# Environment and Natural Resources Trust Fund (ENRTF)
# M.L. 2017 LCCMR Work Plan

**Date of Submission:** September 14, 2016

**Date of Next Status Update Report:** January 1, 2018

**Date of Work Plan Approval:** 06/07/2017

**Project Completion Date:** June 30, 2020

**Does this submission include an amendment request?** No

**PROJECT TITLE: Cedar Creek Natural Area Wolf Recolonization Assessment**

**Project Manager:** Forest Isbell

**Organization:** Cedar Creek Ecosystem Science Reserve, University of Minnesota

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**Web Address:** www.cedarcreek.umn.edu

**Location:** Anoka and Isanti Counties, MN

| **Total ENRTF Project Budget:** | | |
|---|---|---|
| | **ENRTF Appropriation:** | **$398,000** |
| | **Amount Spent:** | **$0** |
| | **Balance:** | **$398,000** |

**Legal Citation: M.L. 2017, Chp. 96, Sec. 2, Subd. 03k**

**Appropriation Language:**
$398,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota, Cedar Creek Ecosystem Science Reserve, to assess wolf recolonization impacts on wildlife, biodiversity, and natural resources and provide educational opportunities at Cedar Creek Ecosystem Science Reserve. This appropriation is available until June 30, 2020, by which time the project must be completed and final products delivered.

**I. PROJECT TITLE: Cascading Effects of Wolf Recolonization**

**II. PROJECT STATEMENT:**

Minnesota's wolves (*Canis lupus*) are expanding southward, and a new pack recently became established at Cedar Creek Ecosystem Science Reserve (henceforth Cedar Creek), which is one of the best-studied ecosystems worldwide, located just north of the Twin Cities (Fig. 1). Our **GOALS** are to assess the potential costs (e.g., unwanted impacts on wildlife, pets, or livestock) and benefits (e.g., potential enhancement of biodiversity and ecosystem functioning, educational opportunities) of this unassisted wolf recolonization.

**OUTCOMES are to**:

1. determine wolf movements inside and outside Cedar Creek, including dispersal to establish new packs;
2. measure the impacts of wolves on wildlife, biodiversity, and ecosystem functioning; and
3. provide wolf-related educational programming to K-12 students and outreach for the general public.

**We will achieve these goals and outcomes by:**

1. using GPS collars to track wolves;
2. establishing a network of trail cameras to assess wolf impacts on wildlife abundances and locations;
3. using existing data and new measurements to assess wolf impacts on plants and soils; and
4. bringing K-12 students to Cedar Creek for field trips and developing a website for citizen scientists.

During 2015, for the first time in approximately a century, a breeding pair of wolves had at least eight pups in a den at Cedar Creek. This new wolf pack is much further south and closer to the Twin Cities than other known packs (Fig. 1). Members of this new wolf pack remained at Cedar Creek, at least through May 2016, as indicated by frequent observations of the wolves, their tracks, and their scat. As members of this pack disperse to establish new packs in coming years, it will be important to assess both the benefits and costs of having wolves so close to a major metropolitan area. Furthermore, Cedar Creek is an ideal site to study the ecological impacts of wolf recolonization because of its decades of comprehensive ecological research, including data from thousands of plots in dozens of multi-decadal studies across the property. The proposed research will combine existing long-term data with new data on the local abundances and spatial distributions of animals, plants, and soil nutrients.

**Background:**

For many millennia, wolf populations were found throughout the continental United States. By the early 1900's, extensive poisoning had extirpated wolves from all but the northeast corner of Minnesota, reducing the population to a few hundred individuals. Protection by the Endangered Species Act has since allowed Minnesota's wolf population to recover by approximately an order of magnitude, and has allowed wolf populations to expand back into Wisconsin and the upper peninsula of Michigan.

Because Cedar Creek is so data-rich, it provides a unique and ideal opportunity to study the recolonization of this top predator. We have collected 20-30 years of data from dozens of long-term studies that provide a detailed description of community structure and ecosystem function in the absence of wolves. Because these data come from literally thousands of experimental and observational plots distributed across our 21 $km^2$ landscape, we could use these plots to measure wolf impacts if we can supplement our research efforts with the necessary tools to measure the fine-scale spatiotemporal distribution of wolves and their associated impacts on prey at Cedar Creek.

The loss of top predators from ecosystems worldwide is one of the most pervasive impacts of humans on nature, but it remains unclear whether recovery of predator populations would reverse these impacts or not. Given that apex predators often exert major top-down cascading impacts on herbivores, plants, and soils, it has been suggested that the recovery of predators might be necessary to restore natural systems to their pre-loss state. Alternatively, loss of predators might result in a critical transition to an alternative stable state that persists even if predator populations later recover. Furthermore, predator recovery might also have little impact in some natural systems where community structure and ecosystem functioning are controlled much more by bottom-up resource limitation than by top-down consumer limitation. Thus, it remains unclear whether predator reintroductions will generally result in rapid and dramatic recovery in natural systems.

Top predators were eliminated from many ecosystems worldwide long before ecology existed as a discipline. For example, all investigations at Cedar Creek over the past 75 years have occurred after the loss of its major top predator, the wolf. The unassisted return of wolves to Cedar Creek provides an opportunity to gain a novel and deep understanding of the mechanisms underlying population, community, and ecosystem dynamics, and to predict whether and how the effects of top predators cascade through terrestrial food webs.

**III. OVERALL PROJECT STATUS UPDATES:**

**Project Status as of January 1, 2018:**

**Project Status as of July 1, 2018:**

**Project Status as of January 1, 2019:**

**Project Status as of July 1, 2019:**

**Project Status as of January 1, 2020:**

**Overall Project Outcomes and Results:**

**IV. PROJECT ACTIVITIES AND OUTCOMES:**

**ACTIVITY 1:** ***Use GPS collars to track wolf movements inside and outside Cedar Creek***
**Description:**

The project will live-trap wolves, and use GPS collars to track their movements, locations, survival, mortality and predation, inside and outside Cedar Creek. Tracking wolf movements will allow us to determine the full range of wolf activity and impacts inside and outside Cedar Creek, including habitat use within Cedar Creek and dispersal to establish new packs outside Cedar Creek. We will also attempt via the GPS locations to find any new dens, and count and observe new litters and monitor their survival. Assessments will also be made of the wolves' movements around human dwellings. The proposed project will attempt to collar and track two to four wolves annually for at least three consecutive years (2017 - 2019).

**Summary Budget Information for Activity 1:**

**ENRTF Budget: $ 89,000**
**Amount Spent: $ 0**
**Balance: $ 89,000**

| Outcome | Completion Date |
|---|---|
| **1.** *Collar at least two wolves (collars record multiple locations per day for 1-2 years)* | May 2017 |
| **2.** *Collar at least two wolves (collars record multiple locations per day for 1-2 years)* | May 2018 |
| **3.** *Collar at least two wolves (collars record multiple locations per day for 1-2 years)* | May 2019 |
| **4.** *Analyze and report location data from wolf collars* | May 2020 |

**Activity 1 Status as of January 1, 2018:**

**Activity 1 Status as of July 1, 2018:**

**Activity 1 Status as of January 1, 2019:**

**Activity 1 Status as of July 1, 2019:**

**Activity 1 Status as of January 1, 2020:**

**Final Report Summary:**

**ACTIVITY 2:** ***Establish camera trap network to determine wolf impacts on wildlife***
**Description:**

The proposed project will also establish a network of motion-sensing and heat-sensing camera traps throughout Cedar Creek. This camera trap network will help us determine the impacts of wolves on the local abundances and spatial distributions of Cedar Creek's diverse animal community, which includes wolf prey (e.g., whitetail deer) and competitors (e.g., black bear). Recent advances allow camera trap networks to provide an efficient way to comprehensively sample diverse animal communities and to determine animal responses to the presence and movements of top predators.

Specifically, to determine the impacts of wolf recolonization on herbivorous prey, such as deer and rabbits, and to identify refuges, we propose to establish a network of camera traps throughout Cedar Creek. We will use recent statistical advances that solve former challenges of estimating animal abundances from camera trap data. We will also build on lessons learned from Snapshot Serengeti, which deployed 225 camera traps across a 1,125 $km^2$ area of the Serengeti and used citizen scientists and experts to reliably classify millions of images. At Cedar Creek, we propose deploying 125 cameras, randomized over an area of 21 $km^2$. The proposed camera density at Cedar Creek is more than 25 times greater than that used in the Serengeti, increasing our ability to resolve the abundances and spatial distributions of rare species.

Cameras will be deployed during the first two months of the project, and will operate continuously thereafter. Images will be collected monthly from an easily accessible subset of cameras, and will be collected from all cameras at least once every three months. During camera deployment, a scale size reference will be photographed at three fixed distances away from each camera to later be used as a size reference for animals present in images, and to estimate the extinction of visibility within the camera view. In addition to resampling existing herbivore exclosure studies, plants and soils will be sampled inside and outside new herbivore exclosures, which will be established at each of the camera trap locations.

**Summary Budget Information for Activity 2:**

**ENRTF Budget: $ 143,000**
**Amount Spent: $ 0**
**Balance: $ 143,000**

| Outcome | Completion Date |
|---|---|
| **1.** *Establish network of 125 cameras to continuously sample the diverse animal community* | September 2017 |
| **2.** *Analyze and report local abundance and spatial distribution data from camera traps* | May 2020 |

**Activity 2 Status as of January 1, 2018:**

**Activity 2 Status as of July 1, 2018:**

**Activity 2 Status as of January 1, 2019:**

**Activity 2 Status as of July 1, 2019:**

**Activity 2 Status as of January 1, 2020:**

**Final Report Summary:**

**ACTIVITY 3:** ***Resample plants and soils inside and outside exclosures to determine cascading impacts of wolves on biodiversity and ecosystem functioning***

**Description:**

To determine whether wolf recolonization rapidly affects plant community structure and productivity, we will test for possible cascading impacts of wolves on plant communities and soil nutrients with a BACI (before-after-control-impact) experimental design, using data collected before and after wolf recolonization both inside (control) and outside (impacted) exclosures. These exclosures experimentally eliminate the top-down cascading effects of wolves and mammalian herbivores on plants and soil nutrients, before and after wolf recolonization. This provides a rigorous test of whether, how, and where recolonizing wolves alter plant biodiversity and ecosystem functioning, including plant productivity and nutrient cycling. Specifically, we will resample plants and soils in existing exclosure experiments, which are distributed across our property to test whether, immediately after wolf recolonization, exclosures: (1) increase plant biomass by less than the long-term average homogeneously across our property, which would be consistent with trophic cascade hypothesis; (2) heterogeneously affect plant biomass, with reduced or opposite effect inside than outside refuges, which would be consistent with the landscape of fear hypothesis; or (3) continue to increase plant biomass by approximately the long-term average, which would be consistent with the alternative stable states hypothesis. Previous deer population densities, which have been monitored and modeled by the Minnesota Department of Natural Resources, will be included as covariates.

**Summary Budget Information for Activity 3:**

**ENRTF Budget: $ 96,000**
**Amount Spent: $ 0**
**Balance: $ 96,000**

| Outcome | Completion Date |
|---|---|
| **1.** *Resample plant community and soil nutrients inside and outside existing exclosures* | September 2019 |
| **2.** *Analyze and report plant and soil data from BACI (before-after-control-impact) study* | May 2020 |

**Activity 3 Status as of January 1, 2018:**

**Activity 3 Status as of July 1, 2018:**

**Activity 3 Status as of January 1, 2019:**

**Activity 3 Status as of July 1, 2019:**

**Activity 3 Status as of January 1, 2020:**

**Final Report Summary:**

**ACTIVITY 4:** ***Develop citizen science website and share results with students and visitors***

**Description:**

A new *Snapshot Cedar Creek* website will be developed to train and utilize citizen scientists to identify wildlife caught on cameras. This website will teach Minnesotans how to identify the wildlife of our state, and will also provide our project with a cost-effective and sustainable method for classifying the large volume of images that will be generated by the camera trap network. Images from Activity 2 will be stored in a database that will populate the *Snapshot Cedar Creek* website, which will be created for citizen scientists to classify each image to species and to report abundance, behavior, and presence of young. Multiple registered citizen scientists will classify each image. An existing algorithm will be used to define consensus on classifications. In Snapshot Serengeti, such classifications were 96.6% accurate for species identifications. Experts will validate a subset of

image classifications. Experts will also confirm classification of all images identified as wolves or coyotes (*Canis latrans*) to avoid misclassification of coyotes as wolves, or vice versa.

Results from the proposed project, as well as curriculum previously developed by the International Wolf Center, will be incorporated into the Cedar Creek Education and Outreach program, which serves thousands of K-12 students and visitors each year through field trips to Cedar Creek, classroom visits, and public events and programming. The project will also provide research training for undergraduate and graduate students, and a postdoctoral researcher.

**Summary Budget Information for Activity 4:**

**ENRTF Budget: $ 70,000**
**Amount Spent: $ 0**
**Balance: $ 70,000**

| Outcome | Completion Date |
|---|---|
| **1.** *Train and utilize more than 10,000 citizen scientists via the Snapshot Cedar Creek website* | May 2020 |
| **2.** *Provide on-site educational programming for more than 10,000 K-12 students and visitors* | May 2020 |

**Activity 4 Status as of January 1, 2018:**

**Activity 4 Status as of July 1, 2018:**

**Activity 4 Status as of January 1, 2019:**

**Activity 4 Status as of July 1, 2019:**

**Activity 4 Status as of January 1, 2020:**

**Final Report Summary:**

**V. DISSEMINATION:**
**Description:**
We will communicate results to the scientific community by submitting approximately three peer-reviewed scientific journal articles for publication. We will communicate findings to the general public through the *Snapshot Cedar Creek* website and by offering education and outreach programs on site in collaboration with the International Wolf Center, and we will continue to collaborate with the International Wolf Center to educate the local community about wolves, and particularly to offer tips for minimizing undesirable interactions between wolves and livestock or pets. Data will be archived and disseminated via the Cedar Creek website. We will continue to communicate with our local County Conservation Officers, Wildlife Services personnel, and other agency representatives involved in wolf conservation and management.

**Status as of January 1, 2018:**

**Status as of July 1, 2018:**

**Status as of January 1, 2019:**

**Status as of July 1, 2019:**

**Status as of January 1, 2020:**

**Final Report Summary:**

**VI. PROJECT BUDGET SUMMARY:**

**A. Preliminary ENRTF Budget Overview:**

***This section represents an overview of the preliminary budget at the start of the project. It will be reconciled with actual expenditures at the time of the final report.**

| Budget Category | $ Amount | Overview Explanation |
|---|---|---|
| Personnel: | $212,000 | 1 postdoctoral scholar at 100% FTE for 2 years to lead field data collection and analysis efforts and publish papers ($109,000). 1 graduate student field assistant at 12.5% FTE (half time during summer) for each of 3 years to sample plants and soils ($25,000). 3 undergraduate students at 23% FTE (full time for 12 weeks) during each of 3 summers to assist with collaring wolves, establishing and maintaining cameras, and sampling plants and soils ($67,000). 1 temporary employee at 7.7% FTE (full time for 4 weeks) for each of 3 years to assist with collaring wolves and managing GPS data ($11,000). |
| Professional/Technical/Service Contracts: | $70,000 | 1 GIS analyst and web developer (TBD, competitive bid) to process data and metadata from collars and cameras, and to develop the citizen science website ($70,000). |
| Equipment/Tools/Supplies: | $104,000 | 6 Lotek GPS collars (estimated at $2,900 each), ATS telemetry receiver and datalogger ($1,600) to track wolf movements. 140 Reconyx PC900 Trail Cameras ($550 each, winter ready, motion- and heat-sensing). 2 Handheld GPS units ($1,000 each) to relocate trail cameras. Supplies: camera supplies (batteries, memory cards, security devices, $4,000), fencing materials to mount cameras ($1,000), clippers to sample vegetation ($1,000). |
| Other: | $12,000 | Chemical analyses of soils at UMN Soils Lab (ammonium, nitrate, total soil nitrogen and total soil carbon @$16 per sample x 250 samples per year x 3 years). |
| **TOTAL ENRTF BUDGET:** | **$398,000** | |

**Explanation of Use of Classified Staff:** NA

**Explanation of Capital Expenditures Greater Than $5,000:** NA

**Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:** 4.7

**Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:** 1.0

**B. Other Funds:**

| Source of Funds | $ Amount Proposed | $ Amount Spent | Use of Other Funds |
|---|---|---|---|
| **Non-state** | | | |
| | $0 | $0 | |
| **State** | | | |
| Indirect costs associated with this project waived by UMN | $212,000 | $0 | |
| **TOTAL OTHER FUNDS:** | **$212,000** | **$0** | |

**VII. PROJECT STRATEGY:**

**A. Project Partners:**

**Partners receiving ENRTF funding**

*None*

**Partners NOT receiving ENRTF funding**

*Dr. Forest Isbell, Associate Director, Cedar Creek Ecosystem Science Reserve and Adjunct Assistant Professor, University of Minnesota, Project Manager, oversee entire project*

*Dr. David Mech, Senior Research Scientist, USGS and Adjunct Professor, University of Minnesota, Co-investigator, co-lead Activity 1*

*Dr. Craig Packer, Professor, Department of Ecology, Evolution & Behavior, University of Minnesota, Co-investigator, co-lead Activity 2*

*Dr. Caitlin Barale Potter, Education and Outreach Coordinator, Cedar Creek Ecosystem Science Reserve, University of Minnesota, Collaborator, co-lead Activity 4*

**B. Project Impact and Long-term Strategy:**

*Results from the project will inform policy decisions regarding the protection of wolves by the US FWS or the management of wolves by the MN DNR, as well as the role of top predators in the restoration of ecosystems by many state and federal agencies and conservation organizations. It will also make major strides in educating the local community and broader general audiences about the role of top predators in ecosystems through the Snapshot Cedar Creek citizen science platform. This project is extremely timely given that expanding wolf populations have for the first time in a century become established on the north side of a major Minnesota metropolitan area. To sustain the proposed project long after 2020, we will seek additional funding from the National Science Foundation (NSF), the National Geographic Society, and other organizations. Cedar Creek is world renowned for conducting high-impact long-term ecological research.*

**C. Funding History:**

| Funding Source and Use of Funds | Funding Timeframe | $ Amount |
|---|---|---|
| *None* | | $ |

**VIII. REPORTING REQUIREMENTS:**

- **The project is for 3 years, will begin on 07/01/2017, and end on 06/30/2020.**
- **Periodic project status update reports will be submitted** *July 1* **and** *January 1* **of each year.**
- **A final report and associated products will be submitted between June 30 and August 15, 2020**.

**IX. VISUAL COMPONENT or MAP(S):**

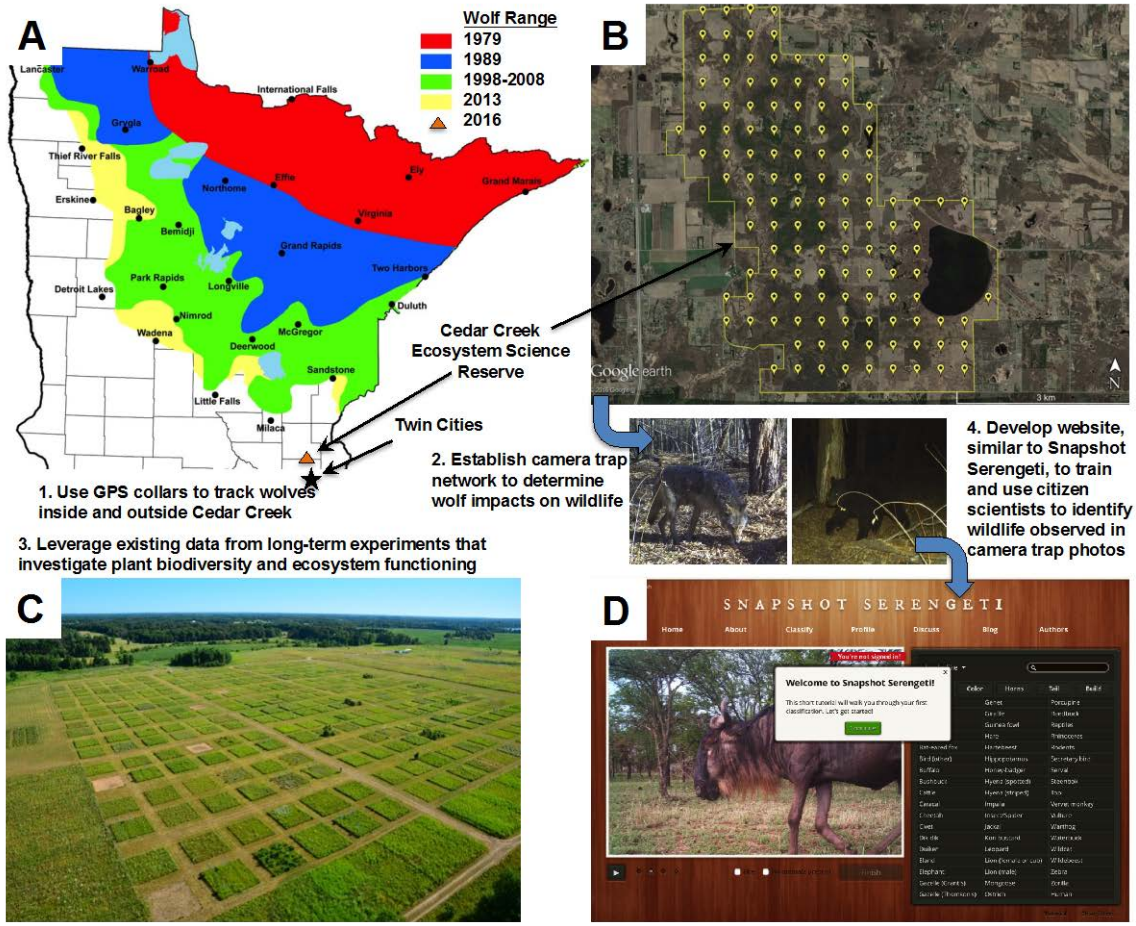


**Figure legend:** (A) Map showing changes over time in wolf range in Minnesota, as well as locations of Cedar Creek and the Twin Cities (source: MN DNR). (B) Map showing Cedar Creek (source: Google Earth). (C) Photo of one long-term field experiment at Cedar Creek (source: Jacob Miller). (D) Photo of a citizen science website similar to the one we propose to develop (source: www.snapshotserengeti.org).

**X. FEE TITLE ACQUISITION/CONSERVATION EASEMENT/RESTORATION REQUIREMENTS:** None

**Environment and Natural Resources Trust Fund**

**M.L. 2017 Project Budget**

**Project Title:** Cedar Creek Natural Area Wolf Recolonization Assessment

**Legal Citation:** M.L. 2017, Chp. 96, Sec. 2, Subd. 03k

**Project Manager:** *Forest Isbell*

**Organization:** *Cedar Creek Ecosystem Science Reserve, University of Minnesota*

**M.L. 2017 ENRTF Appropriation: $398,000**

**Project Length and Completion Date:** *3 Years, June 30, 2020*

**Date of Report:** *September 14, 2016*

| ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET | Activity 1 Budget | Amount Spent | Activity 1 Balance | Activity 2 Budget | Amount Spent | Activity 2 Balance | Activity 3 Budget | Amount Spent | Activity 3 Balance | Activity 4 Budget | Amount Spent | Activity 4 Balance | TOTAL BUDGET | TOTAL BALANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BUDGET ITEM** | ***Use GPS collars to track wolf*** | | | ***Establish camera trap network*** | | | ***Resample plants and soils*** | | | ***Develop citizen science website*** | | | | |
| **Personnel (Wages and Benefits)** | $70,000 | $0 | $70,000 | $58,000 | $0 | $58,000 | $84,000 | $0 | $84,000 | | | | $212,000 | $212,000 |
| Postdoctoral Scholar, $109,000 (82% salary, 18% benefits), 100% FTE each year for 2 years | | | | | | | | | | | | | | |
| Graduate Student Summer Research Assistant, $25,000 (85% salary, 15% benefits), 12.5% FTE each year for 3 years | | | | | | | | | | | | | | |
| 3 Undergraduate Student Summer Field and Lab Assistants, $67,000 (100% salary, 0% benefits), Each position at 25% FTE each year for 3 years | | | | | | | | | | | | | | |
| Temporary and Casual Field Assistant $11,000 (93% salary, 7% benefits), 7.7% FTE each year for | | | | | | | | | | | | | | |
| **Professional/Technical/Service Contracts** | | | | | | | | | | $70,000 | $0 | $70,000 | $70,000 | $70,000 |
| TBD (competitive bid): GIS Analyst and Web Developer to process data and metadata from collars and cameras, and to develop citizen | | | | | | | | | | | | | | |
| **Equipment/Tools/Supplies** | $19,000 | $0 | $19,000 | $85,000 | $0 | $85,000 | | | | | | | $104,000 | $104,000 |
| 6 Lotek GPS collars (estimated at $2,900 each), ATS telemetry receiver and datalogger ($1,600) to track wolf movements | | | | | | | | | | | | | | |
| 140 Reconyx PC900 Trail Cameras ($550 each, winter ready, motion- and heat-sensing) | | | | | | | | | | | | | | |
| 2 Handheld GPS units ($1,000 each) to relocate trail cameras | | | | | | | | | | | | | | |
| Supplies: camera supplies (batteries, memory cards, security devices, $4,000), fencing materials to mount cameras ($1,000), clippers to sample vegetation ($1,000) | | | | | | | | | | | | | | |
| **Other** | | | | | | | $12,000 | $0 | $12,000 | | | | $12,000 | $12,000 |
| Chemical analyses of soils at UMN Soils Lab (ammonium, nitrate, total soil nitrogen and total soil carbon @$16 per sample x 250 samples per year x 3 years = $12,000) | | | | | | | | | | | | | | |
| **COLUMN TOTAL** | **$89,000** | **$0** | **$89,000** | **$143,000** | **$0** | **$143,000** | **$96,000** | **$0** | **$96,000** | **$70,000** | **$0** | **$70,000** | $398,000 | $398,000 |