of comments made on the input forms.

On February 3, 2009, the Fund sent a follow-up note to the state points of contact, updating staff officials on the activities since the focus group meetings. A general project time line was provided to state officials on the expected delivery of the green infrastructure protocol. The protocol document

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defines scales, establishes criteria and thresholds, identifies keystone/umbrella species, and outlines green infrastructure network elements (e.g. core forests, core wetlands, core aquatic systems, core cave/karst systems, hubs, corridors). The update note also highlighted the sequencing of the MSHCP release and the green infrastructure protocol. As the draft MSHCP is the fundamental document from which the state officials address the NiSource project, it was critical for state officials to have the opportunity to review the draft MSHCP prior to examining the draft green infrastructure network protocol. Due to the complexity and scale of the NiSource draft MSHCP, the exact release date was adjusted several times in the spring of 2009.

In light of the adjusted release date of the draft MSHCP to the states, the Fund sent another update on April 23, 2009, to the state points of contact, outlining the schedule changes. Again, state officials were briefed on the role and content of the green infrastructure network protocol. In response to enquiries from state officials from the Commonwealth of Virginia and general concerns over the pending summer field schedule, the Fund proposed in the April update notice a release of preliminary draft green infrastructure network protocol in mid-May 2009.

Subtask 1.2 – Green Infrastructure Network Design Protocol

Protocol Methods

On May 12, 2009, the Fund sent the state points of contact a sample or preliminary draft protocol for review and comment. The Fund received comments from state officials from Indiana and Virginia on the preliminary draft green infrastructure protocol. Based on feedback from focus group meetings from the spring and the review of the preliminary draft green infrastructure network protocol, the Fund staff created a comprehensive draft protocol, also known as a Network Design Package, for each state.

The Network Design Package explained in detail how the green infrastructure network would be created, how it may be adjusted to fit particular state needs, how it interfaces with other state programs, and how it will relate to the upcoming task of identifying and characterizing potential mitigation opportunities for the NiSource MSHCP. The network design methods included approaches that will be standardized across the study area and those that will be state-specific. The draft protocol features: (1) a comprehensive bibliography of relevant planning documents for each state, (2) tailored information for each state on how the GI network relates to current state planning initiatives, including the State Wildlife Action Plan, and (3) a preview of the upcoming mitigation site report and decision support framework task.

The heart of the Network Design Package was the network methods section that described, in an outline form and with a series of spreadsheets, the steps in designing core areas, hubs and corridors for each state. To create the outline, the Fund staff conducted an extensive literature review of all NiSource take species as well as focal species for each ecosystem and landscape feature. In addition, the Fund researched the species recommended as focal species by state officials from the earlier state meetings in 2008. By March 2009, a master species spreadsheet was created highlighting over 314 animal species and their home ranges, minimum preserve size, dispersal distance, separation distance for suitable habitat, separation distance for unsuitable habitat, descriptions of dispersal barriers and dispersal conduits and whether the species was a prime candidate to serve as either an indicator or keystone species. A similar worksheet was created for nine plant species as well. Species determined to be

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appropriate focal species were analyzed further in worksheets summarizing habitat needs and thresholds for core areas, hubs and corridors. These spreadsheets provide invaluable information for state agencies, as they have great use beyond the NiSource Green Infrastructure Network. As state agencies attempt to update their Wildlife Action Plan or address the impact of climate change, the focal species spreadsheets provide a great starting point for additional modeling and planning work.

In addition, within the Network Methods section was a summary of GIS models that would be used including maximum entropy (Maxent – Dudik, Phillips, and Schapire, 2008), functional connectivity (FunConn - Theobald, Norman, and Sherburne, 2006), and least cost path. Maxent is a machine learning technique that can be used to predict the geographic distribution of animal or plant species or other entities of interest (Phillips, Anderson, and Schapire, 2006). Maxent compares a set of samples from a distribution over a defined space, such as recorded locations of a particular species, to a set of features, such as relevant environmental variables, over that same space. The FunConn modeling toolbox for ArcGIS™ provides a spatial context for wildlife species, using graph theory approaches to define functional habitat patches and landscape connectivity. Included in the report was a trial run of a Maxent model and FunConn model of the Indiana Bat (*Myotis sodalis*) for the Upper Wabash River Watershed in Indiana.

On July 2, 2009, the Fund sent the first draft protocol document to the state of Indiana. Throughout July, each state point of contact received the tailored Network Design Protocol for review.

Review of State Plans

One of the first research items was the review of all relevant state plans and regional plans for 13 states. This massive research task was viewed as a crucial step for several reasons. First, in many states, significant landscape conservation planning efforts and regional planning efforts had been undertaken. In these situations, the Fund wanted to assess the utility of the existing statewide landscape scale plans and determine how the green infrastructure network proposed would add value to state planning efforts. Second, state natural resource plans provided an excellent orientation to a region's history, patterns of development, policy-making frameworks, and leverage funding opportunities.

Finally, and most importantly, the content analysis of plans focused on how the green infrastructure network could help fulfill state planning goals. Many state planning initiatives articulated the need for a state level network of natural lands to be outlined, or how such a network would provide ecosystem services to their region. Connecting the value of the green infrastructure network to each state's unique priorities was seen as a highly effective way to help state officials appreciate the green infrastructure network's utility in assisting their organizations' success. The Fund strongly encourages that the green infrastructure network be used by state natural resource agencies as well as by other conservation partners for conservation planning well beyond the mitigation planning for the NiSource project. In fact, parts of the green infrastructure network have been used in two regional planning efforts, "Greening the Crossroads" in central Indiana and "Nashville: *Naturally*" – the open space plan for the City of Nashville and Davidson County. These regional applications of the green infrastructure network speak to the power of its design and its utility in achieving broad public goals and benefits outside of the NiSource project.

The state plan research task was divided into two separate enterprises based on content. One research effort was directed at creating detailed species summaries using each state's Wildlife Action Plan.

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Congress required each state to create a Wildlife Action Plan in order to receive federal funds. The goal of the State Wildlife Action Plan was to articulate a strategy to protect and conserve habitats and associated wildlife at a landscape scale. Congress gave each state the option of organizing its strategy by using a species-by-species approach or a habitat-based approach. States targeted their planning efforts on species of greatest conservation need (SGCN), based on the most current published list of federally endangered, threatened or candidate species and a state's list of endangered species and species of special concern. For each State Wildlife Action Plan, the species with take calculations within the MSHCP were reviewed. For each species the following information was summarized: protection status, location and habitat needs, conservation issues and action to conserve and protect the species or manage its long-term restoration. This summary document of each state's Wildlife Action Plan was used as a reference by the project team at many points during the planning process.

Wildlife Action Plans were encouraged to have spatially explicit prioritization maps, however, few states were able to achieve this level of prioritization or felt comfortable with the level of scientific understanding of particular species to create such maps. With the green infrastructure network, each state will be provided a series of network maps composed of core areas, hubs and corridors that are derived from native focal species. The green infrastructure network provides the states with a science-based, ecologically-oriented framework connecting many of the goals of their Wildlife Action Plan to a landscape scale network. The methods used in creating the green infrastructure network are similar to the species based modeling and extrapolation process used in the Wildlife Action. The focus of the green infrastructure network at the landscape level fulfills a need identified for landscape level analysis of wildlife habitat as called for in many of the Wildlife Action Plans across the 13-state study area for the NiSource Project.

The second part of the state plan research task was to review all other state or regional government sponsored conservation plans. Over 500 plans were reviewed for relevant data and for state and regional planning goals that could be achieved with the green infrastructure network.

Delaware and Maryland have completed statewide green infrastructure networks, and New Jersey and Virginia have completed statewide land conservation prioritization planning processes with major green infrastructure components. These statewide planning initiatives were assessed not only for their policy goals and recommendations, but also for GIS layers to use in building the green infrastructure network. In meetings with state officials, the option of using current state landscape conservation networks either fully or in part was discussed. After much consultation with state officials it was decided that the Fund would produce one green infrastructure network for the entire 13-state area, using the same methodology so that all mitigation opportunities would be evaluated using the same network.

In order to receive federal funds from the Land and Water account, each state must have a Statewide Comprehensive Outdoor Recreation Plan (SCORP). SCORP plans document the outdoor recreation needs and strategies to fulfill those needs; however, they are also required to summarize the state's approach to wetland conservation. A green infrastructure network can frequently provide recreation opportunities and co-location for such items as hiking trails, greenways, bike paths, cross country skiing, horseback riding and opportunities for bird watching. Wetlands systems are major components of a green infrastructure network, thus an understanding of state strategies to stem wetland loss is important. From the 13 states, 12 SCORP plans were reviewed, including a draft plan from West Virginia. In addition to SCORP, six states had statewide greenways plans and trail plans. These plans focused on

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illustrating statewide networks of both existing and planned trails based on identified resources and public input.

Another statewide plan, and precursor to the State Wildlife Action Plans, is the state GAP analysis. GAP analysis, an effort led by the United States Geological Service and contracted to state agencies or state universities, documents the “gap” between protected lands and species in need of protection. GAP plans are highly technical and provide excellent information on species distribution, the status of protected lands and the management of those protected lands. Of the 13 states, 12 GAP plans were collected and reviewed. The first GAP analysis focused mainly on the needs of terrestrial species. After completion of the GAP analysis, several states such as New York, Ohio and West Virginia launched an Aquatic GAP analysis to examine these resources in more detail. Other states did a more limited small watershed approach using GAP analysis.

States that have coast lines along the Atlantic Ocean or the Great Lakes may complete a Coastal Estuarine Land Conservation Plan (CELCP). CELCP provides an assessment of priority land conservation needs and targets conservation within priority areas for coastal communities. The CELCP program run by the National Oceanic and Atmospheric Administration provides state and local governments with matching funds to purchase significant coastal and estuarine land and conservation easements from willing sellers. Seven of the 13 states had completed CELCP plans which were reviewed.

Forest resources are addressed specifically by several different state planning documents. First, many states completed a state forestry management plan addressing the use and management of state forests. There is wide variability in the focus of these plans. Some have acreage goals for acquisition of new state forests while others are highly focused on key management concerns such as invasive species or on forest products production levels supported by state forests. Six statewide forest management plans were reviewed. The federal Forest Legacy program provides funding for the purchase of conservation easements within designated Forest Legacy areas. The initial step in planning the Forest Legacy areas is completion of a statewide Forest Legacy Needs Assessment. Twelve states had conducted Forest Needs Assessments and had designated Forest Legacy areas. Since one of the goals of the decision tools generated for the NiSource project is to help increase the leverage of funding for undertaking significant projects, examining the location of Forest Legacy areas within the green infrastructure network was important.

Seven states completed statewide wetland plans to identify crucial wetland systems and outline the threats to wetlands and the pace of wetland conversion. While several of these plans are older documents, many wetland complexes identified remain intact, and the policy recommendations to protect these resources still have merit.

Finally, many planning initiatives were unique to one state and closely related in theme or spirit to the intent of the green infrastructure network. For example, the Commonwealth of Pennsylvania completed a comprehensive water plan to help decision makers understand both water quality and quantity issues. In New York, a plan for the conservation of grassland birds was developed with targeted focus areas to direct grant funds. Louisiana has a collection of planning documents related to the restoration of coastal wetlands and environmental restoration following Hurricane Katrina. INShape Indiana was a statewide public health initiative to encourage residents to adopt more active and healthy lifestyles – including physical exercise outdoors.

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In the review of planning documents, the issue of the scale of the planning efforts was addressed. Large multi-state efforts were examined as well as regional state sponsored planning efforts. Examples of multi-state planning efforts include The State of Chesapeake Bay's Forests, the Partners in Flight effort to conserve land birds, the Conservation Strategy/Habitat Work Group by Eastern Brook Trout Joint Venture and the Ohio River Valley Ecosystem Mollusk Conservation Plan. A concerted effort was also made to collect and review regional state sponsored plans within counties or watersheds crossed by the NiSource pipeline. For example, watershed plans developed to direct Clean Water Act funds under section 319 were examined on the Internet. In Pennsylvania, a wide variety of planning documents was available including regional greenway networks, coldwater heritage plans, river conservation plans and county heritage inventories. The high level of information available in Pennsylvania was staggering. Often these regional planning efforts qualify a county or watershed for state or federal funds for implementation. Leveraging local, state and federal dollars will be crucial to help maximize the mitigation efforts supported by NiSource. It is believed that the green infrastructure network can provide a framework at the county and regional scale to help future planning efforts.

Subtask 1.3 – Green Infrastructure Network Design

GIS Modeling

The process for modeling the 13-state green infrastructure network was complex and lengthy. Many details of the modeling processes and assumptions are covered in the Green Infrastructure Network Protocol document generated and tailored for each state. The following narrative highlights major steps within the overall project timeline.

The Fund organized a webinar on September 9, 2009 to help state officials review the draft Network Design Protocol report. The intended audience was state technical staff, such as biologists, familiar with green infrastructure and/or the HCP take species and potential focal species for the network design. Included in the invitation for the webinar was a question and answer fact sheet on the MSHCP and other issues. The webinar drew an audience of 25 staff composed of nine states' representatives, as well as a representative from the US Forest Service and several staff from USFWS and the Fund.

By mid October 2009, the Fund had received comments on the Network Design Protocol from state officials from Tennessee, Virginia, New Jersey and Indiana. Most state agency comments focused on additional sources of species information, new GIS layers or additional planning studies to be reviewed.

Starting in the spring of 2010, the Fund staff identified core areas, hubs and corridors of the green infrastructure network. Staff divided the landscape into forest, wetland and aquatic systems, and identified core areas and corridors in each system.

The wetland core areas were completed in May 2010, and associated wetland corridors were delineated in August 2010. Staff relied on the National Land Cover Database's wetland classes, as this was the only data consistently available across all 13 states. Based on peer-reviewed literature on habitat needs of focal species, wetlands that were greater than or equal to 370 acres (150 hectares) were selected as core wetland areas. Wetland connectors were manually identified using National Hydrographic Data (NHD) in three NHD regions (2, 5, and 6). Staff added the stream valleys and riparian cover along these connector streams to identify wetland corridors.

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Modeling work on the forest core areas began in March 2010 and was completed in September 2010 for the 13-state study area. The Fund used the “National Green Infrastructure Assessment” developed by the United States Environmental Protection Agency (EPA). This assessment uses a morphological spatial pattern analysis (MSPA) to identify hubs and links. The Fund used the assessment GIS layer on forest cores as a foundation, building upon this work and extending its usefulness. To provide an ecological context for the analysis, the Fund extracted forest cores from the National GI Assessment using ecoregions as a template. The Fund examined many different ecoregions across the 13-state area. The largest ecoregion within the network was the Interior Plateau, covering 43,033 square miles, and the smallest ecoregion was the Mississippi River Alluvial Plain, which covers 1,029 square miles.

Next, the Fund examined the peer-reviewed literature on focal species, and with feedback from state officials, created a matrix of focal species with acreage thresholds matched to both state boundaries and ecoregions. By using ecoregion boundaries, the Fund was able to cross reference each ecoregion to a suite of focal species and consequentially to a size threshold needed to sustain a viable population of those species. These thresholds indicate the minimal forest acreage that can accommodate the needs of many forest-dependent species. A caveat on the interpretation of focal species thresholds is that this method is an attempt to broadly characterize a landscape and does not mean that these species actually occupy these forest core areas. Focal species thresholds are board indicators, providing general clues as to ecoregion habitat quality and viability. The Fund was unable to obtain sufficient focal species location data to perform Maxent modeling, but the core focal species and habitat associations were part of the network design goals.

Several examples of the use of focal species thresholds may help illustrate the value of the effort. For the Western Allegheny Plateau, the fourth largest ecoregion covering 31,445 square miles, the Fund selected a suite of five bird species with a minimum acreage threshold of between 24 to 37 acres to outline core areas for scrub and early successional forests. Several ecoregions shared focal species. A suite of 16 birds, including the Scarlet Tanager, Oven Bird and Kentucky Warbler, was used to characterize mature broadleaf forests across eight ecoregions. Patches selected were above 247 acres (100 hectares), and optimal forest block size was 9,889 acres (4,000 hectares). The Fund provided “value added” to the EPA National GI Assessment, enhancing its overall quality by incorporating species thresholds to select the suitable forest core areas.

In September 2010, the Fund began utilizing a least cost path model to identify optimal connections between core forest areas, preferring intervening forest and avoiding urban areas and roads. Due to the large 13-state study area and complexity of the model, more than two months was required to identify least cost paths to connect core forest. As least cost path models provide simple linear connection between core areas, additional time was required to provide buffers for these linear features to a proper size to serve as wildlife corridors. Forest corridors were at least 656 feet (200 meters) wide, based on interior forest bird requirements and a study that showed that corridors greater than 656 feet (200 meters) wide generally had less than 10% exotic invasive plants. A width of 984 feet (300 meters) was preferable.

Aquatic core areas were completed in August 2010 with stream corridors outlined in September. Staff ran four different iterations of core streams, adjusting the methodology each time to improve model output. The Fund identified catchments containing freshwater mussels, which are generally sensitive to flow stability and water quality. Staff added brook trout streams with a Population Integrity score of 10

or greater, using Trout Unlimited's Conservation Success Index. In addition, state specific priority layers were used such as Kentucky's Priority Watersheds for Conservation of Imperiled Fishes and Mussels, Tennessee's Aquatic Priority Habitat, New Jersey's mussel streams from its Landscape 3.0 planning process, native brook trout streams in West Virginia, and catchments containing viable populations of Nashville Crayfish (*Orconectes shoupi*). The Fund discarded catchments with less than 5% impervious cover. This threshold captured 99% of the freshwater mussel occurrences in the Ohio River drainage. Stream segments with acid mine drainage, impoundments, channelized, or classified as intermittent streams, were also removed. Finally, core streams had to run at least 6.2 miles (10km) with suitable conditions, as described above.

Concurrent to the analysis on core areas, the Fund modeled hubs for the overall green infrastructure network. Hubs are large contiguous blocks of land that contain core areas. Hubs are intended to be large enough to support populations of native species, and serve as sources for emigration by species into the surrounding landscape, as well as providing other ecosystem services like clean air, water, and recreation opportunities. Frequently, hubs include working lands such as commercial timberlands and farmlands, and require a collaborative approach to conservation success. As hubs provide a protective buffer around core areas, a critical step in creating the hubs was buffering the core forest, wetland and stream areas to include edge transitions and protection from disturbances and pollution.

Next, staff added modeled Indiana bat summer habitat, Indiana bat hibernacula plus a 10-mile buffer, modeled mussel stream reaches plus a 328-foot buffer (100 meters), modeled Nashville Crayfish reaches plus a 328-foot buffer, modeled Madison cave isopod (*Antrolana lira*) habitat in Virginia, known Madison cave isopod locations in West Virginia, and occupied Louisiana black bear (*Ursus americanus luteolus*) habitat. The Fund also added rare species and community occurrences from state Natural Heritage Programs and applied a 328-foot buffer to these locations. Staff also included state priority areas like Large Forest Tracts (>1,000 acres) in Kentucky (although these would also be included in core forest), NY Natural Heritage Important Areas, NY Important Bird Areas, Ohio caves, TN Natural Areas, and TN Very High or High Priority aquatic, terrestrial, and subterranean habitat.

The Fund modeled occurrences of mature broadleaf forest for part of the study area. In the eastern United States, mature hardwood forest provides habitat for many species of native flora and fauna, but is much less common now than historically. We performed pilot modeling in Charles County, Maryland, where we compared fine-scale geographic data available locally to coarse-scale data available nationally. As expected, a model constructed with the best locally available data, including LiDAR-derived canopy height and fine-scale soil maps, outperformed a model constructed with nationally consistent data. However, the model using national data nevertheless accurately identified most mature hardwood forest sites and excluded most young forest. We then applied the coarse-scale approach to four states: Pennsylvania, Ohio, Kentucky, and Tennessee. Average test AUC (area under the receiver operating curve) based on 10 replicates varied from 0.76 to 0.80 when comparing mature hardwood forest locations to general forest locations. The maximum training or test sensitivity plus specificity threshold, depending on the state, captured 78-79% of positive locations while rejecting 74-81% of negative locations, and covered 5-9% of the states.

Next, staff removed developed and barren land, along with major roads. Finally, staff removed tendrils and small patches less than 247 acres (100 hectares). The final hubs were then compared to state-specific analogues in Delaware and Maryland to assess the modeling accuracy. Because the NiSource hubs utilized GIS layers common to the entire 13-state study area, there were not as many hubs as the

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state specific green infrastructure plans had highlighted since those smaller scale plans utilized more detailed data and in-depth analyses. However, as the size of the hubs increased, there was a greater level of agreement between state level plans and the NiSource green infrastructure network on hubs, confirming integrity and accuracy of the analysis.

In late September 2010, the Fund planning team met in North Carolina to integrate the last state agency comments into the decision trees. At this time, the process for characterizing the green Infrastructure network was discussed. As green infrastructure networks are vast, additional analysis often is needed to prioritize areas within the network, so that the high quality or most vulnerable resources are conserved first. The green infrastructure network is a collection of many different parts, and the network characterization focuses on prioritizing the areas of the network that serve the greatest number of different benefits. For example, a network section that was a core aquatic area, served as a corridor and was part of a hub would be a higher priority than would a section that was just a hub. The network characterization results were included in the decision trees to help decision makers compare the value of projects within the green infrastructure network.

Fieldwork on Indiana Bat

One of the key parts of the planning process was the coordination of additional fieldwork for take species under the MSHCP. State officials were consulted throughout the planning process on their field activities, plans for future fieldwork, and gaps in field data on MSHCP take species. The Fund coordinated extensive fieldwork for the Indiana Bat and the Madison Cave Isopod over the summer of 2009.

The summer distribution of the Indiana Bat was one of the major data gaps identified by both state officials and US FWS staff that the Fund team strived to close. TCF hired Environmental Solutions & Innovations Inc. (ESI) and worked closely with Dr. Dale Sparks and Dr. Virgil Brack of ESI to gather information on the summer distribution of the Indiana Bat throughout its range within the NiSource states. Based on previous studies of the Indiana Bat summer roosting period, ESI deployed recording devices known as AnaBat detectors between May 23 and September 1, 2009. AnaBat detectors record bat calls as they travel among potential roosting and foraging habitats. This study used such detectors (including models AnaBat II and SD1). These AnaBat detectors were selected because they have been widely used, their data can be easily stored on flash cards, an extensive call library exists, and regulatory authorities better understand their limits.

Fieldwork and the locations of AnaBat monitors were selected at three scales. First, biologists from ESI, USFWS, and TCF examined capture records of Indiana bats from across the range and selected potential gaps within the summer distribution. This level of selection relied primarily on data contained in the most recent draft of the revised USFWS 2007 Indiana Bat Recovery Plan that provided county-scale presence/absence records, and was supplemented by ESI's in-house database that included specific capture sites. Once target counties were selected, aerial photography and vegetation maps of selected counties were examined in order to locate 1) mature forest where the bats may roost, and 2) flight corridors where bats commuting to and from roosting areas would be most easily detected. It is important to note that in highly fragmented habitats such as those of western Tennessee and Kentucky, the emphasis was on locating potential roosting areas, whereas in landscapes dominated by forests (e.g., Appalachia) the emphasis was on locating potential commuting corridors. Potential sampling

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locations were distributed throughout targeted counties in an effort to increase the probability of detecting Indiana bats.

The final scale of habitat selection was targeting the actual location of the AnaBat detectors in the vicinity of a sampling site. Ultimate decisions about bat detector locations required balancing a variety of factors. The single most limiting factors were property access and permission from landowners. Preferred sites were those with limited acoustic clutter and maximal bat traffic. Field crews accessed sites for AnaBat detectors using the following criteria: 1) adjacency to riparian corridors running through open landscapes; 2) adjacency to fencerows through open habitats; 3) within utility corridors; 4) water sources including ponds, lakes, and open stretches of rivers; 5) canopy gaps within forests; and 6) along other open linear corridors, including logging trails. ESI conducted 642 nights of AnaBat sampling in eight states. They processed the data first by filtering out background noise, then by using a filter provided by the USFWS–Kentucky Field Office that analyzed individual bat calls and isolated calls made by Indiana bats. Finally, staff attempted to identify all bat species present by examining visual depictions of the call sequences.

Of the 88,902 calls identified to particular bat species, 3,951 represented species currently listed as endangered (3,073 Indiana bat calls, 877 gray bat (*Myotis grisescens*) calls, and a single Virginia big-eared bat (*Corynorhinus townsendii virginianus*) call). Calls made by Indiana bats were detected in all eight states and were distributed as follows: 3 sites in Kentucky, 3 sites in Maryland, 5 sites in New York, 17 sites in Ohio, 27 sites in Pennsylvania, 2 sites in Tennessee, 6 sites in Virginia, and 6 sites in West Virginia. In October 2010, ESI submitted a draft final report for review by USFWS and the Fund. By working collaboratively with state officials and USFWS, the Fund expanded the knowledge base on summer distribution of the Indiana Bat through the Section 6 grant. The additional information was used in habitat modeling efforts for the Indiana bat.

Fieldwork on Madison Cave Isopod

As a result of conference calls (among the Fund, NiSource and USFWS representatives) in May 2009 regarding data needs to assess the impact of NiSource activities covered within the MSHCP on Madison Cave Isopod (MCI) populations, it was decided that USFWS required better data to estimate take of the species as a result of NiSource activities. USFWS directed the Fund to acquire the services of a geotechnical firm to assess the nature of karst within the NiSource covered lands. The Fund contracted GeoConcepts Engineering, Inc. to perform the assessment. The project commenced August 2009, and the final report was completed December 2009.

The assessment used a multi-phased approach where karst features were identified remotely within the covered lands and via field reconnaissance within the right-of-way (ROW). In all, 227 karst-related closed depressions and 33 caves were identified within the covered lands. Of this total, 114 closed depressions and 22 caves fell within the known range of the isopod, with the remainder occurring within potential geological habitat where the isopod has yet to be collected. Though neither caves nor closed depressions with open throats were discovered by GeoConcepts Engineering within the existing ROW, four complexes of karst features with a series of open throats that receive drainage from the existing ROW were identified. In addition, areas with vegetated closed depressions that are internally drained and may be areas of potential future subsidence were also identified.

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While none of the current known occurrences of MCI were within the ROW and the closest known occurrence to the covered lands is 0.5 mile from the edge of the covered lands and 1 mile from the ROW, the geographic extent of the species is believed to be much larger than any individual sampling point. Thus, activities within the ROW have the potential to impact the species through subsurface impacts. The subterranean nature of the species and the complexity of karst make it appropriate to base estimates of take on activities occurring within the ROW affecting populations located outside of the ROW. The surface karst features mapped during the assessment were utilized by USFWS to calculate take and may be used in the future for additional take calculations for other projects by estimating associated subsurface impacts occurring as a result of activities near karst features located within the mapped MCI distribution.

Modeling of Freshwater Mussels Habitat

In 2009-2010, the Fund sought to identify suitable habitat for freshwater mussel conservation or reintroduction for the five takes species in the draft MSHCP: Clubshell (*Pleurobema clava*), Fanshell (*Cyprogenia stegaria*), Northern Riffleshell (*Epioblasma torulosa rangiana*), Sheepnose (*Plethobasus cyphus*), and James Spiny mussel (*Pleurobema collina*). The analyses were limited to coarse-scale variables at the reach and catchment scale. Microhabitat features such as stream substrate or submerged vegetation might be inferred by larger scale conditions, but are best measured by field surveys. These modeling GIS layers were completed in summer 2010.

The Fund utilized maximum entropy modeling (Maxent), which estimates the spatial distribution of the species (i.e., predicts suitable habitat) by assuming nothing about that which is unknown (maximizing entropy), but matching the relationships between recorded occurrences and underlying variables. Unlike other techniques such as logistic regression, maximum entropy modeling does not require reliable species absence data, which are rarely available. Maxent can also produce solutions with a small set of observations, although the larger the number of observations, the more accurate model output is likely to be. Also, the environmental variables do not need to be independent.

Output also includes the receiver operating characteristic (ROC) curve, which in this case tells the user how well the model distinguished species occurrences from random locations. The area under the ROC curve (AUC) should be as close to 1.0 as possible; an AUC of 0.5 indicates predictability no better than random chance. Thresholds can be identified that most efficiently identify potential species habitat (fraction of occurrences included vs. the area selected). Model output also includes estimates of variable importance and graphs of predicted suitability vs. individual variables.

We selected the Maxent threshold that captured the highest proportion of known mussel occurrences, while including the least area of catchments. Generally, this corresponds to maximum sensitivity plus specificity, but several thresholds were examined. The Fund identified the majority Maxent value within each NHD catchment. Then, those catchments corresponding to Maxent values above the test maximum sensitivity plus specificity threshold were selected and grouped into spatially contiguous sections. From these, groupings that also contained catchments with Maxent values greater than the most parsimonious threshold were selected. Then the NHD flow lines within those catchments were selected, and the length of these contiguous sections was calculated using a GIS software extension called Hawth's Tools (Spatial Ecology, 2010). The length of each stream segment with suitable habitat was compared to the presence of the mussel being modeled. Sections below the minimum length that

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contained the mussel being modeled were filtered out, thereby identifying stream reaches that met both modeled habitat and length thresholds.

Although state and university biologists are likely to know already where the best conditions are, the Maxent model could conceivably help target reintroduction of cultured mussels. Reintroductions should be preceded by field surveys, then pilot testing of survival and recruitment.

Nashville Crayfish Modeling and Stream Buffer Research

During the spring of 2010, the Fund concluded extensive modeling and policy research on the habitat needs of Nashville Crayfish (*Orconectes shoupi*), a species restricted to the Mill Creek watershed in Davidson and Williamson Counties in central Tennessee. Much of the Mill Creek watershed is heavily developed for residential and commercial use. The southern portion of the watershed is more rural.

The first part of the research was a habitat modeling effort using Maxent modeling as a method to predict the geographic distribution of crayfish within Mill Creek. In January 2010, the Fund completed an initial habitat model for Nashville Crayfish (*Orconectes shoupi*), based on 1994-2007 data from the Tennessee Natural Heritage Inventory Program and variables calculated from NHDPlus, 2001 National Land Cover Dataset (NLCD), geology, and other data. After exploratory tests of the data, the Fund modeled occurrence of viable *O. shoupi* locations using maximum entropy and spatial application. This predicted about a third of the stream reaches in the Mill Creek watershed to be excellent or good habitat for *O. shoupi*. In most cases, the model identified the main stem and lower portions of tributaries, and rarely selected headwaters. There was concern, though, that recent development may have degraded some of the identified habitat.

Since that time, David Withers (Heritage Zoologist, TN Natural Heritage Program) supplied more recent locational data (up to 2010, and including sites with no occurrences), and estimated population viability for all locations. The Fund also contracted WorldView Solutions Inc. to classify 2008 aerial imagery to 1-meter resolution, creating a highly accurate land cover after three rounds of classification review. Finally, Fund staff and David Withers walked several sections of Mill Creek and a number of tributaries, noting local conditions, and stream and *O. shoupi* responses to stressors like drought, tree clearing, and urbanization. We found individuals throughout the main stem (despite record flooding in May 2010 that was intense enough to move large slabs of limestone). Many of the tributaries were dry during the visit; some individuals moved to remnant pools, some buried themselves to the saturation zone, and some upper reaches contained no individuals at all.

The Fund revised the *O. shoupi* habitat model using the data above and generalized boosted regression modeling in the statistics program R (R Project, 2003). The model applies to all streams in the Mill Creek watershed. Univariate and correlative analyses showed larger streams, more rural areas, better buffered sites, and Lebanon limestone bedrock to more likely contain viable populations of *O. shoupi*. A preliminary boosted regression tree model correctly identified 91% of viable *O. shoupi* locations but only 67% of locations without the species. Because this is an endangered species, our goal was to identify 90% of occurrences; to increase the absence accuracy would decrease the presence accuracy.

Interestingly, the metric representing agricultural pollution loading was a strong predictor of Nashville Crayfish population viability using the Maxent model. The Fund believes this is correlative rather than causative, because it represented two factors: (1) total drainage area, and (2) drainage from the rural

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portion of the watershed rather than the urban portion. Excellent or good populations of the Nashville Crayfish occurred primarily in larger perennial streams, rather than in headwaters. In general, headwater streams are more prone to drying out than larger streams. The result of the modeling effort was a map of the Mill Creek watershed displaying streams and tributaries that could support Nashville Crayfish populations. This mapping information provides a crucial tool in evaluating mitigation proposals.

The policy section of the research for the Nashville Crayfish focused on collecting and integrating peer-reviewed literature, practitioner guidance and land use planning ordinances on riparian buffers. Stream buffers also offer a host of other public benefits such as water quality improvements, pollutant removal and corridors for wildlife movement. Riparian buffers would benefit the Nashville Crayfish by maintaining or improving overall water quality – in particular controlling sediment, protecting and/or expanding tree canopy to provide sufficient shade for temperature control and support food web dependencies, and providing in-stream stable wood for shelter. The existing regulations of Davidson County were examined as well as the revised state guidelines on wet weather conveyances. The riparian protection efforts of the cities of Austin, Texas; Indianapolis, Indiana; Raleigh, North Carolina; Charlotte, North Carolina; Atlanta, Georgia; Louisville, Kentucky; and Memphis, Tennessee were examined. The Fund recommended the adoption of variable width buffers and other changes to riparian buffers within the Davidson County Open Space Planning effort known as Nashville: *Naturally*.

Task 2 - Development of Potential Mitigation Site Reports

Mitigation site reports are intended to serve as source material for NiSource as it develops its mitigation package in the MSHCP and also can be used by USFWS and the states for other purposes including State Action Wildlife Plan implementation and other conservation planning purposes.

Subtask 2.1 – Guidance for Mitigation Site Reports

Criteria Development

To assist with developing mitigation guidance, NiSource provided the Fund with an advanced draft copy of chapters of the MSHCP for review. Of particular use was Chapter 6, which provided a detailed examination of each take species covered, the degree of impact from NiSource activities, biological goals and objectives, measures to avoid and minimize impact, the draft take calculations, and anticipated compensatory mitigation. The habitat needs of each MSHCP take species described in Chapter 6 were reviewed and woven into the mitigation guidance reports to the states.

Each take species has a set of project selection criteria that will be used to help evaluate and rank potential mitigation projects. The MSHCP currently includes nine take species where potential mitigation projects meeting specific requirements will need to be identified over the 50-year timeframe of the MSHCP.

The Fund generated a list of mitigation project selection criteria for each species based upon analysis within the MSHCP. The criteria were organized into categories, including habitat quality, project location, likelihood of protection in perpetuity, protection of other listed species, support for green

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infrastructure goals, advancement of state and regional planning goals, and ability to leverage other financial and partnership resources.

To prepare for the meetings with the states, the Fund organized a series of conference calls with USFWS and NiSource to review take species habitat needs and other elements of the decision tree. In April of 2010, three conference calls were held with USFWS and NiSource. The first call focused on the suite of freshwater mussels and the Nashville Crayfish. The next conference call was devoted to the Bog Turtle (*Clemmys muhlenbergii* – Northern Population), and the final conference call reviewed the Indiana Bat. The dialogue between the Fund, NiSource, and USFWS on criteria for habitat quality, long term stewardship and links with other species priorities was very constructive. Clarifying language from draft Chapter 6 of the MSHCP and its degree of use and style within the criteria was another outcome of the species focused conversations with USFWS and NiSource staff.

State Mitigation Meetings

In mid-March 2010, the Fund notified the state points of contact about efforts to organize meetings in the summer and fall of 2010 to review mitigation guidance, decision trees and potential mitigation sites. As state agencies have extensive experience with habitat planning and on-the-ground knowledge of many of the take species, state review of habitat quality data and assumptions was a critical cross check to the material provided by USFWS. Once USFWS approves the NiSource MSHCP, an application process for mitigation projects will begin. As state natural resource agencies are the likely applicants who would be preparing applications, obtaining state agency feedback on the actual applications was critical. Making sure the applications are understandable in terms of language, technical detail required, and the scoring systems were all areas for feedback from state officials. Helping state agency staff understand how the decision-support tools may evaluate applications and making the application process transparent will result in better proposals. Outlining how state officials can improve their applications with using matching funds or leveraging other program dollars increases the impact of the mitigation funds from NiSource.

Within the contact letter to the state officials was an update on the MSHCP process and forecasted timeline on the release of the draft MSHCP and public comment period. Most importantly, to help state officials with their review, a draft copy of the state specific take species sections of Chapter 6 from the MSHCP was included as a reference. The release of a draft Chapter 6 to state agencies was a very important step to build an understanding of the mitigation decision tools, build trust in the planning process and coordinate the linkage of the mitigation planning with the regulatory oversight of MSHCP. State officials were asked to provide feedback on convenient times for a meeting by April 15, 2010.

To help orient state officials for the upcoming meetings and address questions on the MSHCP, USFWS hosted a webinar on May 26, 2010. An update on the timeline for the MSHCP was provided by USFWS. The role of the upcoming meetings with the states on mitigation planning was discussed and context provided. The effort to keep state officials engaged and informed spoke to the importance of the state review, and the challenge of maintaining an active engagement with a changing time table for the MSHCP. However, the planning process for the mitigation work helped keep state officials informed while work was completed on the MSHCP.

Twelve state meetings, with a total of 90 participants, were convened to review the mitigation criteria and opportunities in summer 2010: (NJ June 1, MD June 7, IN June 9, KY June 10, OH June 14, NY June

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23, PA June 29, DE July 20, TN July 28, MS Sept 15, WV Sept 21, and VA Sept 27.) Both Mississippi and Delaware had conference calls with the Fund staff to review the needs of the single species within their states, while others were done in person. A meeting with Louisiana was not convened since the Louisiana Black Bear was removed as a take species. Each state was provided with a Mitigation Guidance report that outlined the requirements for mitigation proposals, copies of the take species decision trees in spreadsheet form, instructions on downloading information from the Fund portal, questions on take species for directed input on the decision trees, copies of mitigation opportunity maps and a summary of potential state leverage opportunities.

The state mitigation option meetings began with an overview of the NiSource project, and a quick examination of the green infrastructure planning process. It was important to provide an overview of the green infrastructure method as new state staff attended the meetings and because roughly a year had passed since the last meetings with the states.

Following the project overview, the Fund provided an introduction to the decision tree structure. After the orientation to the decision trees, participants were divided into species-specific teams to review and comment upon the decision trees. Facilitators utilized poster size versions of the decision trees to aid in the review. Several maps were provided as reference materials including mitigation opportunity maps and a preliminary GI forest core area map. The bulk of the meeting time was devoted to reviewing the habitat quality assessment portions of the decision tree. The Fund staff asked specific questions of state officials for each criterion. This set of questions was an important tool to ensure consistent feedback and make sure the meeting time was focused on challenging issues.

State officials provided keen insight into species habitat parameters, thresholds and clear language to describe habitat components within the decision tree framework. State officials also provided guidance on the relative weights between criterion within the decision tree. For freshwater mussel species, state officials were asked to provide feedback on the relative priority and habitat quality of watersheds and river systems where the mussel species were documented so as to direct mitigation to the populations with the best chance of survival or rebound. The Fund team reminded state officials to make similar comments when the MSHCP was open for public comment since the public comments and responses to those comments constitute the official guidance document. The Fund team anticipates that the language and content in the MSHCP and the materials describing the mitigation application process will be made consistent once the final MSHCP is completed.

The final portion of the state meeting was devoted to examining the opportunity dot maps that had been drafted based on the state input meetings in 2009. State officials reviewed the conservation opportunities highlighted and confirmed their status. As new state agency staff attended the 2010 meetings, additional opportunity areas were added to the opportunity maps. State officials identified or confirmed a total of 234 opportunities with the following breakdown per species: Bog Turtle 61, Nashville Crayfish 11, Mussels 67, Indiana Bat 89, and the Madison Cave Isopod 5. The opportunity maps are rough guidance for the Fund, NiSource and USFWS on potential project areas and are likely to change over time. However, these maps are a helpful snap shot of the best locations for projects for the NiSource take species.

Coinciding with the state meetings were several opportunities for fieldwork and collaboration. After the Tennessee state meeting on July 28, the Fund conducted fieldwork on the Nashville Crayfish at locations across the Mill Creek Watershed with David Withers, Heritage Zoologist with the Tennessee Natural

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Heritage Program. In addition, staff from the Metro Parks Department and the Land Trust for Tennessee joined the field survey team to assess potential land conservation opportunities that would benefit both the Nashville Crayfish and the surrounding communities. A total of seven sites were visited in Davidson and Williamson Counties, and 17 Nashville Crayfish were recorded.

Following the Kentucky meeting, the Fund staff toured the Commonwealth's Center for Mollusk Conservation, a cutting edge program focused on producing mussels in a hatchery environment for reintroduction. Prior to the meeting with the state of Indiana, the Fund toured the Indiana Bat mitigation sites acquired by the Indianapolis Airport Authority for its Habitat Conservation Plan for airport expansion. Through an innovative partnership with Hendricks County Parks and Recreation, part of this land will be managed as the Sodias Nature Park, which will provide recreational opportunities, monitoring of the Indiana Bat and public educational opportunities on this species.

The Fund staff convened a special decision tree integration meeting at the USFWS National Conservation Training Center in Shepherdstown, WV on August 18. Comments from state officials for the meetings that had taken place were reviewed and combined into a revised decision tree for use in the fall meetings with officials from West Virginia and Virginia. The purpose of a midstream revision to the decision trees was to build upon the state comments and maximize the quality and focus of the remaining state reviews. In essence, the decision trees had three rounds of reviews (two with state review and one with USFWS), leading to a robust output.

Subtask 2.2 – State Mitigation Site Reports

Decision Trees

During the fall 2010, the Fund created a series of tools to help decision makers evaluate mitigation proposals. For each take species, maps, spreadsheets, and species habitat information were collected and synthesized into a 'decision tree'. A decision tree is a set of criteria and weights that will be used to quantitatively evaluate the benefits of potential mitigation opportunities on a consistent scale so that projects can be appropriately compared. Decision makers use the decision tree to methodically evaluate each project, determining what extent a potential mitigation project meets the particular take species mitigation needs and desires (including habitat quality, location, likely protection in perpetuity, and protection of other listed species) as well as how it supports the green infrastructure network design, advances state and regional planning goals, and leverages other financial and partnership resources.

Each criterion spans a range of characteristics from most to least suitable in terms of meet species mitigation requirements. Where each project falls within this range is represented numerically on a standard scale from 0-100 that represents how well it satisfies that particular criteria (100 being the highest). In addition to the score for each criterion, weights are assigned relative to other criteria within its 'branch of the tree' since some factors are more important than others in evaluating a potential project. In addition, criteria have a 'logic structure' that designates them as mandatory, sufficient, or desired based on their contribution to species protection.

The design of the decision trees is based on a state-of-the-art method known as 'logic scoring of preference' (LSP) to ensure that all criteria and weightings are designed to reflect fundamental properties of human reasoning and ensure that the benefits calculated accurately reflect the desired

intent of decision makers. Dr. Jozo Dujmović, one of the world’s pioneers in the use of LSP for decision making, has designed a customized desktop software package (ISEE) and a web-based application (LSPWeb) to support the ongoing refinement of the species decision trees as the MSHCP begins to be implemented in 2011.

The most intensive part of the decision tree creation and verification was the evaluation sheet for habitat quality. The Fund staff reviewed Chapter 6 of the draft MSHCP for detailed elements of habitat quality that could be used to evaluate and separate “average” projects from “outstanding” projects. It was critical that habitat quality elements highlighted in the decision tree have a direct reference within the MSHCP. In addition, considerable thought and effort went into crafting criteria that would evaluate roles of future land use changes, stewardship issues and long term monitoring of the site. An example of a decision tree for freshwater mussels is provided below:

1 Freshwater Mussels Mitigation Projects

11 Habitat Mitigation Needs

111 Mandatory Requirements

1111 Mitigation Units

1112 Site Assessment

11121 Buffer Size & Shape

11122 Intact Buffer Sites

11123 Mussel Distribution

1113 Physical Conditions

11131 Substratum

11132 Water Quality

11133 Bed Stability

11134 Barriers to Fish Passage

1114 Species Occurrence

11141 Known & Potential Host Fish

11142 Mussel Population Viability

11143 Mussel Diversity

11144 Mussel Density

11145 Detrimental Invasive Species

1115 Project Location

112 Desired Characteristics

1121 Protection in Perpetuity

11211 Point & Nonpoint Pollution Risk

11212 Sedimentation & Substrate Removal Risk

11213 Stream Impoundment Risk

11214 Stream Buffer Clearing Potential

11215 Project Monitoring

1122 Listed Species Protection

11221 NiSource MSHCP Take Species

11222 Federal & State Listed Species

12 Strategic Conservation Goals

121 Green Infrastructure Network

122 Adopted Plans & Leverage

1221 State Wildlife Action Plans

1222 Conservation Planning

1223 Collaboration

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Mitigation Site Reports

One of the final steps in the overall project was the preparation by the Fund of customized mitigation site reports organized by species. These reports provide selection criteria and an initial list of potential mitigation project opportunities that are likely to meet the requirements outlined in the MSHCP.

Additional information on individual projects will be required at the time of mitigation need as outlined in the Mitigation Proposal Requirements section of the MSHCP. Whether a mitigation proposal can be funded will depend on a number of factors, including but not limited to the species affected, the location of the mitigation activities compared to the location of the species impacts, the cost of the mitigation proposal, whether the proposal satisfies the mitigation proposal criteria, and the scientific justification for the mitigation proposal.

All mitigation project selection will be governed by the decision making process outlined in the MSHCP. A final MSHCP will not be available before the end of the Section 6 grant project. The weights and logic structure outlined in the enclosed decision trees is likely to be adjusted in the future by USFWS and NiSource, in consultation with the states.

The species decision trees and criteria represent the culmination of the entire planning project, from project fieldwork, GIS modeling of the green infrastructure network and outreach efforts with state agencies. The mitigation reports provide state agencies with a comprehensive view of the habitat needs of NiSource MSHCP take species and a framework for prioritization that will prove useful for both the NiSource project as well as other planning efforts. Engagement of state agencies in reviewing draft material such as the decision trees has also enriched the detail and accuracy of the MSHCP, providing USFWS and NiSource with keen insights into habitat requirements, state leverage funding sources and specific mitigation opportunities.

Subtask 2.3 – Decision Support Framework for Evaluating and Ranking Mitigation Sites

A key to implementing the MSHCP is to evaluate and rank potential mitigation opportunities for take species. The Fund has prepared a comprehensive set of decision support tools to facilitate the selection of the best possible mitigation opportunities as they arise over the course of the implementation of the MSHCP.

GIS Map Document

The Fund has delivered a customized ESRI ArcGIS™ map document (.mxd) that includes key GIS layers for decision support for desktop use. This map document and data was used to prepare the species mitigation site reports for task 2.2. The GIS layers help place mitigation projects in a regional green infrastructure context and help visually demonstrate how a potential mitigation opportunity will contribute to the protection of the species across its range. Below is a summary list of the data provided in the map document:

Freshwater Mussels: Potential Freshwater Mussel Mitigation Opportunities, Take Mussel Species Counties of Occurrence, NiSource Potential Take Counties for Mussels (based on draft HCP Chapter 6),

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Freshwater Mussel 8-digit HUC Occurrences, Mussel Species Modeling Results (James Spiny mussel, Clubshell, Fanshell, Northern Riffleshell, Sheepnose)

Indiana Bat: Potential Indiana Bat Mitigation Opportunities, Counties within 10-Mile Buffer of Priority I/II Hibernacula, Counties with Occurrences (ESI AnaBat Summer 2009), Counties with Known Summer Habitat, NiSource Potential Take Counties for Indiana Bat (based on draft HCP Chapter 6), Modeled Habitat Patches and Quality (Maxent Suitability Model)

Bog Turtle: Potential Bog Turtle Mitigation Opportunities, Bog Turtle Counties of Occurrence, Bog Turtle Recovery Subunits

Nashville Crayfish: Potential Nashville Crayfish Mitigation Opportunities, Mill Creek Watershed + Streams, Mill Creek Greenways, Mill Creek Floodway + 75 Feet, Mill Creek Davidson County Open Space, Mill Creek – Detailed Land Cover, Nashville Crayfish Habitat Suitability Model

Madison Cave Isopod: Potential Madison Cave Isopod Mitigation Opportunities, Madison Cave Isopod 8-Digit HUCs, Madison Cave Isopod Occurrence and Potential Take Counties, Madison Cave Isopod Geologic Units (Index of Cave and Closed Depression Densities)

Green Infrastructure Network Design: Mature Hardwood Forests (PA, TN, KY, OH only), Core Aquatic Habitats, Aquatic Corridors, Core Wetlands, Wetland Corridors, Core Forests, Forest Corridors, Hubs, Characterized Green Infrastructure Network

References for Searches and Display: State and County Boundaries, NiSource Covered Lands Counties, Ecoregions, Hydrologic Units (HUCs), NiSource Covered Lands, Protected Lands

Decision Tree Software

The Fund has delivered both a desktop (ISEE V1.1) and web-based applications (LSPWeb V1.0: <http://www.seas.com/LSPweb/login.php>) for the development and modification of species decision trees and associated mitigation projects. Please see the species mitigation report deliverables for subtask 2.2 and the application user manuals for more information on their use.

Optimization Software

The Fund has provided an Excel™ based application that allows users to identify an optimal set of mitigation projects within a fixed budget and/or to explore the relative cost effectiveness of potential projects. The Fund collaborated with Dr. Kent Messer from the University of Delaware to develop the Optimization Decision Support Tool (ODST). The ODST is an Excel™ based application that allows users to evaluate mitigation opportunities based on a variety of evaluation techniques: (1) identifying an optimal set of mitigation projects within a fixed budget constraint, (2) exploring the relative cost effectiveness of mitigation projects and selecting the portfolio with the highest benefit: cost ratio, and/or (3) identifying the minimum cost required to achieve a defined benefit level.

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The Fund believes that optimization tools will assist decision makers in dramatically extending the limited financial resources devoted to mitigation. The Fund and Dr. Messer have demonstrated with the application of optimization to conservation programs that significantly more acreage can be conserved with higher overall conservation benefits with the use of optimization in direct comparison to more traditional approaches. Please see the application user manual for more information on its use.

Decision Support Tool User Manuals

ISEE - SEAS. Integrated System Evaluation Environment - ISEE User Manual - V1.1 © 2010

LSPWeb - SEAS. LSP method for evaluation over the Internet V1.0 © 2010

ODST – Messer, Kent D. and Dmitry Volodin, University of Delaware, Optimization Decision Support Tool Reference Guide - Lite Version© 2010

Next Steps

In mid-December 2010, the Fund contacted state agency staff and provided a final project status report. It is expected that the MSHCP Federal Register notice will be released in late January 2011. State officials were informed about the range of reports and GIS resources completed through the project and their availability on the Fund web portal site. As the Federal Register notice and potential issuance of an Incidental Take Permit will take place outside the contract period for the Section 6 grant, the Fund has provided a set of tools that anticipates that elements of the MSHCP will be adjusted over time. The Fund informed the states that it will host a webinar for USFWS staff and state officials on the green infrastructure network and to provide an orientation to participants on the material covered within mitigation site reports in 2011. It is anticipated that the Fund may be requested by NiSource, USFWS or state agencies to provide additional training and/or modify the decision support tools over time. These adjustments to decision support tools fit naturally within the course of a planning cycle.

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