M. L. 2018 Project Abstract
For the Period Ending June 30, 2022

PROJECT TITLE: Conserving Minnesota's Nine Species of Freshwater Turtles
PROJECT MANAGER: Seth Stapleton
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03k as extended by M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18

APPROPRIATION AMOUNT: $300,000
AMOUNT SPENT: $280,716
AMOUNT REMAINING: $19,284

Sound bite of Project Outcomes and Results

The Minnesota Zoo conducted research and implemented conservation actions including nest site protection and head-starting to bolster wood turtle populations. We studied methods to mitigate road mortality of turtles, with results suggesting that simple tube barriers may be effective. Our outreach efforts raised awareness and encouraged action to benefit conservation.

Overall Project Outcome and Results

Native turtles are a key component of diverse, healthy, and resilient aquatic ecosystems, inspiring connections to nature for children and adults alike. However, populations of turtles in Minnesota face numerous threats, including habitat loss and degradation, high predation of incubating nests, and mortality on roadways. With this project, the Minnesota Zoo sought to improve the conservation of turtles by 1) collecting data to quantify two key threats – road mortality and nest predation – and implement and evaluate mechanisms to mitigate these threats; and 2) building public awareness by developing educational and outreach materials for use during on- and off-site programming.

We outfitted imperiled wood turtles with radio and GPS transmitters, improving our understanding of their habitat needs and allowing us to identify and protect nesting sites. We reared hatchling wood turtles in captivity for their first year of life to improve their chances of survival in the wild and bolster depleted populations while other threats are addressed. To date, we have successfully released 68 one-year-old wood turtles back to the wild.

We also investigated strategies to mitigate mortality of turtles on Minnesota's roadways via cost-effective mechanisms including wildlife warning signs and small barriers. Although warning signs did not significantly reduce turtle mortality, corrugated pipe barriers were promising and yielded a decline in mortality of ~50%.

Finally, a variety of materials, including interpretive signage, a 3-dimensional snapping turtle model, and a children's book, were created to support educational and outreach programming and inspire public action to benefit the conservation of turtles. Healthy populations of turtles are an integral component of aquatic systems, and we anticipate that our results will inform effective management strategies that can benefit conservation at sites state-wide.

Project Results Use and Dissemination

Sharing information about the importance of turtles and their conservation was a key objective of this project. The Minnesota Zoo used a variety of platforms to disseminate significant findings and engage the general public in the conservation of Minnesota's aquatic resources, ranging from informal talks, public lectures and tabling events to media spotlights and distributing content on our social media channels. Media highlights include features on PBS's *Prairie Sportsman*, Kare 11's *Minnesota Bound*, a Minnesota Lottery commercial, and a variety of other print and television media outlets. This professionally-produced video highlights the ecology and conservation of turtles in Minnesota.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2018 ENRTF Work Plan Final Report (Main Document)

Today's Date: August 15, 2022

Final Report

Date of Work Plan Approval: June 5, 2018

Project Completion Date: June 30, 2022

PROJECT TITLE: Conserving Minnesota's Nine Species of Freshwater Turtles

Project Manager: Seth Stapleton

Organization: Minnesota Zoo

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Location: Dakota County /statewide

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$300,000**
	Amount Spent:	**$280,716**
	Balance:	**$19,284**

Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03k as extended by M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18

Appropriation Language: $300,000 the second year is from the trust fund to the Minnesota Zoological Garden to improve the long-term viability of Minnesota's imperiled turtle populations by researching threats, identifying mitigation strategies, implementing mechanisms to reduce threats and mortality, and creating related outreach and educational materials. This appropriation is available until June 30, 2021, by which time the project must be completed and final products delivered.

M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18. ENVIRONMENT AND NATURAL RESOURCES TRUST FUND EXTENSIONS. [to June 30, 2022]

I. PROJECT STATEMENT:

With its vast network of lakes and waterways, Minnesota is home to an abundance of aquatic and semi-aquatic wildlife, including nine species of native freshwater turtles. Turtles are a key component of diverse, healthy, and resilient aquatic ecosystems, often functioning as an indicator species that reflect broader environmental conditions. Turtles also inspire connections to nature for children and adults alike.

Minnesota's turtles, however, face numerous threats during different life stages, including habitat loss and degradation, collection for the pet trade, high predation of incubating nests, and mortality of juveniles and adults on Minnesota's roadways. These issues threaten the long-term viability of some populations, and as a result, two species – the Blanding's turtle and the wood turtle – are now listed as threatened in the State and globally endangered.

With the support of ENRTF, the Minnesota Zoo will work to improve the long-term viability of turtle populations in Minnesota. We will expand our current partnership with Minnesota Department of Transportation (MnDOT) and Department of Natural Resources (DNR) to quantify two of the primary threats facing imperiled turtles and implement and evaluate mechanisms to mitigate these threats. The Zoo will also use its large visitor-ship and its expertise in education and outreach programming to promote public awareness of turtle conservation and encourage individual actions that benefit healthy and biodiverse aquatic systems. We anticipate that local and state management authorities will be able to use the results of this project to devise and implement effective management strategies that can benefit conservation of turtles at sites state-wide.

The specific objectives for this project are:

1) To collect foundational data that characterizes two key threats – road mortality and nest predation – currently facing Blanding's turtles, wood turtles, and other Minnesota species;

2) To implement and evaluate at least 3 mechanisms to improve the conservation of imperiled turtles, including cost-effective measures to reduce mortality on roadways and strategies to improve hatching success;

3) To develop educational and outreach materials and use on- and off-site programming as vehicles to share key conservation messages to >1 million annual visitors at the Zoo and beyond.

II. OVERALL PROJECT STATUS UPDATES:

First Update January 31, 2019

The Minnesota Zoo's freshwater turtle conservation initiative, supported by the Environment and Natural Resources Trust Fund, completed a successful initial field season. Dr. Tricia Markle was hired to conduct research and outreach activities and began her full-time position during July, 2019. We vetted and selected 17 sites from across the greater metropolitan region and collected foundational data quantifying road mortality during summer and early fall, 2018. We documented high rates of turtle mortality at several sites and will be installing and testing mitigation treatments beginning this spring. We also outfitted 8 wood turtles across 5 sites in southeastern Minnesota with GPS transmitters to document their movements, spatial ecology and habitat use. We are currently analyzing locality data to evaluate potential nesting sites at which predator exclusion fencing may be most effective in protecting turtle eggs.

Zoo staff also have worked to disseminate information on turtle ecology and their conservation both at the Zoo and off-site. We are in the process of developing education and outreach materials, and we are working with other departments to further raise public awareness of turtle conservation by creating on-site displays and social media resources. We have participated in multiple speaking engagements and are expanding our turtle conservation partnerships.

Second Update June 30, 2019

The Zoo's Conservation staff have continued to successfully implement our freshwater turtle conservation initiative over the past 5 months. During May, we resumed monitoring at sites around the greater metro region as part of a study designed to quantify rates of turtle mortality on Minnesota's roads and explore cost-effective alternatives for mitigation. At 3 sites, we installed temporary turtle crossing signs, which will remain in place during the period of peak turtle activity (May – July) to evaluate their efficacy in reducing mortality. We are investigating additional strategies that may be implemented in 2020 to mitigate mortality.

In partnership with the Department of Natural Resources, we are continuing to track wood turtles to inform management and conservation efforts. During May and June, we deployed GPS transmitters on 10 adult wood turtles to quantify habitat use and identify nesting sites. We constructed electrified fencing at 2 prospective nesting sites this spring to evaluate its effectiveness in reducing predation and improving recruitment.

Zoo staff also developed several outreach materials during the winter months, including creating a coloring and fact sheet about wood turtles, printing Blanding's turtle stickers to complement this handout, and devising a hands-on activity to raise awareness about turtles. We are partnering with departments across the Zoo to develop on-site signage, a public awareness video, and a 3-dimensional model for use with outreach programming. We are assisting the Zoo's Education staff with an initiative tracking wild turtles on-site, offering a unique, hands-on citizen science initiative, and we continued to disseminate information about turtle conservation through public talks and events, email blasts to Zoo members, and other outlets.

Third Update January 31, 2020

We completed the second full field season of the Minnesota Zoo's freshwater turtle initiative in mid-October, 2019. We conducted road mortality surveys at 15 sites across the greater metro region during 2019, with mitigation treatments (temporary turtle crossing signs) installed at 3 sites in Washington County. Additional data collection in 2020 will provide two complete seasons of before – after data to analyze the effectiveness of road signs in reducing mortality of turtles and other small wildlife. The Zoo is exploring options with Dakota and Hennepin Counties for deploying additional mitigation strategies (such as road paint and / or dynamic traffic signs) at sites in spring, 2020.

In close collaboration with the DNR, Zoo staff continued researching wood turtle populations and implemented conservation actions in southeastern Minnesota. Through summer and fall, 2019, we tracked 19 turtles over three sites with GPS and VHF transmitters. Data are being used to quantify movements, habitat use, potential threats, and locations of nesting sites, all of which are critical in developing management strategies for this species. At two nesting sites, we constructed predator exclusion electric fencing; we maintained and monitored these fences through summer, 2019. Two wood turtles nested within the fenced enclosure at one of these sites, and hatchlings were observed there in late summer. This is a significant development for this population, which is believed to have high nest predation and very low levels of recruitment. During analysis of GPS data from wood turtles tracked during 2017 – 2019, we identified new potential nesting sites and plan to expand nest protection measures in 2020.

Zoo staff continue to share information about Minnesota's turtle populations, the threats they face, how the Zoo, DNR and other partners are working to improve turtle conservation in the state, and what the general public can do to help. News clips, social media posts, and public talks continue to provide a platform for us to tell the story of turtle conservation efforts in Minnesota, while Zoo Conservation and Education staff connect directly with various groups both on- and off-site. We are developing new materials, including an interpretive sign that will be installed at the Zoo this spring, and we have disseminated hundreds of copies of the children's book "A Turtle's Dangerous Journey."

Amendment Request January 31, 2020
We are requesting that funds be shifted within budget category Equipment/Tools/Supplies from the predator exclusion fencing line to the GPS transmitter line (both within Activity 2).

- Predator exclusion fencing line would be reduced by $8,500 to a revised budget of $11,775.
- GPS transmitter budget would increase by $8,500 to a revised budget of $22,500.

Supplies associated with predator exclusion fencing are significantly less than anticipated, and we are requesting to reallocate some of that funding to purchase additional GPS transmitters to track wood turtles at our study sites. These transmitters have proven critical to identifying specific nesting sites so that we are able to 1) construct the predator exclusion fences in the best possible locations and 2) monitor the individual nests to evaluate predation and hatching success. We used all funding in the current ENRTF budget for GPS transmitters deployed during 2018 and 2019. Deploying additional transmitters during 2020 will be very valuable to evaluating the effectiveness of the fencing and improving wood turtle conservation in the state.

Amendment Approved by LCCMR 2/8/2020

Fourth Update June 30, 2020
The COVID-19 pandemic presented challenges to project implementation over the past several months. Essential fieldwork generally has proceeded as planned, but most outreach and educational activities were cancelled or postponed. We initiated road mortality research during the first week of May. We are monitoring 12 sites during 2020, including 4 sites with temporary “turtle crossing” signs designed to raise driver awareness and 1 site with an 8-inch pipe barrier that we are evaluating as a means to reduce attempted road crossings; the remainder serve as reference (control) sites. We are not collecting data from 3 sites in Dakota County that were monitored in previous years, as the county is planning a major road reconstruction at these sites beginning this summer.

We continued tracking wood turtles outfitted with VHF transmitters through the winter months. In partnership with the Minnesota DNR, we deployed GPS and VHF transmitters on more than 20 adult and juvenile wood turtles in May, including 15 adult turtles outfitted with GPS devices for fine scale monitoring of habitat use. In mid-June, DNR and Zoo staff monitored nesting turtles for several nights and protected 8 wood turtle nests. Eggs from some nests were returned to the Zoo for incubation to safeguard against predation and other potential threats (e.g., inundation due to heavy rain). A subset of hatchlings will be reared at the Zoo during their first year and released next summer. From eggs incubated in 2019, 13 wood turtles were reared at the Zoo over the winter and released back to the site at the end of June, 2020. We also installed predator exclusion fences at 2 sites to further protect nests and inform our assessment of fencing efficacy.

Finally, numerous outreach activities and the development of educational materials were postponed due to COVID-19, including production of a video highlighting turtle conservation in Minnesota, creation of a 3D turtle model, and implementation of an on-site citizen science initiative. Zoo staff continue to share key messages about turtle ecology and conservation via social media and online platforms.

Fifth Update January 31, 2021
We completed the project’s third field season during October 2020. Despite continued challenges stemming from the Covid-19 pandemic, we collected field data as planned throughout the year. For the road mortality study, we conducted surveys at 12 sites around the greater metro region. Mitigation treatments were installed at 5 sites, including 4 sites with temporary turtle crossing signs and 1 site with a small barrier comprised of corrugated pipe. We now have collected a full season of data before and after installation of mitigation treatments. Preliminary data suggest mixed results for the warning signs, but the pipe barrier results are promising.

We continued tracking wood turtles during summer – fall, 2020, including 22 adults and 4 juveniles outfitted with GPS or VHF transmitters. Unfortunately, an adult female was killed by farming equipment in July, and 2 other adult turtles later went missing in the same area, presumed to have been killed during by agricultural activities. These losses highlight some of the human-induced threats facing wood turtles. We maintained predator exclusion electric fencing at 2 nesting sites through the summer, and in partnership with the DNR, we confirmed 8 wood turtle nests at 2 of 4 study areas. A subset of eggs from these nests was returned to the Zoo for incubation and head-starting; 35 of these 38 eggs hatched. Fifteen hatchlings were released near the nesting sites in mid-September, and we are rearing the remaining 20 individuals at the Zoo as a continuation of our head-starting initiative. We found evidence of successful hatching at 2 remaining protected nests.

Outreach efforts continued to be hampered by the Covid-19 pandemic. A large inflatable Blanding's Turtle was featured at "Nature Illuminated," the Zoo's winter drive-through event, and we highlighted turtle conservation efforts through social media channels. Additional accomplishments included the completion of a durable, 3-dimensional snapping turtle model for use during outreach activities and the near-completion of a short film highlighting Minnesota's turtles and our efforts to conserve them.

Project extended to June 30, 2022 by LCCMR 6/30/21 as a result of M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18, legislative extension criteria being met.

Sixth Update June 30, 2021

The project's fourth field season began in May 2021. Although we completed most road mortality data collection last year, we are continuing to monitor one site outfitted a corrugated pipe barrier (and a corresponding control site) to further inform the utility of pipe as a potential road mortality mitigation measure. We also are collecting another year of data from several sites in Dakota County in anticipation of a road reconstruction project that will begin later this year. This project is near the Zoo and will include wildlife underpasses that may be monitored by Minnesota Zoo and Dakota County Park staff in the future.

The Zoo's wood turtle conservation efforts are continuing to demonstrate success. In partnership with the DNR, we are currently tracking ~30 wood turtles outfitted with VHF and GPS transmitters in southeastern Minnesota, including 6 new adults added to the sample this spring, 5 of which are mature females. During June, Zoo and DNR staff collected 68 wood turtle eggs that are being incubated at the Zoo. Additional eggs are incubating with the DNR, and we protected one additional nest *in situ*. A subset of these hatchlings will be reared at the Zoo for the coming year as part of our collaborative head-starting program. Twenty head-start wood turtles collected as eggs last year and reared at the Zoo for the past 11 months were released back to their natal sites earlier in June.

Education and outreach efforts continue to be significantly impacted by the COVID-19 pandemic: school groups and summer camps have not yet returned in-person to the Zoo, and many other educational activities related to turtle conservation remain on hold. However, the Zoo has continued to provide important conservation messaging to the public via other mechanisms. Our short film on Minnesota's turtles and the ongoing work to conserve this important natural resource is complete and is being shared online and on Zoo site. Recent media coverage includes a piece on WCCO-TV, articles in the Star Tribune and Dakota County Tribune, and filming for an upcoming PBS show.

Seventh Update January 31, 2022

A one-year extension to our timeline (resulting from the pandemic) enabled us to complete an additional season of field research. This included collection of road mortality data at five sites in the greater Twin Cities metro region. The additional year of data will enable a more robust assessment of whether corrugated tubes can act as effective barriers to keep turtles off roadways. Data also will inform an upcoming road reconstruction project in Dakota County where mitigation efforts will include wildlife underpasses and barriers.

In summer 2021, we also continued to track wood turtles in southeastern Minnesota using VHF radio telemetry. Several new adult turtles were found during the season and incorporated into the study, increasing the number of individuals monitored this year to 32. Working closely with the Minnesota DNR, Zoo staff assisted in locating multiple wood turtle nests. To improve survival and recruitment of wood turtles, we collected eggs from several of these nests for incubation at the Minnesota Zoo. Of 68 total eggs, 62 successfully hatched. Half of these were released to their natal sites in the fall, and the remainder are being reared at the Zoo until spring, 2022 to increase their likelihood of survival.

In addition, GPS data collected during previous years of this project are being analyzed to quantify the spatial ecology of wood turtles at our study sites. Preliminary analyses suggest that female wood turtles move faster and further than male turtles. Females also tend to have larger home ranges and spend less time in the river than males. We are continuing to analyze these data to improve our understanding of their habitat use.

Finally, communication of turtle conservation efforts continues through social media outlets, conference presentations and other venues. Two new interpretive signs will soon be installed at the Minnesota Zoo to raise public awareness about the life history and conservation needs of Minnesota's common snapping and painted turtles.

Final Update June 30, 2022

Fieldwork for the project was completed in fall, 2021, and for the past several months, we have focused on data analysis, interpretation and writing. For the road mortality research, our results suggest that corrugated plastic pipes may offer an inexpensive barrier alternative, reducing turtle mortality at the study site by an average of 50% across the two years. Temporary warning signs targeting driver awareness were less effective, with mortality decreasing at some sites, but increasing at others.

We have continued our work to improve the conservation of wood turtles this spring and summer with the support of a second grant from the Environment and Natural Resources Trust Fund. In partnership with the Minnesota DNR, we tracked more than a dozen adult female wood turtles at 3 sites during the nesting season. In addition, we will release 31 head-started wood turtles, reared at the Minnesota since last summer, back to the wild in the next few weeks. We are continuing to modify our analyses of wood turtle spatial data to better understand their habitat use and nest site selection.

Finally, turtle conservation in Minnesota has been highlighted via the Zoo's social media outlets, features in PBS's Prairie Sportsman and an upcoming episode of Minnesota Bound, and a television spot produced by the Minnesota Lottery.

Overall Project Outcomes and Results

Native turtles are a key component of diverse, healthy, and resilient aquatic ecosystems, inspiring connections to nature for children and adults alike. However, populations of turtles in Minnesota face numerous threats, including habitat loss and degradation, high predation of incubating nests, and mortality on roadways. With this project, the Minnesota Zoo sought to improve the conservation of turtles by 1) collecting data to quantify two key threats – road mortality and nest predation – and implement and evaluate mechanisms to mitigate these threats; and 2) building public awareness by developing educational and outreach materials for use during on- and off-site programming.

We outfitted imperiled wood turtles with radio and GPS transmitters, improving our understanding of their habitat needs and allowing us to identify and protect nesting sites. We reared hatchling wood turtles in captivity for their first year of life to improve their chances of survival in the wild and bolster depleted populations while other threats are addressed. To date, we have successfully released 68 one-year-old wood turtles back to the wild.

We also investigated strategies to mitigate mortality of turtles on Minnesota's roadways via cost-effective mechanisms including wildlife warning signs and small barriers. Although warning signs did not significantly reduce turtle mortality, corrugated pipe barriers were promising and yielded a decline in mortality of ~50%.

Finally, a variety of materials, including interpretive signage, a 3-dimensional snapping turtle model, and a children's book, were created to support educational and outreach programming and inspire public action to benefit the conservation of turtles. Healthy populations of turtles are an integral component of aquatic systems, and we anticipate that our results will inform effective management strategies that can benefit conservation at sites state-wide.

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Reducing mortality of turtles on Minnesota's roadways
Description:
Turtle mortality on Minnesota's roadways is a significant challenge, particularly during the spring and late summer as turtles move among feeding grounds, reproductive sites, and overwintering areas. The Zoo, in close partnership with the Minnesota Department of Transportation (MnDOT), will conduct research to better quantify this threat and evaluate potential mechanisms to mitigate turtle mortality on our roads. Study sites around the greater metropolitan region, as well as southern and central Minnesota, will be selected based on the presence of turtles (particularly imperiled species) and the logistical feasibility of monitoring and installing signs and other measures. Roadways managed by state or local authorities will be considered during the initial vetting process.

We will collect foundational data to document turtle use of and mortality along selected segments of roadways. These efforts will begin at a limited scale prior to the granting period (i.e., during early 2018) and continue through 2018. We will complete at least weekly foot patrols of study sites during seasons of peak movement (late spring, early summer, and late summer), with less frequent surveys at other times of the active season. In collaboration with MnDOT and after consultation with local authorities (where appropriate), we will then implement mechanisms (at select sites) to mitigate turtle mortality such as dynamic traffic signs, road paint and temporary speed reduction zones. We will monitor their impact for two years post-installation. We will also develop training materials for use by citizen scientists to broaden our reach and potentially increase monitoring capacity. Activity 1 will yield information on cost-effective options for reducing mortality of turtles on roads, and we anticipate that effective mitigation measures may be applied elsewhere in the State and at larger spatial scales. To achieve the desired outcomes for both Activities 1 and 2, the Zoo must dedicate a staff person to conduct field surveys, analyses and reporting.

ENRTF BUDGET: $133,113

Outcome	Completion Date
1. Road surveys conducted to collect baseline movement and mortality data.	October, 2018
2. Mechanisms to reduce mortality on roads installed.	April, 2019
3. Efficacy of potential mitigation measures evaluated via post-implementation surveys.	October, 2020
4. Completion of final analyses and preparation of project report and manuscript for publication in peer-reviewed literature, summarizing key findings and recommendations.	June, 2021

First Update January 31, 2019

In summer 2018, the Minnesota Zoo hired a turtle biologist, Dr. Tricia Markle, to conduct field work and research for the road mortality study and other activities associated with this award. Beginning in early June 2018, we identified and vetted 17 sites along state, county, and city roads for surveys. These sites cover 3 general areas in the greater Twin Cities metro region: north of the Twin Cities (near Scandia), west of Minneapolis in the vicinity of Lake Minnetonka, and south of St. Paul in areas around the Minnesota Zoo (Figure 1). We used online databases of turtle records, such as HerpMapper (https://www.herpmapper.org/), to narrow the pool of candidate sites to focus on those with historical records of turtle mortality. Sites were ultimately selected based on their proximity to wetland areas (i.e., near habitat for turtles), the presence of turtle remains in preliminary searches, and the feasibility of monitoring and installing mitigation measures. Further, localities around Scandia and the Minnesota Zoo fall within the known distribution of the State of Minnesota Threatened Blanding's turtle and are thus priority areas for road mortality mitigation.

During this initial field season, we collected foundational, pre-treatment data on turtle road mortality, and we opportunistically documented other observations of wildlife mortality. Data collection at these sites began in early June 2018 and ended in mid-October. By mid-fall, temperatures had dropped to a point where turtles were no longer found on roadways. Sites were typically sampled on a weekly basis, resulting in 17 to 20 total visits per site. Sites with fewer visits where those that were not added until near the start of the state fiscal year 2019, corresponding to availability of funding associated with this award and the transition of Dr. Markle's position to full-time status.

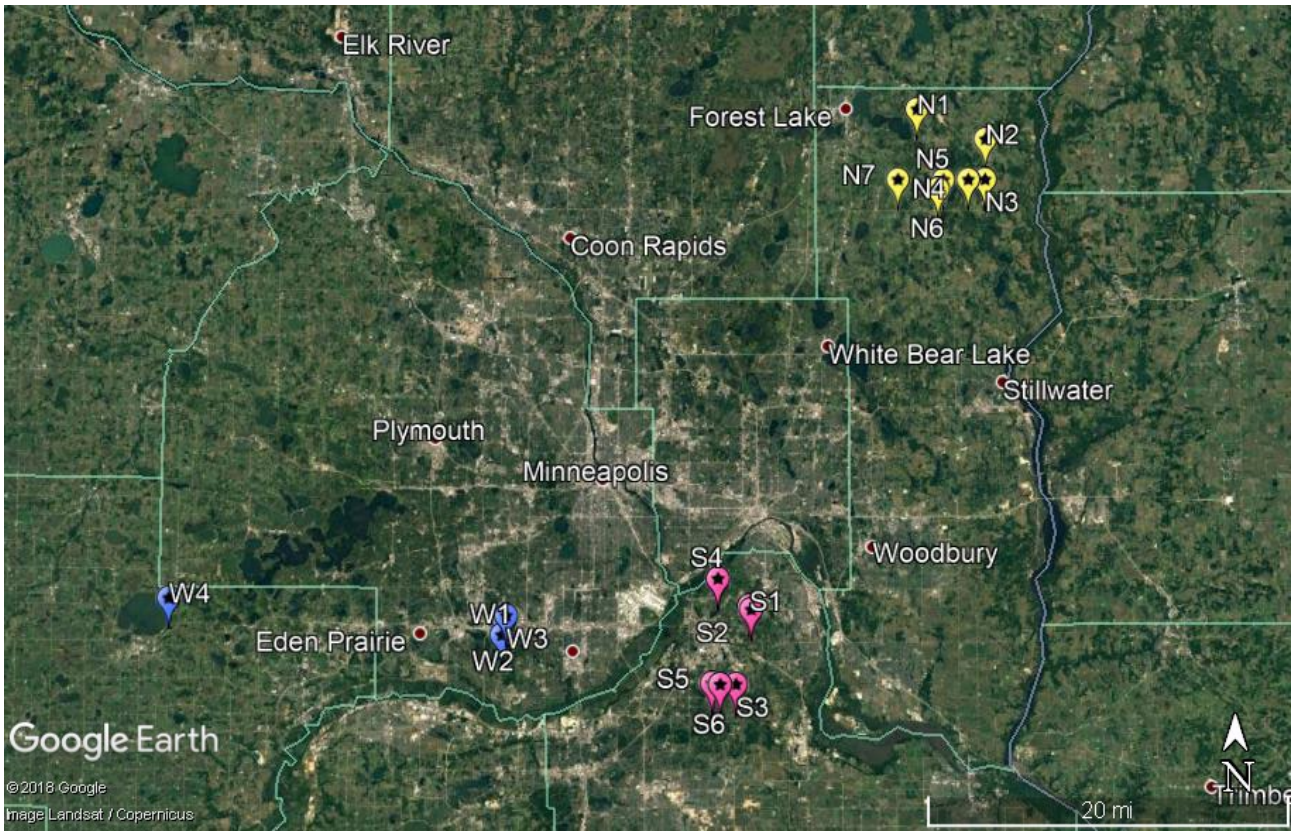

Figure 1. Road mortality study survey sites monitored during late spring – early fall, 2018, in the greater Twin Cities metropolitan region.

To collect mortality data, observers walked single file along each road segment, recording all deceased (and any live) animals on roads and within the first ~2 feet of the shoulder. Site boundaries were delineated with spray paint to ensure consistency in monitoring effort. Over the course of the season, we encountered a total of 313

turtles (Table 1); the vast majority of these observations were deceased. A small number of live turtles (6) were encountered on roads during the surveys. When safe to do so, live turtles were assisted across the highway in the direction they were headed.

Sites varied greatly in frequency of turtle encounters, ranging from 2 to 47 total turtles over the course of the season. Because sites varied in length from ~400 to ~1,800 f, we standardized for segment length to better facilitate comparisons among sites (see Table 1). We observed the highest rate of encounters at site North 2 (N2; 3.3 turtles/100 feet), where we documented only 0.3 turtles / 100 feet at site West 4.

Turtle movements (based on mortality rates) seasonally varied, reaching peaks in late spring and again in the early fall. Presumably, the increased activity in June was related to movements to foraging areas from overwintering sites and / or females searching overland for appropriate nest sites. The peak in early fall is likely related to the movements of turtles back to overwintering sites. We also observed several snapping turtle hatchlings on roads in the early fall.

In cooperation with state and county road authorities, we currently are selecting sites for the installation of measures to mitigate turtle mortality on Minnesota's roadways. Before turtles emerge this spring (i.e. by late April), we anticipate installing seasonal, flashing signs to raise driver awareness of turtle crossing hotspots at a sample of sites. These treatment sites will be paired with corresponding controls. Our selection of sites for mitigation treatments is semi-randomized, based on the presence of turtles, logistical feasibility of sign installation, and broad geographic representation. Because monitoring at some sites did not begin until mid-summer, 2018 due to capacity constraints, we will continue to collect baseline data in these areas to ensure that we are best able to evaluate the effectiveness of mitigation strategies via our before-after control-impact study design. As such, installation of mitigation measures may extend to spring, 2020. We will continue to explore alternative techniques for mitigation, such as road paint.

Table 1. Observations of turtles documented during mid-June - October, 2018 at sites north of the Twin Cities (near Scandia), west of the Minneapolis near Lake Minnetonka, and south of St. Paul in areas around the Minnesota Zoo. Sites: N = North, S = South, and W = West.

Site	Painted Turtles	Snapping Turtles	Unknown Species	Total Turtles	Site Length (feet)	Turtles / 100ft
N1	19	4		23	1,155	2.0
N2	18	2	1	21	638	3.3
N3	6		1	7	1,250	0.6
N4	24	3		27	1,437	1.9
N5	16	3		19	1,738	1.1
N6	26	10		36	1,392	2.6
N7	20			20	1,456	1.4
S1	22	9		31	1,155	2.7
S2	6	4	1	11	638	1.7
S3	13	1		14	1,250	1.1
S4	4	2		6	1,437	0.4
S5	32	7	8	47	1,738	2.7
S6	5	1	1	7	1,392	0.5
W1	19	4	1	24	1,805	1.3
W2	1		1	2	378	0.5
W3	10	5		15	813	1.8

W4	3	4		3	1000	0.3
Total	**244**	**55**	**14**	**313**		

Following installation of initial mitigation measures during spring 2019, we will monitor sites weekly (after temperatures are warm enough to promote movement of turtles) to document their effectiveness in reducing road mortality. We will also deploy traffic counters in 2019 to quantify traffic volume and speed as a potential predictors of road mortality.

Second Update June 30, 2019

We began monitoring sites as part of the road mortality study on May 6, 2019. As in 2018, sites were distributed among regions north of the Twin Cities near Scandia, southwest of the Twin Cities in the Bloomington area, and south of St. Paul around the Minnesota Zoo. Of the 17 sites that were monitored last year, we stopped monitoring 2 this season due to road construction. We removed a third site from the study because of low documented rates of mortality and replaced it with a site that we believe will yield higher rates of mortality and thus strengthen our results and inferences. Weekly foot-based surveys will continue through late summer / early fall until about mid-October, after most turtle movements have ended for the season.

To evaluate the effectiveness of relatively inexpensive mitigation strategies, we selected 3 sites in the Scandia area for installation of turtle-crossing signs. Selection of sites for mitigation was semi-randomized, based on the presence of target species, logistical feasibility of sign installation, and geographic representation of the area. We worked with Washington County Public works to produce six identical signs (one facing each direction of traffic at each of the three sites) reading “Turtle Crossing Next 600 Ft” (Figure 2). The 600 foot-distance represents the average length of turtle crossing “hotspots” in the area. After discussion with Washington County Public Works and MnDOT staff, we decided that a silhouetted image of a turtle on signs may make them targets for theft; hence, we designed signs using exclusively text.

Signs were temporarily installed on May 30 and will remain in place until July 15, a window which corresponds with the period of peak turtle activity (associated with movements among foraging areas and to / from nesting sites). Other research has suggested that temporary wildlife warning signs are more effective than permanent installations since the public may become desensitized to signs over a relatively short period of time (i.e., within weeks). In addition, the temporary appearance of the sign installation (i.e., signs posted on sandbag-supported frames along the road shoulder) is believed to be more effective in attracting driver attention. We anticipate that assessing temporary warning signs as a mitigation strategy will continue next year; data collected in 2019 and 2020 will be analyzed with pre-treatment data to evaluate the effectiveness of temporary signs. Each treatment site also has a corresponding control site along the same stretch of road to help control for variation among sites and across years in factors such as traffic volume and local environmental conditions. Further, we are temporarily deploying traffic counters at each site to better understand the relationship between traffic volume and turtle mortality.

We are continuing to collect baseline road mortality data for the remaining sites in anticipation of testing additional mitigation measures in 2020.

Figure 2. Temporary turtle crossing road sign installed in Washington County to evaluate its effectiveness at reducing turtle road mortality.

Third Update January 31, 2020

We began road mortality surveys this season on May 6, 2019 and completed them on October 23, 2019, at a point when most turtle movements had ceased. As in 2018, we conducted weekly, foot-based surveys and documented mortality of turtles and other small wildlife (e.g., mammals, snakes, birds, and amphibians). Sites were surveyed an average of 24 times through the season.

Three sites that were monitored in 2018 (Sites N1, W4, and S4) were removed from surveys for 2019. At Site N1, construction is scheduled to begin in 2020, and the site is located on a blind curve that we considered too dangerous for surveying. At W4, we documented a small number of turtles in 2018, suggesting that it is not a site with particularly high mortality, and there was not a comparable site along the road to provide a control. At S4, the local jurisdiction added fencing along both sides of the road to prevent public access to certain areas. This new fence likely impacted wildlife crossings there and thus limited its utility in this study. To offset the removal of these sites, we added a new site (N8) to our northern cluster, bringing the current number of sites we are monitoring to 15 (Figure 3).

Turtle movements again varied by season, with a strong peak in activity during late spring (May – June) and another peak in late summer / early fall (August – September). We documented 430 turtle mortalities during 2019, with encounters by site ranging from 7 to 61 (Table 2). After standardizing for site length, we recorded the highest encounter rate at site S5 (5.2 turtles / 100 ft), whereas site S6 had the lowest encounter rate (0.5 turtles / 100 ft). Mortality numbers were higher during 2019 than 2018, presumably because the 2019 field season started nearly 2 months earlier at most sites (i.e., early May versus late June). We documented a relatively small number of hatchlings (n = 35) during sampling; we also observed 10 live turtles crossing roadways and assisted them to the other side of the road. One important note is that 4 mortalities documented in 2019 were state-threatened Blanding's turtles. We did not confirm a dead Blanding's turtle at any sites in 2018, but this may be due to the later start date of surveys in 2018. Female Blanding's turtles are known to move long distances to find nesting sites, and June is typically when they face the highest road mortality threat.

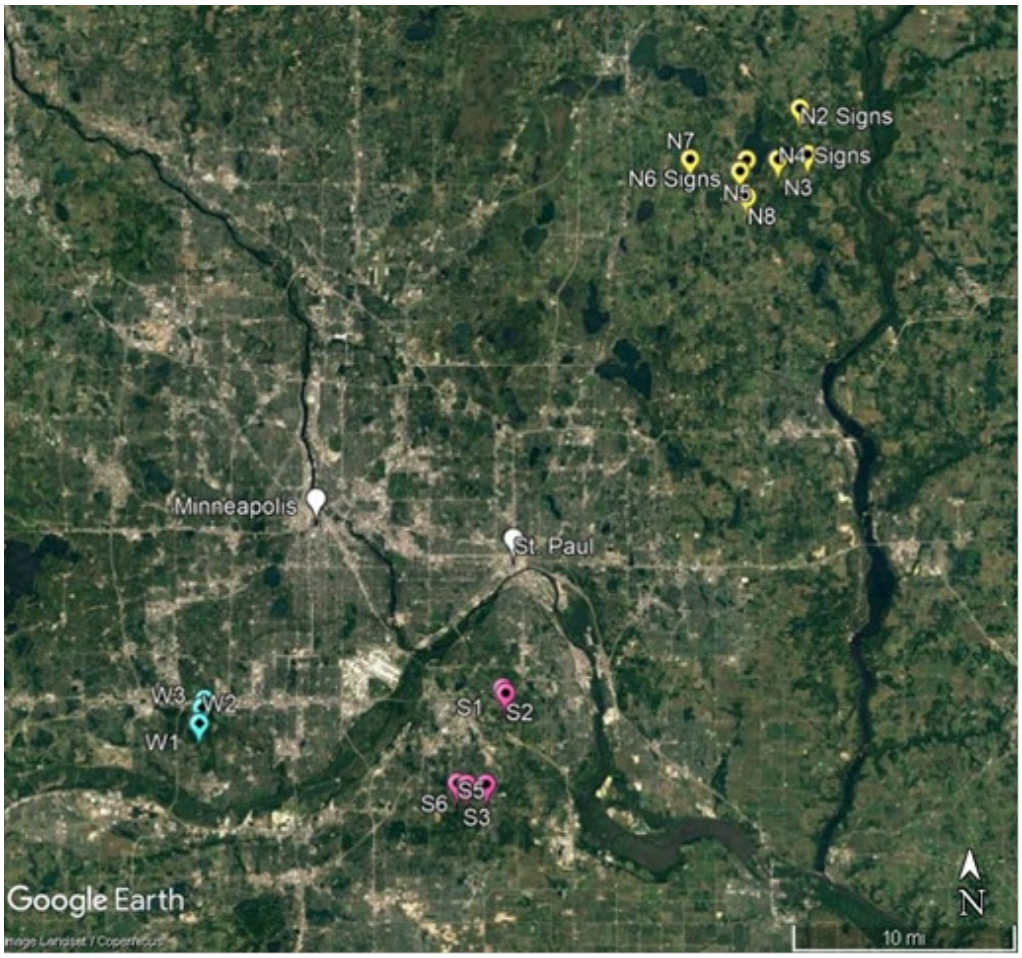

Figure 3. Road mortality sites monitored in 2019, including 15 total sites in the greater Twin Cities metropolitan area, with three sites (N2, N4, and N6) receiving mitigation treatments (temporary "Turtle Crossing" signs).

In spring 2019, we began to deploy treatments to test the effectiveness of relatively inexpensive mitigation measures. Three sites in Washington County were chosen for initial treatment with wildlife warning signs reading "Turtle Crossing Next 600 Feet". Signs were temporarily installed at sites during peak turtle movement (May 29th to July 12, 2019). We monitored corresponding control sites along the same stretch of road to account for between-year and among-site variability. We intentionally installed signs on a temporary basis, as drivers may become desensitized to wildlife signs after a period of a couple of months. After signs were removed, we continued to collect mortality data until the fall.

In addition to turtle crossing signs, we deployed traffic counters at each site on a temporary basis. Traffic counters allowed us to collect data on traffic volume and timing over a multi-day period. This data will be integrated in modeling to help us better understand the relationship between traffic volume and wildlife mortality. Along with the treatment and primary control sites, we continued to monitor the remaining 9 sites to obtain multi-year baseline road mortality data and to provide secondary controls. We anticipate incorporating additional mitigation treatment sites in 2020, potentially including road paint, dynamic road signs, and small barriers. We are currently exploring options with road authorities in Dakota and Hennepin Counties.

For three of our study sites along Cliff Road in Dakota County, road mortality data are being used to inform a road reconstruction project in which multiple wildlife underpasses are being considered. Zoo staff are actively partnering with the Dakota County Parks and Transportation staff to address wildlife considerations for this project. Early construction is scheduled to begin in late 2020, so we are not considering other road mitigation at these mortality hotspots (Sites S3, S5, and S6) in the short-term. We also are collaborating with Parks staff to

develop a monitoring plan for these sites post-construction to evaluate the effectiveness of the newly installed wildlife underpasses.

Table 2. Observations of turtles documented during May 6 – October 23, 2019 at sites north of the Twin Cities (near Scandia), south of St. Paul in areas around the Minnesota Zoo, and west of the Twin Cities near Hyland Park. Sites: N = North, S = South, and W = West.

Site	Painted Turtle	Snapping Turtle	Blanding's Turtle	Unknown Species	Total Turtles	Site Length (feet)	Turtles / 100ft
N2	22	0	0	0	22	638	3.4
N3	58	2	1	0	61	1,250	4.9
N4	21	1	0	0	22	1,437	1.5
N5	21	2	1	0	24	1,738	1.4
N6	24	21	2	0	47	1,392	3.4
N7	20	5	0	0	25	1,456	1.7
N8	16	8	0	1	25	1,175	2.1
S1	32	7	0	0	39	1,155	3.4
S2	4	5	0	0	9	638	1.4
S3	12	5	0	0	17	1,250	1.4
S5	36	17	0	0	53	960	5.52
S6	2	5	0	0	7	625	1.1
W1	40	8	0	0	48	1,805	2.7
W2	5	2	0	0	7	378	1.9
W3	17	7	0	0	24	813	3.0
Total	**330**	**95**	**4**	**1**	**430**		

Fourth Update June 30, 2020

We began monitoring road sites for the 2020 season during the week of May 4. We are conducting weekly surveys of 12 sites throughout the summer, a reduction from the 15 sites sampled in 2019. Specifically, we removed 3 sites along Cliff Road in Dakota County this year, as the road will be reconstructed in the near future. Mortality data collected there during the past 2 years is being used to inform mitigation strategies for the reconstruction project: Dakota County Transportation staff are recommending installation of 3 wildlife underpasses at sites with high wildlife mortality, as well as retaining walls and fencing to direct animals under the road for safe passage. Initial construction of utilities is scheduled this spring and summer, while the full reconstruction will not be complete until at least 2021. Although the Zoo is unlikely to conduct post-construction surveys to determine if these underpasses are effective in reducing wildlife mortality, Dakota County Parks staff hope to gather post-installation data.

To inform our evaluation of mitigation strategies, we once again installed temporary turtle-crossing signs at 3 locations in the Scandia area of Washington County. We implemented a crossover design and switched control and treatment sites from 2019 to obtain a complete season of reference data and post-installation treatment data at each site. In addition, we installed signs at a site in the south metro, yielding a total of 4 'treatment' sites this year. Signs are identical, reading "Turtle Crossing Next 600 Ft," with the 600-foot distance representing the average length of turtle crossing hotspots in the study. Signs were installed the first week of May and will remain in place until the first week of July. This timeline aligns with the seasonal peak in movements as adult female turtles seek out nesting sites. We are also monitoring corresponding control sites and deploying traffic counters to quantify traffic volume. Preliminary data suggest that vehicle traffic is reduced this spring, presumably as a result of COVID-19 pandemic-related impacts.

Finally, we partnered with Dakota County Transportation staff to evaluate the efficacy of a new barrier design in mitigating wildlife road mortality (Figure 4). Dakota County installed a section of 8-inch corrugated drainage pipe at the base of a guard rail, in addition to a corresponding section near a pond on the other side of the road. The ends of the pipe were curved back to the wetland to encourage turtles to stay off the roadway. Unfortunately, we were unable to add a barrier adjacent to a section of the lake to the south due to driveway placement and a narrow shoulder. We added sandbags adjacent to the pipe, which can function as 'exit' ramps for wayward turtles that find their way onto the road. The pipe, which is rolled out near the road and then staked to ground, is relatively easy to install and much less expensive than other barrier (e.g., fencing) options. If preliminary results are promising, we hope to evaluate this alternative at additional sites next year.

Figure 4. Construction of new 8-inch pipe barrier in Dakota County to keep turtles and other small wildlife off roadways.

Fifth Update January 31, 2021

As a result of an unseasonably cool October, we completed the 2020 road surveys on October 15. We visited each of the 12 sites 24 times over the course of the season via weekly surveys. We documented 207 turtle mortalities in 2020, with sites ranging from 4 to 42 occurrences (Table 3). Due to Covid-19 restrictions, traffic was reduced for at least the first half of the summer; this reduction likely is contributing to the overall decrease in turtle road mortality this season. However, we documented similar patterns of activity as in previous years, with peak turtle movements in May – June, followed by a secondary spike in late summer. We observed the highest mortality rate (based on standardization by length) at site N6 (3.02 turtles / 100ft); site N5 had the lowest mortality rate (0.29 turtles / 100ft).

Table 3. Observations of turtles documented May 4 - October 15, 2020 at sites north of the Twin Cities near Scandia, south of St. Paul in areas around the Minnesota Zoo, and west of the Twin Cities near Hyland Park. Sites: N = North, S = South, and W = West. Shaded rows indicate sites with mitigation treatments: N3, N7, N8, and W3 had temporary road crossing signs, and a pipe barrier was installed at S1.

Site	Painted Turtle	Snapping Turtle	Blanding's Turtle	Unknown Species	Total Turtles	Site Length (feet)	Turtles / 100ft
N2	10	1			11	638	1.72
N3	18				18	1,250	1.44
N4	10				10	1,437	0.70
N5	3		1	1	5	1,738	0.29
N6	33	7	2		42	1,392	3.02
N7	18		1		19	1,456	1.30
N8	16	9			25	1,175	2.13
S1	24	2			26	1,155	2.25
S2	15				15	638	2.35
W1	18	5			23	1,805	1.27
W2	4				4	378	1.06
W3	8	1			9	813	1.11
Total	**177**	**25**	**4**	**1**	**207**		

We removed the temporary turtle crossing signs (installed at 4 sites [N3, N7, N8, and W3] in early May) on June 30, 2020, such that their installation encompassed peak turtle activities associated with nesting movements. After signs were removed, we continued to monitor both treatment and control sites for the duration of the season. Preliminary results suggest a reduction in turtle mortality when the signs were in place. However, the pandemic-related reduction in traffic volume likely is related to this decrease in mortality. As such, statistical analyses will need to accommodate traffic volume to determine if signs are having the desired effect. As in 2019, we documented 4 deceased state-Threatened Blanding's turtles this year. We also encountered 8 live turtles at sites during our surveys. Seven painted turtles were assisted across the road, but a large snapping turtle was found injured and was taken to a wildlife rehabilitation center for treatment. We observed at total of 20 hatchling turtles on roads in 2020.

In addition, we partnered with Dakota County Transportation to install 2 ~800 ft sections of 8-inch corrugated pipe at site S1, allowing us to evaluate its effectiveness as a barrier to turtle movements. The pipe is much less expensive than other potential barriers such as chain link fencing, and its installation was completed in a single morning. Initial results appear promising: turtle mortality decreased from 20 in 2019 to 6 in 2020 (~70% reduction) along that stretch of road in which the pipe was installed on both sides (Figure 5). However, the barrier could not be installed along the entire length of this wetland complex, so some turtles accessed the roadway from an adjacent pond to the southwest. In general, the pipe held up well over the course of the summer, but a modest amount of maintenance was required where a small mammal dug under the pipe and where a section was damaged by a mower. We anticipated that tall vegetation falling over the pipe might create a ramp for turtles to crawl over the barrier, but we found no evidence of this issue. Although we collected only 1 year of pre- and post-treatment data from a single site, we believe that the results of this pilot study are encouraging enough to justify additional research. This work is likely beyond the scope of this study, but the Minnesota Department of Transportation has expressed an interest and may test similar barriers in the future.

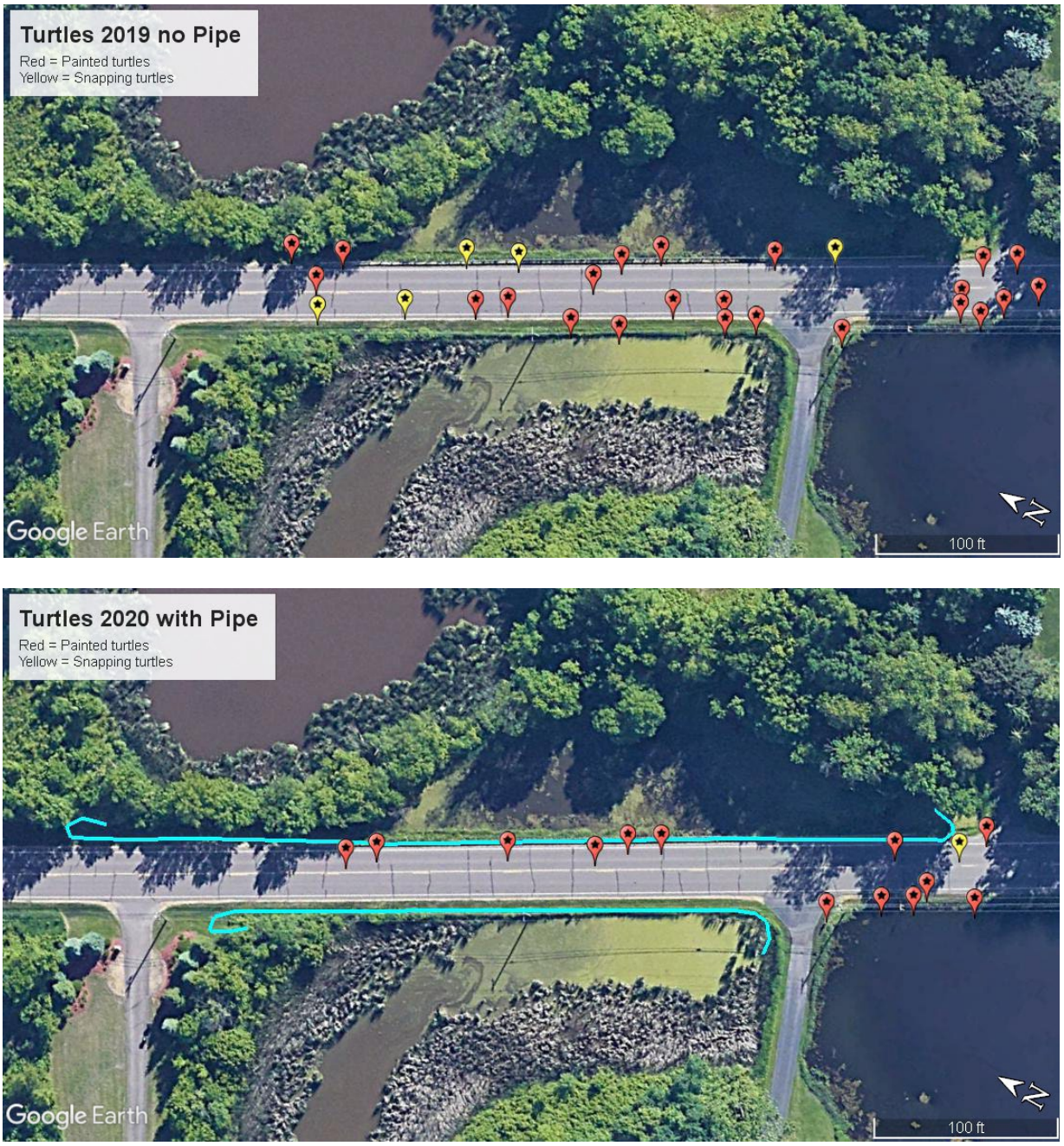

Figure 5. Site S1 before (top) and after (bottom) pipe barrier installed. Barrier indicated by blue lines. Turtle mortality was dramatically reduced from 2019 to 2020 after the barrier was put in place. Note that some turtles still have access to the roadway from a pond in the southwest where a barrier could not be installed.

Sixth Update June 30, 2021

Despite the challenges presented by the pandemic, we completed most road mortality data collection in 2020 as initially planned. However, we are continuing to monitor several sites this year to bolster our dataset. We began monitoring these sites the week of May 3 and will conduct weekly surveys until mid- to late October 2021. The sites that we are continuing to monitor (S1, S2, S3, S5, and S6) are located in Dakota County and occur along Cliff Road and Argenta Trail.

At Site S1, an 8-inch corrugated drainage pipe barrier that was installed in Spring, 2020 has remained in place. To further evaluate the effectiveness of this mitigation measure, we are monitoring the site this summer, which will provide 2 years of data post-treatment installation. Site S2 is located along the same stretch of road and serves as a control. We initially hoped to expand this treatment type to additional sites this year, but reduced capacity as a result of the pandemic precluded scaling up this work in 2021.

Sites S3, S5, and S6 occur along Cliff Road in a section slated for reconstruction starting in Fall, 2021. The Zoo is working with Dakota County Parks staff to continue monitor these sites and establish baseline data on road mortality. County reconstruction plans include small animal exclusion fencing and wildlife underpasses at two of the sites. We anticipate continuing to monitor post-construction to quantify the effectiveness of the project for reducing road mortality of turtles and other small wildlife. Trail cameras will be installed in the underpasses to document wildlife usage of these tunnels.

Seventh Update as of January 31, 2022

We continued to monitor five sites in association with our road mortality study during 2021 (S1, S2, S3, S5, and S6). All sites are located in Dakota county and occur along Cliff Road and Argenta Trail; data collection for the season concluded on October 21, 2021. We documented a total of 119 turtle mortalities this year, with sites ranging from 5 to 42 occurrences (Table 4). We observed the highest mortality rate (based on standardization by length) at site S5 (4.4 turtles / 100ft); site S2 had the lowest mortality rate (0.8 turtles / 100ft).

Table 4. Observations of turtles during road mortality surveys at sites near the Minnesota Zoo, May 3 - October 21, 2021. A pipe barrier mitigation treatment was installed at Site S1 (shaded).

Site	Painted Turtle	Snapping Turtle	Blanding's Turtle	Total Turtles	Site Length (feet)	Turtles / 100ft
S1	22	5	0	27	1,155	2.3
S2	5	0	0	5	638	0.8
S3	28	2	0	30	1,250	2.4
S5	31	11	0	42	960	4.4
S6	8	7	0	15	625	2.4
Total	**94**	**25**	**0**	**119**		

In our second year of data collection in association with the pipe barrier in place along Argenta Trail, we documented 14 turtles along the section of road where the pipe was installed on both sides (Figure 6). Unfortunately, a car drove through the barrier towards the end of the season, and a small number of turtles appeared to have accessed the road through a gap before repairs could be made. Despite the compromised integrity of the pipe barrier, total mortality remained below the recorded pre-treatment levels (20).

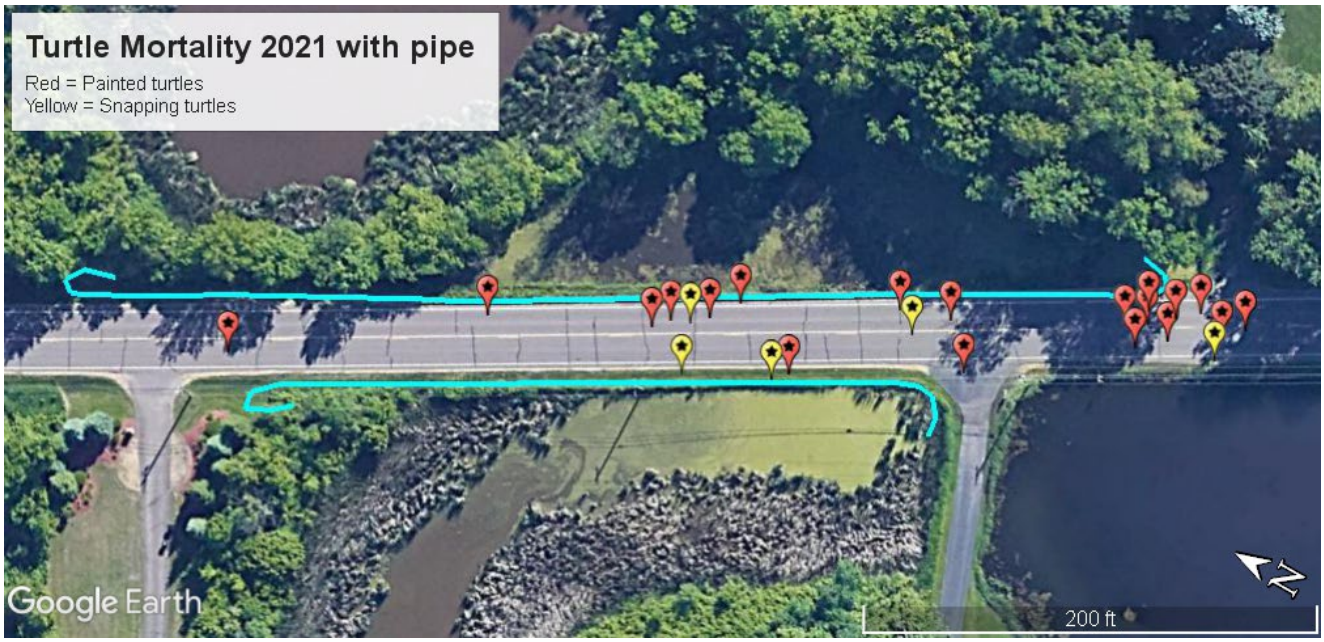

Figure 6. Turtle mortality documented at Site S1 during 2021. The pipe barrier is indicated by blue lines. Note that some turtles still have access to the roadway from a pond in the southwest where a barrier could not be installed.

Data gathered from sites S3, S5, and S6 along Cliff Road further establish baseline numbers on road mortality in that area. The Zoo will continue to partner with Dakota County Parks to monitor the effectiveness of mitigation efforts for an upcoming road reconstruction project at that site, which may include barriers and wildlife underpasses.

Final Update June 30, 2022

We completed road mortality data collection during fall, 2021. The corrugated pipe barrier yielded a reduction in turtle mortality by ~50%, on average, over the two years of this study, an encouraging result that warrants further research. We have been in contact with staff from Washington County who may explore this design at a site there. During a complimentary study supported by the Minnesota Department of Transportation, we found that fencing barriers with wrap-around end treatments and fine mesh hardware cloth at the base are a very effective means to reduce turtle mortality on Minnesota's roadways. Both studies suggest that these designs successfully direct turtles away from roadways.

Our preliminary results suggest that warning signs may be less effective at reducing mortality of turtles: we documented slight decreases in mortality at some sites and increases at others. We are currently conducting a multi-year analysis to more rigorously evaluate whether warning signs yield statistically significant reductions in overall turtle mortality. We hope to have results finalized later this summer and will publish our findings in a scientific journal.

Finally, Dakota Country has started reconstruction work on Cliff Road where mortality data were collected in previous years. Plans include barriers and wildlife underpasses; we intend to work with Dakota County Parks staff to monitor mortality at the sites post-construction.

Final Report Summary

Road mortality poses a significant threat to turtles, with estimates suggesting that tens of thousands of individuals are killed on Minnesota roadways every year, including Threatened Blanding's and wood turtles. Our work sought to quantify turtle road mortality and evaluate cost-effective measures for mitigation. In partnership

with the Minnesota Department of Transportation and Dakota, Hennepin, and Washington Counties, we tested two potential cost-effective measures: temporary warning signs denoting turtle crossing zones and small tube barriers. Although other options including road paint and reduced speed zones were considered, these were deemed less desirable by local road authorities.

To assess temporary warning signs, we selected 17 sites in the greater Twin Cities Metro area for collection of weekly pre-treatment data in 2018, with 307 turtle mortalities recorded at these sites. We installed temporary "Turtle Crossing" signs at three sites in 2019 and at four different sites again in 2020. Data were collected both before and after sign installation at treatment and corresponding control sites. Our preliminary results suggest that warning signs may not be effective at reducing mortality of turtles: we documented slight decreases in mortality at some sites, but increases in mortality at others. We are currently conducting additional analyses to more rigorously evaluate whether warning signs may yield significant reductions in turtle mortality.

We also investigated the efficacy of 8-inch corrugated drainage tubes. A key feature of this design was wrap-around "j-hook" end treatments to direct turtles back to the wetlands. The pipe barrier worked well and yielded a reduction in turtle mortality of ~50%, on average, over the two years of this study. While this design was only tested at a single site, the decrease in mortality warrants further investigation to see if it may offer an effective low-cost alternative for some locations.

This project is already impacting local development projects. Dakota County is using road mortality data that we collected to inform a road reconstruction project in which multiple wildlife underpasses are under currently under construction. These underpasses will be tied into effective turtle barriers. Another wildlife passage is being considered in Hennepin County, and a metal grate from a previously blocked culvert passageway in Washington County where Blanding's turtles are present has been removed. We also have received communication that concerned citizens have been asking the local governments to identify means to help turtles.

ACTIVITY 2:

Description: Improving hatching success of riverine turtles

Loss of incubating eggs and hatchlings remaining in nests to predators such as raccoons is a significant issue for Minnesota's turtles. For imperiled species such as the wood turtle, nest predation poses a major threat to long-term population viability, particularly in areas with higher human populations and recreational activity: the presence of people often brings mammalian predators if visitors leave trash and other belongings behind.

To collect baseline data on nest predation and to evaluate mechanisms to improve hatching success, we will outfit endangered wood turtles with GPS transmitters. (Surveys to locate wood turtles will be led by the Minnesota DNR.) Transmitters will be programmed to collect regular positional data, enabling us to identify key nesting sites for wood turtles and likely other species. This work began in 2017 in the Cannon and Straight River watersheds and, with ENRTF support, will be expanded to additional watersheds in central and southern Minnesota in 2018 and 2019. We will then install electrified fences at selected nesting sites that will allow turtle access to nests but exclude mid-sized mammalian predators. Cameras will also be installed at each site to document visitation rates by turtles and predators. Nest site monitoring will continue through spring 2021. Fencing will be installed at the beginning of the nesting season in 2019 and 2020. We will visit sites regularly (at least weekly) to quantify sign such as tracks, evidence of digging and nesting, and evidence of predation, to maintain camera systems, and to ensure the fencing is structurally sound and functioning properly. We will remove fencing in late summer (September) and excavate nests which appear to have hatched. As an ancillary benefit, transmitters will enable us to document habitat use of wood turtles. Results from Activity 2 will be used to inform effective management strategies to improve hatching success.

ENRTF BUDGET: $152,387

Outcome	Completion Date
1. Surveys conducted, and wood turtles outfitted with transmitters to collect nesting site and movement data.	October, 2019
2. Predator exclusion fencing constructed and maintained at select nesting sites. Fencing of nesting sites will begin during spring, 2019.	September, 2020
3. Sites monitored post-installation to assess effectiveness in reducing mortality. Monitoring of nesting sites will begin during spring, 2019.	September, 2020
4. Completion of final analyses and preparation of project report and manuscript for publication in peer-reviewed literature, summarizing key findings and recommendations.	June, 2021

First Update January 31, 2019

In partnership with the Minnesota DNR, Minnesota Zoo staff affixed GPS transmitters to the carapace (upper shell) of 8 wood turtles (6 females and 2 males) in May – June 2018. Five of these individuals were previously tracked in 2017 and were outfitted with VHF radio transmitters to facilitate easy recovery. The other 3 individuals were located in new areas by standard search methods. One additional male was opportunistically captured during September 2018 and subsequently was outfitted with a VHF transmitter, bringing the total to 9 adult wood turtles tracked during 2018. Watersheds where wood turtles are being monitored include the Cannon, Straight, and Zumbro Rivers, all of which are located in the southeast portion of the state. (We note that, because GPS transmitters were deployed prior to the beginning of this award (i.e., July 1, 2018), transmitters were purchased with another source of funding in 2018; during 2019, GPS transmitters will be purchased with ENRTF support.)

After GPS transmitters were deployed, we relocated each turtle about every 2 weeks to download locality data. We programmed transmitters to collect positional data every four hours during deployment. Data were typically downloaded remotely (on site, at a maximum distance of ~200 m from the turtle), minimizing the need for disturbance. GPS positional data were collected until September 2018, when battery power was starting to run low for the transmitters. During September, we exchanged the GPS transmitters for standard VHF transmitters, which have a longer battery life. These transmitters have allowed us to monitor site use over the winter (all turtles were located during late fall) and will facilitate relocating them during spring, 2019, for redeployment of GPS transmitters.

We are now analyzing spatial data from the 2018 field season. Locality data are being used to determine potential nesting sites where nest protection measures can be deployed beginning in spring 2019. Wood turtles tend to nest in open, sandy areas adjacent to rivers and streams. Based on these criteria, we will identify potential nesting sites where female turtles were present during the 2018 nesting season (late May – late June). As female wood turtles often nest in the late afternoon and evening, positional data from this time of day are of particular interest. We are also using Geographic Information Systems (GIS) and statistical software to quantify movements, estimate home ranges, and calculate habitat use.

For spring 2019, we plan to select at least two sites for nest protection. At each site we anticipate testing two different types of predator exclusion fencing: an electric fence and an enclosed “turtle box”. Electrified fences will be constructed to permit access to all species of turtles, including large snapping turtles, but will help to exclude mammal predators such as raccoons, which have a tendency to climb over rather than under obstacles. Box enclosures will be wood turtle-specific, with a wire enclosed top to exclude predators and an opening only large enough to permit access to smaller turtle species. Both methods have been employed for wood turtle conservation in Wisconsin and have relative benefits and limitations. Electric fences have higher material costs

and require more maintenance, but benefit all turtle species. Turtle boxes have lower material and maintenance costs, and the screen top can be more effective at excluding predators. However, they exclude species larger than wood turtles. With both predator exclusion options constructed at the same sites, we will test relative effectiveness at protecting turtle nests and whether wood turtles more readily use one design. We will install multiple cameras at each site to document visitation by turtles and predators. In addition to treatments, we will also monitor control areas at each site. Sites will be surveyed at least weekly through the spring and summer to check for signs of nesting and predation attempts and for maintenance.

Second Update June 30, 2019

Minnesota Zoo staff continued to monitor overwintering wood turtles outfitted with VHF transmitters during February – April, 2019, as conditions allowed. Major early spring flooding, however, presented challenges with accessing several sites.

During May – June, 2019, Zoo staff worked with the Minnesota DNR to attach GPS transmitters to the carapaces of 10 adult wood turtles at 3 locations in southern Minnesota. Six of these turtles were monitored in 2018, and we exchanged their VHF units for GPS transmitters to facilitate collecting regular positional data. The other 4 turtles outfitted with GPS transmitters were located via foot-based surveys jointly conducted by the Zoo and DNR this spring. Our sample includes 2 individuals (1 male and 1 female) from a site along the Cannon River and 8 individuals (7 females and 1 male) from two sites along the Straight River. We refocused our telemetry efforts at these 3 sites because we believe that there may be opportunities to partner with the land managers and landowners to implement management strategies that will ultimately benefit wood turtles.

In addition, we outfitted 4 wood turtles (3 females, 1 male) with VHF transmitters at a relatively high-density site in southeastern Minnesota (the same site where 4 individuals are being monitored with GPS transmitters). Three juvenile wood turtles from a headstarting initiative in 2017 were also tracked in 2019 with VHF. (We note that all VHF transmitters were purchased via other, non-ENRTF sources of funding.) We will continue to monitor turtles through about mid-September. We are remotely downloading data from turtles outfitted with GPS transmitters about biweekly; the DNR and Zoo are jointly tracking turtles with newly-affixed VHF transmitters about once per week. These data will be pooled with data collected during previous years and in 2020 to better quantify the movements, habitat use, and general spatial ecology of wood turtles in southeastern Minnesota.

To evaluate strategies that may reduce nest predation, we first examined positional data collected with GPS units deployed on wood turtles in 2017 and 2018. This process allowed us to identify a small number of potential nesting sites. Wood turtle nesting sites are typically open, sandy, and south-facing, located in close proximity to a river. After consultation with landowners, we identified two initial sites for installation of predator exclusion fencing during spring, 2019. Although we hypothesize that nest 'boxes' constructed largely of lumber and hardware cloth are likely effective in protecting wood turtle nests, we decided to use electric fences for nest protection at these sites due to challenges with access and topography.

Installation of predator exclusion fencing included clearing the perimeter of vegetation and laying down weed fabric, which precludes vegetation from growing and rendering the electric fence ineffective. We then installed rabbit fencing on top of the weed fabric to prevent small mammalian predators from digging under the electric fence. Initial preparation at the first site also included clearing vegetation from the interior area and adding a large quantity of sand to make it more appealing to nesting turtles (Figure 7). The second site was sufficiently sandy and open and did not require additional preparation.

Figure 7. Predator exclusion electric fencing to protect wood turtle nesting area.

We next installed a solar-powered electric net fence beginning 4 inches from the ground and extending 24 inches high, with the lowest hot (i.e., electrified) wire set at 8 inches. These specifications enable all sizes of turtles to pass beneath the fence, but encourage small to mid-sized mammalian predators to attempt to cross over the fence, at which point they receive an electric shock that we anticipate will deter further movement into the nesting site. The fencing perimeter at both sites is ~100 feet, yielding a protected area of ~400 square feet per site. At least 3 trail cameras are set-up per site to help determine if 1) turtles are entering and nesting in the fenced areas and 2) the electric fence is an effective deterrent for mammalian predators.

We are visiting nest protection sites at least weekly to confirm the fence is functioning properly, to maintain the camera systems, and to look for any evidence of turtle use or predation. We also note that intensive telemetry (conducted by the DNR and Zoo) was especially critical during the June nesting season to identify actual nesting sites. As of mid-June, we have confirmed that 2 wood turtle nests have been laid within one of the enclosures.

Fencing will be removed during fall (after any nests laid within the protected area have hatched). We anticipate scaling-up this work in 2020 and possibly exploring other fence designs (e.g., the turtle nesting 'box' described above) to continue to evaluate the efficacy of exclusion fencing in reducing nest predation and improving hatching success and recruitment.

Third Update January 31, 2020

We continued to track wood turtles outfitted with GPS and VHF transmitters through summer, 2019 (Figure 8). Across 3 study sites in southeastern Minnesota, we monitored a total of 14 adult turtles (10 with GPS transmitters and 4 with VHF transmitters). In addition, we tracked 3 juvenile turtles fitted with VHF transmitters. We located 2 new adult turtles in fall, 2019 (a male and female); these individuals were outfitted with VHF transmitters, bringing the total number of wood turtles we are tracking to 19.

From May to October, 2019, we visited each site about every 1 – 2 weeks, during which time we collected positional and other data from turtles fitted with VHF transmitters and downloaded GPS data from other

transmitters. DNR staff also tracked turtles to help ensure frequent and regular monitoring. These data will be pooled with information collected during previous years (and in 2020) to better quantify movements, habitat use, and general spatial ecology of wood turtles in southeastern Minnesota. The data will also be used to help inform additional nesting sites to consider for protection in 2020.

Figure 8. Adult wood turtle with GPS transmitter attached (left). Adult wood turtle with VHF transmitter (above).

Throughout the summer, we monitored and maintained two predator exclusion fences that were constructed in the spring. Routine fence site maintenance included camera and fence checks to ensure proper function, and removal of overgrown weeds from within the enclosure and along the fence line. In addition, we looked for evidence of turtles entering the fenced area (e.g., turtle tracks, digging areas) and indications that predators were breaching the fence (e.g., depredated turtle nests, damage to the fence itself). Fencing material was removed in late September, several weeks after any hatchlings would have left their nest sites.

At protected site 1 (the newly constructed nesting area at which supplemental sand was added), we know from GPS data that 2 female wood turtles moved through the area, but there was no evidence (e.g., camera footage, tracks) of turtles entering the protected nesting area or attempting nesting within the enclosure. Trail cameras did reveal attempts by raccoons to enter the enclosed area; on one occasion, a raccoon was indeed successful in entering. It remains unclear how the raccoon entered, although the electric fence may have been breached in an area where it was slightly higher from the ground. The spot was modified, and no further raccoons (or other turtle predators) were observed in the fence area. Of the 3 female wood turtles monitored at this site, an individual was observed digging ‘test’ nests on an unstable cutbank of the river, another is believed to have nested further upstream at a site that may be amenable to future nest protection, and the third remained in a new location downstream that was created after spring flooding.

At the second protected nest site, 5 trail cameras were set along the fence perimeter and were successful in capturing images of a wood turtle (and a softshell turtle) entering and nesting in the site. In addition, DNR staff were present for several consecutive nights during the nesting season and documented 2 wood turtles nesting inside the enclosure and an additional 3 individuals nesting outside the enclosure. As the fencing design was still in the experimental stage, small screen boxes were placed over each confirmed nest to provide added protection (Figure 9). Additional cameras were set to monitor each individual nest to document nest predation attempts and signs of hatching. On 2 consecutive nights, we captured footage of a raccoon breaching the electric fence. We believe that this occurred during a flooding event in which the bottom section of the fence became submerged in water and the fence's electrical current automatically switched off. The raccoon, however, did not attempt to dig into nests protected within the fence. For 2020, we plan to move the fencing structure higher on the bank to reduce issues with flooding. In late August, we found that all of the cameras at the fence site had been stolen. Fortunately, DNR staff were on-site during one of the hatching days and

confirmed

Figure 9. Electric fence installation at site 2 (left). Additional nest protection box for wood turtle nest (right).

9 wood turtle hatchlings in the nesting area and hatchling exit holes at each of the nests. This is a great success, given that estimates suggest that >95% of unprotected turtle nests are depredated and recruitment levels in this population are believed to be very low.

Of the 5 nests documented at the second nest protection site, 3 nests were in very precarious locations – 1 in a corn field, and 2 that were low on the riverbank and susceptible to being destroyed in flooding events. The DNR requested the Zoo's assistance in initiating an impromptu head-starting program to incubate these eggs and raise the young until they reach a larger size and are less vulnerable to predation. All eggs were removed from 2 nests; with the third nest, half the eggs were collected and the other half were moved higher up the embankment.

Thirteen eggs incubated at the Zoo successfully hatched in early August. These individuals are being reared until late spring – early summer, 2020 (Figure 10) and will be released back to the site when conditions are favorable. A subset of the largest head-starts will be monitored with VHF transmitters to document post-release survival, movements and habitat use.


Figure 10. Headstart hatching wood turtles at MN Zoo, Aug. 3rd, 2019 (left). Two of the thirteen successfully hatched wood turtles for headstarting program at MN Zoo (right).

For spring 2020, we plan to again install electric fencing at the two nesting areas from 2019. The fenced area for the second site will be doubled, and we hope to construct an electric fence in at least one more location in southeastern Minnesota. We are also considering testing a large "turtle nesting box" structure (constructed of wood and hardware cloth or metal screening) adjacent to an electric fence. The box structure will be fully covered with screen and allow us to evaluate which design is more effective at keeping out mammalian predators, as well as whether wood turtles are more likely to nest in sites protected by 1 of the 2 designs.

Fourth Update June 30, 2020

We monitored wood turtles outfitted with VHF transmitters (16 adults and 3 juveniles) during the winter to quantify overwintering sites. In May, Zoo staff, in close collaboration with the DNR, deployed new GPS and VHF transmitters on wood turtles to facilitate monitoring during the 2020 season. Unfortunately, 2 adult female turtles, both monitored during previous seasons, died from unknown (likely natural) causes during winter – spring. These are the first recorded mortalities in this study and represent a significant loss to the depleted wood turtle population in southeastern Minnesota.

During 2020, turtles were outfitted with GPS and VHF transmitters at the 3 sites monitored in previous years as well as a new site in southern Minnesota. Despite the loss of 2 adult females during winter - spring, a number of new turtles were discovered this spring and incorporated into the study, bringing the total individuals currently outfitted with transmitters to 24 (21 adults [14 females and 7 males] and 3 juveniles; 15 GPS transmitters and 9 VHF transmitters). We continue to visit sites about every 2 weeks to relocate individuals and download positional data from GPS transmitters. The DNR also continues to partner with landowners to further restoration efforts at these sites.

As in 2019, we constructed 2 electric predator exclusion fences, removed some vegetation to entice turtles to nest at these sites, and installed camera traps to monitor access by nesting turtles and potential predators. This year, we doubled the size of the protected area at the site at which we documented multiple wood turtles nesting in 2019 (Site 2). Recent land management near this historic nesting area has created a large amount of potential nesting habitat. Given the availability of nesting habitat and the low densities of turtles, we did not install an additional wooden "turtle box" enclosure, as such efforts are typically more effective at sites where larger numbers of turtles nest in smaller areas.

Zoo and DNR staff tracked turtles for several nights during nesting season in mid-June and confirmed 8 wood turtle nests, including one located within the protected enclosure at Site 2. As in 2019, eggs from several nests

considered particularly vulnerable were returned to the Zoo for incubation. Most will be released shortly after hatching, but a subset will remain through the winter and spring as part of a head-starting initiative.

During late June, 13 juvenile wood turtles hatched in 2019 and subsequently reared at the Zoo were released at the site at which the eggs were initially collected (Figure 11). Within minutes, these turtles were exploring their new environment and finding food to eat. Each individual was uniquely marked with a microchip (PIT tag) to facilitate future identification. We did not outfit these turtles with VHF transmitters due to COVID-19 related constraints, but hope to track future cohorts.

Figure 11. One-year old head-start wood turtles were released to the wild during late June 2020 (left and right).

Fifth Update January 31, 2021

The 2020 field season was full of challenges related to the Covid-19 pandemic. Despite capacity limitations and other constraints, we succeeded in monitoring wood turtles outfitted with GPS and VHF transmitters. At one of our sites in southeastern Minnesota, we found 2 additional turtles and incorporated them into the study in early summer, increasing our sample of telemetered individuals to 22 adults and 4 juvenile (15 GPS transmitters and 11 VHF transmitters) in 2020. Three juveniles that were head-started at the Zoo and released in 2018 continue to do well. Unfortunately, one adult female was killed by farming machinery in a field, and two other adult turtles (1 male and 1 female) disappeared late in the summer and are suspected to have suffered similar fates. Loss of even a single breeding adult can significantly impact a small population of turtles. These losses highlight the threats that these turtles face and the urgency for action.

Throughout the field season, Zoo and DNR staff visited each site on average every 2 weeks, with GPS data downloaded monthly. The GPS data collected over the past four years are being analyzed to quantify movements, habitat use, and general spatial ecology of wood turtles in southeastern Minnesota.

We continued to monitor and maintain the two electric predator exclusion fences that were installed in the spring. (Due to capacity limitations resulting from the pandemic, we were unable to expand nest protection efforts in 2020 to test the effectiveness of other exclusion fences, such as larger turtle nesting box structures.) The exclusion fence at site 2 was installed higher on the bank this year and did not require repairs from flooding damage as it did in 2019. Regular maintenance included camera checks, removal of overgrown weeds, and ensuring that wires remained evenly spaced. Our cameras captured some turtle activity at site 2, but as in 2019, we did not identify turtle activity at site 1. We are continuing to review camera footage, but to date have not evidence that small mammalian predators breached the fence in 2020. At site 2, a single turtle nested inside the

fenced enclosure; this nest subsequently was protected with a smaller nest box. We removed fencing material in late September, several weeks after any hatchlings would have left the nesting sites.

In partnership with the DNR, we were able to confirm 8 wood turtle nests in 2020, including one that was located within the protective fence enclosure at site 2. Five nests were found at site 2 and 3 at site 4. No nests were confirmed at the other two sites despite multiple evenings of tracking female turtles during peak nesting season. Although we initially protected all nests with hardware cloth, one nest was completely depredated by a mole that dug underneath. Two other nests protected with wire fabric and flagging stakes were destroyed by farming equipment in early July after miscommunication with the landowner (Figure 12). All eggs were lost from one nest, but we were able to salvage and transport 6 eggs from the other nest to the Zoo to incubate. As in 2019, partial or whole clutches from several nests considered particularly vulnerable nests were returned to the Zoo for incubation. Thirty-five of the 38 eggs returned to the Minnesota Zoo for incubation successfully hatched in early August. A few weeks after hatching, 15 of these individuals were released near their nest sites. The remaining 20 turtles are being head-started at the Zoo and will be released in summer 2021, after they reach a larger size that is less vulnerable to predation.

Figure 12. July, 2020. Left: Protected wood turtle nest destroyed by farming equipment. Right: Wood turtle outfitted with GPS transmitter found on edge of field that was tilled just hours before.

The nest laid within the electric fence at site 2 successfully hatched by August 2020. We excavated the contents and identified shells from 5 hatched eggs, 1 deceased embryo remaining within the egg, and 10 eggs that did not develop. A second nest protected by a small nest box also successfully hatched, with 3 hatchlings and one nonviable egg documented (6 eggs from this nest were removed earlier and incubated at the Zoo).

Sixth Update June 30, 2021

Minnesota Zoo and DNR staff continued to radio-track 26 wood turtles through winter, 2021 to document their overwintering sites. We have not recorded any mortalities of turtles outfitted with transmitters this year, and an additional 6 turtles (5 adult females) were incorporated into the study this spring. The majority of this sample is outfitted with VHF transmitters, although the DNR deployed several GPS transmitters on wood turtles at a site with more significant data gaps. Data collected via GPS transmitters deployed in previous years is being analyzed to quantify important characteristics of wood turtle spatial ecology including home ranges, movements, and seasonal habitat use.

During June, DNR and Zoo staff worked collaboratively to collect as many wood turtle eggs as possible across several sites in southeastern Minnesota. Eggs were collected during the evening hours (when wood turtles typically nest; Figure 13); it was also during this time that most new turtles were located and added to this

study. We collected 88 eggs from 9 nests and further protected 1 nest *in situ*. Sixty-eight eggs were returned to the Zoo for incubation (with the balance incubated by the DNR); a subset of these hatchlings were reared at the Zoo as part of our head-starting initiative, with a targeted release in spring, 2022. The remaining hatchlings will be released shortly after hatching.

In addition, the 20 one-year old wood turtles head-started at the Zoo for the past year were released at their natal sites in late June 2021. These turtles were uniquely marked to facilitate their identification in the future. We are not radio-tracking these juvenile turtles, but we anticipate outfitting a sample of newly released head-starts with VHF transmitters in 2022 to allow us to document their survival, habitat use and general spatial ecology.

We did not establish any electric fences to protect nesting areas this year, based on our experiences in previous years. With the small and fragmented wood turtle population in southeastern Minnesota, it can be very difficult to predict exactly where individuals will nest in a given year. In addition, wood turtles are opportunistic in selecting their nesting sites; if weather conditions are not favorable, or if more suitable habitat is created elsewhere, turtles may nest in new areas. For example, a freshly tilled agricultural field or new river cutbank (created by a storm event) may be attractive to turtles, but these sites may not be conducive to the establishment of an electric fence (e.g., due to flood events, challenging topography or agricultural equipment). During 2019 and 2020, we created and fenced 2 protected areas: we did not document turtles nesting at the first site in either year, and we recorded two nests in 2019 and a single nest in 2020 at the second site. This return on our investment of time – particularly given our limited capacity – was too low to justify deploying fences again this year. As environmental conditions change and the population recovers, predator exclusion fences may prove to be a useful management tool in the future.

Figure 13. A wood turtle outfitted with a GPS transmitter excavates her nests before laying eggs during June 2021.

Seventh Update as of January 31, 2022

Despite capacity limitations and other constraints associated with the Covid-19 pandemic, we were successful in monitoring wood turtles outfitted with VHF transmitters in southeastern Minnesota throughout the summer and into the fall. When possible, detailed locality and behavioral data were recorded for individuals. In addition

to adult turtles, we continued to monitor three juvenile turtles who were released as head-starts in 2018 (Figure 14).

Figure 14. VHF tracked juvenile (left) and adult male (right) wood turtles. Turtles were found foraging in reed canary grass in close proximity to one another in summer, 2021.

Of the 68 eggs incubated at the Zoo during summer, 2021, 62 successfully hatched during late July and early August, 2021. A few weeks after hatching, 31 young turtles were released near their natal sites. The remaining 31 turtles are being head-started at the Zoo and will be released in spring 2022, after they reach a size that is less vulnerable to predation.

We also are analyzing GPS data collected during previous years to quantify movements and estimate home range size of wood turtles. Using the R package 'amt' (Signer et al. 2011), we calculated movement speed for all turtle relocations occurring four hours (+/- 5 min.) from the previous successful GPS fix (movement distance [m]/time[hour]). Overall, female turtles had faster average movement rates (3.62 m/hr) compared to males (2.95 m/hr). Female movement rates were fastest in June and July, whereas male turtles maintained relatively consistent movement rates throughout the active season (Figure 15).

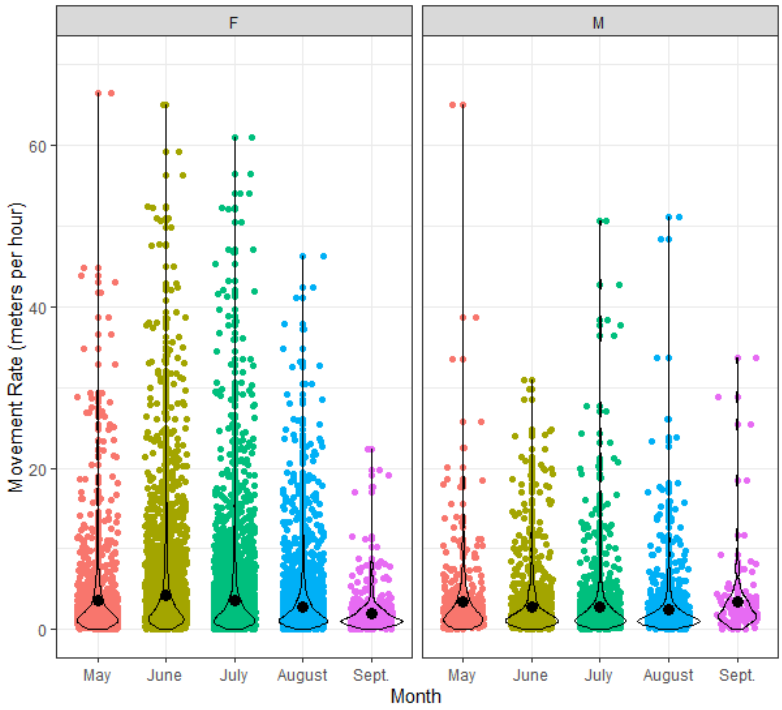

Figure 15. Movement rates by month by sex (females = left panel; males = right panel). Large black points represent mean values for the month.

We also calculated both 50% and 95% home range areas for turtle-years (i.e., for those turtles monitored in multiple years, we estimated home range size for each year) based on the following estimators: 1) minimum convex polygon (MCP), 2) kernel density estimator (KDE), 3) local convex hull (LoCoH), and 4) the autocorrelated KDE (aKDE) that first requires fitting a continuous-time movement model to the relocation data for each turtle-year. We chose to use multiple estimators because the MCP and KDE provide values that are comparable to most historical studies; the LoCoH is a very conservative estimator that is often applied when relocation data are limited in space due to physical barriers or behaviors that result in relocations along linear features (e.g., along rivers and streams); and the aKDE accounts for uncertainty related to fix frequency and movement characteristics. The resulting home range sizes were averaged by sex (Table 5).

Home range sizes varied based on estimator, and as expected, the largest differences were between the most (LoCoH) and least (aKDE) conservative estimators. Female wood turtle home range sizes were larger than males on average, and significantly larger based on the aKDE approach. Variation among individuals was far greater for females than males, driven by some individual females who traveled greater distances from streams, often to use crop fields.

Table 5. Mean and 95% confidence intervals for wood turtle home range sizes (km^2) using the 95% value (95% isopleth, 95% MCP) by sex.

Estimator	Sex	Mean	SE	Lower 95% CI	Upper 95% CI
MCP	F	0.15	0.04	0.06	0.24
MCP	M	0.07	0.02	0.02	0.12
KDE	F	0.30	0.11	0.07	0.53
KDE	M	0.14	0.04	0.04	0.24

LoCoH	F	0.03	0.01	0.02	0.04
LoCoH	M	0.02	0.00	0.01	0.03
aKDE	F	1.06	0.23	0.60	1.51
aKDE	M	0.27	0.05	0.16	0.37

Final Update June 30, 2022

We are continuing to modify our analyses of the multi-year, GPS telemetry dataset collected from adult wood turtles across southeastern Minnesota. This work will improve our understanding of the spatial ecology of wood turtles, including seasonal variability in movements, ranges, and habitat use as well as important characteristics of nesting sites, information which will be critical as we work to create and restore nesting areas over the next few years. As part of the new ENRTF grant supporting phase 2 of this project, we have continued monitoring wood turtles via radio telemetry this spring. In close collaboration with the Minnesota DNR, we tracked more than a dozen adult female wood turtles at 3 sites during the nesting season and successfully collected ~70 eggs, which will be hatched at the Zoo this summer. A subset of these individuals will be reared (i.e., head-started) at the Zoo until summer, 2023. Later this summer, we will release 31 head-start wood turtles, reared at the Minnesota Zoo for the past 11 months, to their natal sites in the southeastern portion of the State.

Final Report Summary

Mortality of incubating turtle eggs and hatchlings remains a primary threat to the long-term recovery of depleted wood turtle populations. To quantify this risk and inform conservation efforts targeting improved hatching success, we outfitted adult female wood turtles with VHF and GPS transmitters, facilitating the identification of nesting sites at four locations in southeastern Minnesota. Once nesting sites were identified, we installed electric fencing to exclude mid-sized mammalian predators such as raccoons, skunks, and foxes.

Over 2 years, a total of 3 wood turtle nests were successfully protected within the electric fencing. The majority of wood turtles, however, nested outside the enclosures, necessitating the use of small nest protection boxes to prevent access by predators. Despite these efforts, nests were still lost to agricultural activity and predators such as moles digging under the protective structures. As other nests remained in areas susceptible to flooding and/or agriculture, in 2019 the Zoo initiated a head-starting program at the request of the DNR, incubating eggs and raising young in captivity until they reached a size less vulnerable to predation. In the first year, we successfully hatched 13 eggs at the Zoo and reared these individuals for one year before releasing them to the wild in 2020. In the two years following, an additional 97 eggs successfully hatched at the Zoo, with roughly half released shortly thereafter and 50 raised for a year as headstarts. This program has been expanding and will continue for the next few years with the support of a second ENRFT appropriation. Although electric fencing may be appropriate for some turtle populations that congregate in high densities in specific areas, it did not meet expectations for small and fragmented populations of wood turtles in southeastern Minnesota, as many of these turtles nest opportunistically in different areas each year. Collecting eggs and rearing hatchlings has provided much greater returns, despite intensive staff efforts required for egg collection and head-start care.

In addition to using spatial data of female turtles to locate nesting sites, we continued to track 8 to 26 wood turtles each year, including adult males, adult females, and juveniles. Analysis of GPS data revealed that female wood turtles move faster than males on average and have larger home range sizes. These spatial data also were useful in identifying additional potential nesting sites and key habitat characteristics. We are continuing to analyze the multi-year spatial dataset to better understand seasonal variability of movements and habitat use, which will inform future management and habitat restoration projects.

ACTIVITY 3:

Description: Building public awareness at the Zoo and beyond

The Zoo will leverage its ~1.3 million annual visitors and its expertise in education and outreach programming to raise public awareness about the conservation of turtles in Minnesota and our aquatic resources. Our efforts will include both on-site programming and outreach events at communities around the State. The Zoo's well-regarded Zoomobile programs, which feature Blanding's and wood turtles, give citizens from across Minnesota the opportunity to experience wildlife up-close in their own communities. Using Zoomobile as a platform to share key conservation messages off-site, we will develop outreach materials centered on Minnesota's turtles, such as workbooks and informational booklets, which can be shared and left behind after any Zoomobile program that incorporates turtles.

At the Zoo, we will develop similar turtle conservation messaging with the Zoo's Close Encounters program, which enables visitors the opportunity to experience wildlife up-close at the Zoo. We will also develop and install interpretive graphics and contract a videographer to produce a short (3 – 5 minute) video to convey these same conservation messages to Zoo visitors.

ENRTF BUDGET: $14,500

Outcome	Completion Date
1. Outreach materials promoting the conservation of turtles in Minnesota developed and printed.	June, 2019
2. Interpretive graphics and video outlining the biology and conservation of freshwater turtles developed and installed.	June, 2019
3. Outreach materials disseminated via Zoomobile and other programs. Dissemination of these materials will begin during summer, 2019.	June, 2021

First Update January 31, 2019
We are working with several Zoo departments to raise public awareness about turtle conservation on-site. We are collaborating with the Zoo's interpretive program staff to design new signage to highlight turtle ecology and conservation, and we are developing a video to detail research and conservation efforts as well as actions the public can take to promote turtle conservation. We also are exploring opportunities for interactive activities and interpretive materials that may be used by our volunteer corps and in conjunction with the Zoo's Close Encounter programs (e.g., 3-dimensional, durable turtle model to educate Zoo visitors about turtle anatomy and engage them in conservation). With graphic design staff, we created an outreach poster outlining turtle biology and our conservation efforts for use at future public events. In addition, we are partnering with the Zoo's Education and Zoomobile teams to identify ways to better incorporate turtle conservation messaging in their programs. Initial ideas include affixing VHF transmitters to turtles naturally found on the Zoo's property, providing student groups an opportunity to gain hands-on experience with scientific field research, learn about habitat needs of turtles, and participate in citizen science data collection.

Zoo staff also contributed to the development of a children's book. The book's story-telling approach highlights the perils that a Blanding's turtle may face, including road mortality, predation, and habitat degradation - all of which are very relevant to our conservation messaging. We anticipate using these books in our classroom-based education programs and in outreach activities such as Zoomobile programs.

Second Update June 30, 2019
We are continuing to partner with departments across the Zoo to develop and implement a variety of activities designed to promote public awareness of Minnesota's turtles and improve their conservation. During the winter, Conservation staff worked with our colleagues in the Zoomobile and Education departments to create a

wood turtle coloring and fact sheet for children. This handout has been distributed – and well-received – at several events over the past 5 months. To supplement this handout, we printed turtle stickers that feature an image of a Blanding's turtle from the forthcoming children's book to which the Zoo contributed as fun giveaways. We also submitted an order for 1,000 copies of the children's book (as part of its first printing) and anticipate that these copies will be available early in fiscal year 2020. Books will be distributed by Zoomobile and Education staff during off-site outreach events and on-site visits by school groups.
New signage highlighting Minnesota's turtles and their conservation is under development and will be installed by the end of the summer. We have identified a videographer to develop a short public awareness video and are finalizing the script. We anticipate that filming will take place in late summer / early fall so that the videographer, who is currently traveling, is able to accompany Zoo staff in the field. In addition, we are working with the Zoo's interpretive and volunteer services staff to create a rugged, 3-dimensional model of a turtle that can be disassembled. This model will serve as an outreach tool to help facilitate discussions about turtle biology. We have identified an artist to complete this project and currently are compiling model specifications.

Conservation staff created a hands-on activity for kids (and adults) for use at outreach events. This activity provides experience with radio telemetry, a frequently used technique in wildlife management and conservation, as participants attempt to find a 'hidden' toy turtle. Once individuals have located the turtle and developed an understanding of the field method, they bring their 'data' to a map which allows us to document the location of the turtle. This format provides an opportunity to discuss the risks that wild turtles face and their conservation needs. The activity has proven to be an effective tool for communicating about Minnesota's turtles and the Zoo's initiative.

Finally, Conservation staff are assisting the Zoo's STEM educators with an on-site initiative providing students with an opportunity to track wild turtles at the Zoo. We have deployed VHF transmitters on 2 painted turtles and 1 snapping turtle as part of this project (funding for VHF transmitters is provided by other, non-ENRTF sources). This initiative will allow children to track turtles and participate in data collection as part of a unique citizen science initiative.

Third Update January 31, 2020
In the latter part of 2019, the Zoo continued to work on several efforts to build awareness for turtle conservation. On-site at the Zoo, staff developed a large interpretive graphic highlighting turtle conservation (Figure 16); the sign has been printed and is ready for installation this spring. In addition, Zoo staff helped to provide content for the children's book "A Turtle's Dangerous Journey." This book was printed during summer, 2019, and is currently being disseminated to the public (Figure 17). Over 200 copies have been provided to school and community groups and the general public via tabling events, school group visits, and Zoomobile outreach programs. Minnesota Zoo e-blasts and newsletters continue to highlight turtle conservation initiatives, including recent internal posts on our head-starting project and a piece on what turtles do during the winter months. January was also Members Month at the Zoo, and turtle conservation was a featured topic, with a tabling event and associated outreach materials.

In spring and summer 2020, turtle conservation staff will be partnering with Zoo Education staff to help implement a new STEM-based summer camp program. The course will include tracking wild turtles on Zoo site, presentations by Conservation staff, and independent projects developed by the campers.

Figure 16. Two components of a new interpretive sign being installed at the Minnesota Zoo this spring.

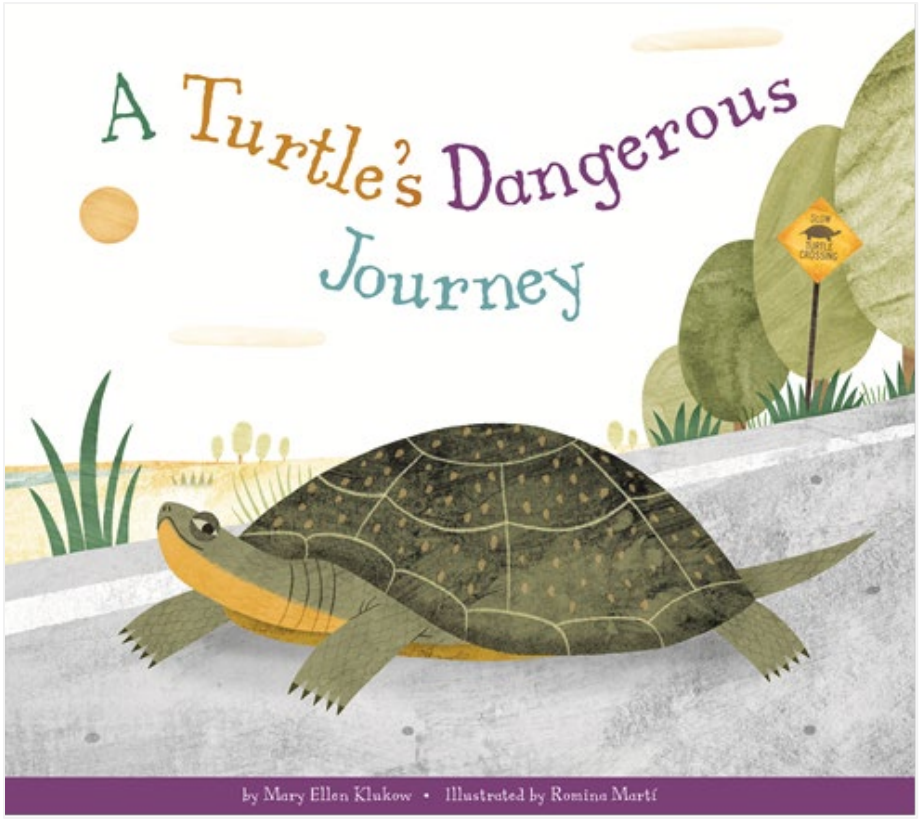

Figure 17. Cover of the children's book "A Turtle's Dangerous Journey".

We have secured a videographer for a short video highlighting turtle conservation and research efforts in Minnesota. Zoo staff are drafting the script, and filming is scheduled for May 2020. Our original plan to film in the fall was delayed due to scheduling conflicts and the early onset of winter temperatures. We anticipate that the film will be completed by early summer, 2020.

Off-site, Zoo staff continued to engage the public through events and talks. Turtle conservation was featured by the Zoo at a tabling event during STEM day at the Minnesota State Fair. With a hands-on turtle telemetry activity, turtle biofacts (shells, eggs, photos), and the children's book, we interacted with hundreds of fair attendees throughout the day. The Zoo's road mortality research also has received media attention, initially through an internal video for MnDOT, followed by an interview with KSTP news which aired on the evening news.

Notably, a staff member at St. John Lutheran School saw the KSTP piece and reached out to Zoo Conservation staff for guidance on a competitive STEM project that were completing. The students were compelled to help turtles on roads and created a presentation and plan to raise awareness and funds for turtle crossings in their community. The group even advanced to a state-level competition for their idea.

Fourth Update June 30, 2020
Whereas the research elements of the project proceeded generally as planned during early 2020, many outreach activities, as well as the development of educational materials designed to raise public awareness about turtle conservation, have been postponed or cancelled due to COVID-19. Summer camps, an on-site citizen science initiative, and public presentations – all outlets for disseminating information and improving the conservation of turtles – have been impacted by the pandemic.

In addition, a videographer was scheduled to film and produce a short video about the conservation of Minnesota's turtles this spring, for dissemination at the Zoo and through our social media outlets. Filming remains on hold, but we hope to move forward with this project later this year. Finally, we are partnering with an artist to create a 3D turtle model that may be disassembled and used with outreach and education programs. We anticipate this project's completion anticipated later this summer.

Fifth Update January 31, 2021
Although outreach activities continued to be hindered by the COVID-19 pandemic during the second half of 2020, we were able to advance a handful of activities that will build public awareness about turtle conservation. In partnership with Saint Paul Public Schools Nutritional Services, Zoo Education staff distributed materials at 3 different sites (Harding High School, Cherokee Heights Elementary School, and Mayfield Elementary School) during August 2020. The goal of this effort was to get books and resources about conservation into the hands of children who may not have had access to technology over the summer. Some 600 copies of the book "A Turtle's Dangerous Journey" were distributed to kids picking up curbside meals at these sites.

During the summer, a volunteer film student joined Conservation staff to document the release of head-start wood turtles hatched at the Zoo in 2019. The student is finalizing a short video that will allow the Zoo to share this head-starting initiative with the public. In addition, we contracted with a professional videographer to facilitate filming our conservation activities in early August. The videographer is creating a short film highlighting Minnesota turtles and associated conservation efforts. We anticipate that the video will be completed and available for sharing with the general public by the spring.

Finally, the 3-dimensional, life-size snapping turtle model was completed this fall. This durable piece was custom-designed and 3D printed. The top shell (carapace) can be removed to view the internal anatomy; 8 organs are detailed, with several that are removable (Figure 18). The model will support our outreach activities and serve as a great engagement tool to help build awareness about Minnesota's native turtles.

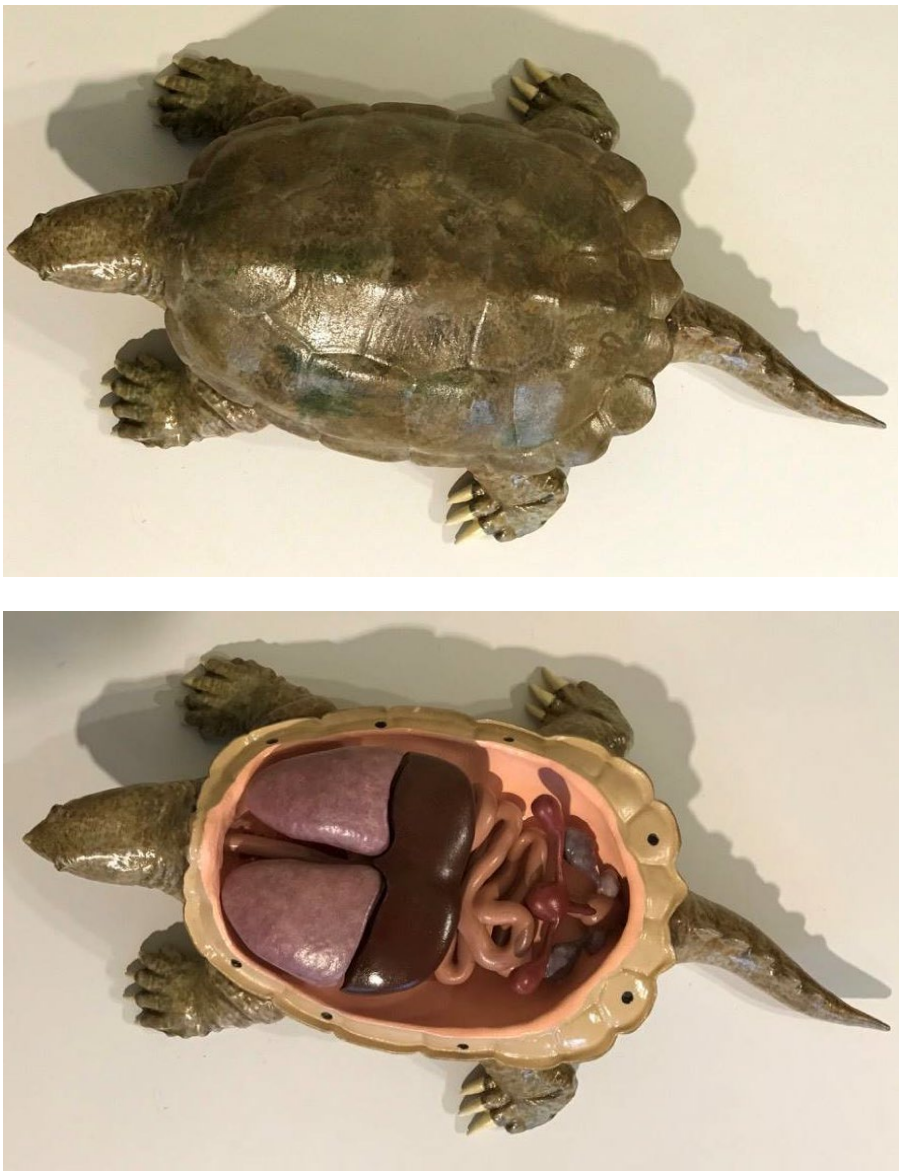

Figure 18. 3D-printed snapping turtle model. Top: External view of model. Bottom: Shell removed for view of internal anatomy. Several organs are removable.

Sixth Update June 30, 2021

The Minnesota Zoo's education and outreach efforts continued to be significantly impacted by the pandemic during the first half of 2021. Summer camps remain virtual, but Zoo education staff highlight turtle ecology and our conservation work in these programs. Increased visitation capacity also will expand opportunities to engage visitors with conservation messaging on campus.

We are creating 2 new interpretive signs for display at the Zoo that will share information with the public about Minnesota's turtles. These signs will feature snapping turtles and painted turtles, species that exist on Zoo campus and are commonly observed by the public at the Zoo's Main Lake. These new additions will complement the interpretive sign addressing turtle conservation that was previously designed and installed.

We also are excited to share that the short film highlighting Minnesota's turtles and ongoing efforts to conserve this natural resource is now complete. A link to the video, which already has been shared with thousands of the Zoo's member and donor households, is located here; visitors have the opportunity to view the video on campus as well.

Seventh Update as of January 31, 2022
Many of the outreach-associated activities and events that were enjoyed by the public before the pandemic (e.g., summer camps) will be returning to the Minnesota Zoo later this year. In addition, two new interpretive signs have been designed and will be installed near the Zoo's Main Lake this spring. The signs highlight information on snapping and painted turtles that are native to the Zoo's campus and often observed by the public. This will compliment other turtle conservation messaging on site. Finally, we have ordered an additional 1,000 copies of the book "A Turtle's Dangerous Journey," promoting turtle awareness and conservation, to distribute to kids during on and off-site events.

Final Update June 30, 2022
On-site education and interpretive programming returned to the Minnesota Zoo this spring and summer! School groups resumed visitation and field trips earlier this year, and in-person summer camps are again underway following a multi-year, pandemic-induced hiatus. Zoo staff are sharing turtle conservation messages with campers and the general public, and the Conservation and Education teams are creating opportunities for campers and other visitors to learn about – and contribute to – wildlife research by conducting radio telemetry of native turtles on Zoo grounds. In addition, the conservation of Minnesota's turtles will be featured at a Wild Nights event at the Zoo later this summer.

Finally, signs detailing the ecology of turtles commonly observed at the Zoo – as well as ongoing conservation efforts – have been installed around the Zoo's Main Lake, providing a new means to share information with visitors.

Figure 19. Painted turtles, snapping turtles, and associated turtle conservation efforts are highlighted in new signs installed at the Zoo's Main Lake.

Final Report Summary

The Minnesota Zoo created a diversity of tools and resources to build public awareness and encourage action on behalf of turtles and other aquatic wildlife with this project. Despite major setbacks associated with the COVID-19 pandemic beginning in early 2020, the Zoo continued its role as a valued resource for conservation messaging and outreach. When it was not possible to gather together, virtual camps were used to connect students to turtle ecology and engage them in problem-solving for turtles at risk.

Education and Conservation Departments partnered to create a wood turtle coloring and fact sheet, turtle stickers, a poster for tabling events, and a hands-on turtle tracking game. In addition, the Zoo provided content and feedback to a publisher creating a children's book on turtle conservation - "A Turtle's Dangerous Journey." The Zoo has distributed >1000 copies to the public via tabling events, school group visits, and outreach programs. These hand-outs and activities have proven to be effective tools for communicating about Minnesota's turtles and our conservation initiatives.

To further highlight the Zoo's conservation efforts, we contracted with a professional videographer to film and produce a short video, which has been widely shared on the Zoo's social media outlet. In addition, a local artist designed and created a life-sized, 3-D printed snapping turtle with take-apart internal anatomy. This model is now being used for interpretive programs and serves as a great engagement tool to help build awareness about Minnesota's native turtles. Further, three signs detailing the ecology of turtles commonly observed at the Zoo – as well as ongoing conservation efforts – have been installed around the Zoo's Main Lake, providing a new means to share information with visitors.

Finally, Conservation staff are assisting the Zoo's STEM educators with an on-site initiative, providing students an opportunity to track wild turtles outfitted with radio transmitters at the Zoo. We have deployed VHF transmitters on 2 painted turtles as part of this project for students to collect and analyze real scientific field data.

IV. DISSEMINATION:

Description:

Updates on activities and progress will be shared with collaborators via regular reports, and information about this work will be disseminated to the general public by the Zoo's Conservation, Marketing and Education departments as frequently as possible. These communications may include ZooMobile and other public presentations by staff and sharing information on the Minnesota Zoo's web page and social media outlets. In addition, Zoo staff and volunteers will be instructed in speaking with the public about turtles and the benefits of turtles for healthy aquatic ecosystems. Results of research addressing mechanisms to mitigate road mortality and improve hatching success will be submitted for publication in peer-reviewed scientific journals and presented at professional conferences.

First Update January 31, 2019
The Zoo raised awareness of freshwater turtle conservation through several venues during 2018:

- Dr. Markle outlined our turtle conservation initiative at the Zoo's Director's Reception in September 2018.
- In October 2018, we participated in the international "Imagine a Day without Water" campaign, where Zoo staff called attention to the importance of clean water. One of the features addressed how turtles help to keep our aquatic environments healthy and, in turn, how they need a clean environment to survive.
- In November 2018, we contributed content to the Zoo's regular e-newsletter and wrote a blog outlining the negative consequences of road and sidewalk salts on freshwater ecosystems, as well as ways that the public can help reduce their impact. In January 2019, we drafted additional content for the e-newsletter and authored a blog describing the fascinating ways that turtles survive cold winters in Minnesota.
- Also in January, Dr. Markle presented our turtle conservation initiatives at a state-wide herpetological coordination meeting. She shared our work with students and staff at Carleton College during a talk there as well.
- Finally, Zoo staff were invited to contribute to the state's Minnesota Wood Turtle Conservation plan as members of the newly formed Wood Turtle Team. This planning process will be ongoing throughout 2019.

Second Update June 30, 2019
The Zoo continued to promote awareness of Minnesota's freshwater turtles and encourage public action on behalf of turtle conservation during the first half of 2019:

- Zoo Conservation staff drafted content about 1) the impacts of plastics on both freshwater and marine turtles and how the public can help to reduce plastic pollution (February 2019) and 2) increased turtle activity during spring and how the public can safely help turtles cross roads (May and June, 2019). Content was distributed by email to >40,000 Zoo member and supporter households.
- In March 2019, Dr. Markle was featured in an interview on Fox 9 Morning Buzz. She discussed the turtle conservation initiatives conducted by the Minnesota Zoo. This interview was part of a promotion for a Women in Science Day at the Bakken Museum, at which Zoo staff tabled with information, activities, and giveaways to promote turtle conservation.
- Zoo Conservation staff shared information on Minnesota's water resources and freshwater turtle conservation efforts at a meeting of the Minnesota Herpetological Society, a public talk in Eagan, and a naturalist training course at the Zoo.

- Throughout the winter and spring, Zoo staff continued to contribute to the state's Wood Turtle Conservation Plan through meetings and information sharing. A draft of the Plan is anticipated later this year.

Third Update January 31, 2020
We continued to share information about turtle conservation in Minnesota and the ongoing efforts of the Zoo and our partners during the second half of 2019:

- Zoo staff participated in a full-day tabling event at the Minnesota State Fair as part of STEM day (August 22, 2019). Education and Conservation staff interacted with several hundred fair attendees, providing information on our freshwater turtle conservation program, conducting a hands-on telemetry activity, and sharing the children's book.
- In November 2019, Dr. Markle presented on the Zoo's turtle conservation and research program at the national Spotted, Blanding's and Wood Turtle Symposium in Berkeley Springs, West Virginia.
- Dr. Markle was interviewed about the road mortality project for an internal MnDOT video describing the inter-agency partnership, which was shared across multiple social media channels. Subsequently, she completed an interview with KSTP News that aired on the evening news.
- We drafted a short article for an internal newsletter describing threats to wood turtles and detailing the Zoo's new head-starting initiative. Other internal communications included a talk to the Zoo's volunteer corps during the fall. External talks detailing the Zoo's turtle initiative have included public lectures in Eagan and Minnetonka.
- The Zoo featured freshwater turtle conservation during a recent Members Appreciation Day (Jan. 23, 2020). Activities included an outreach tabling event and children's book signing.
- Zoo staff across various departments have distributed >200 "A Turtle's Dangerous Journey" books, highlighting the threats turtles face in Minnesota and the Upper Midwest and what we can do to help, to school and community groups and the general public.

Fourth Update June 30, 2020
As a result of the COVID-19 pandemic and the Minnesota Zoo's closure in mid-March, the past several months have presented challenges in disseminating information. However, recent activities have included:

- In February, Dr. Markle discussed the conservation of Minnesota's turtles at a seminar hosted by the University of Minnesota's Conservation Sciences Graduate Program and at the Twin Cities' monthly "Nerd Nite Out" event.
- Conservation staff presented information about the Zoo's turtle conservation initiative at winter and spring board meetings and internal Zoo-wide staff meetings.
- The Zoo featured educational pieces about turtle conservation and the State's ongoing conservation efforts through various social media channels.
- Zoo staff continue to contribute to the state's Wood Turtle Conservation Plan. A final draft of the plan is now being reviewed by team members.

Fifth Update January 31, 2021
The pandemic continued to limit our ability to conduct outreach. As such, our activities largely have pivoted to online and virtual platforms. Highlights from the past several months include:

- In July, a blog outlining the release of one-year-old wood turtles head-started at the Zoo was incorporated in the Zoo's monthly member newsletter and shared on the Zoo's Facebook page.

- In August, the State's Wood Turtle Planning Team (of which Zoo Conservation staff are members) completed the Minnesota Wood Turtle Conservation Plan. The purpose of the plan is to identify strategies to advance the conservation and recovery of wood turtles. The document identifies issues, 10-year goals, prioritized strategies, and targeted implementation activities.
- In November, Dr. Markle gave an online presentation to the American Association of State Highway and Transportation Officials' Committee on Environment and Sustainability, detailing our efforts to reduce turtle road mortality.
- From November – January, Minnesota turtle conservation was highlighted as part of the Zoo's outdoor special event "Nature Illuminated". The drive-through event featured a giant inflatable Blanding's turtle (a species categorized as Threatened by the State of Minnesota) and associated messaging outlining the threats facing and conservation of Minnesota's turtles.
- Conservation staff again presented information about Minnesota's turtles and our efforts to conserve them at internal Zoo-wide staff meetings.

Sixth Update June 30, 2021

Although in-person events and speaking engagements remain limited, the Zoo's turtle conservation initiative has received considerable media coverage in recent months. Highlights of media coverage and other dissemination outlets include:

- In April, the Zoo's road mortality research and partnership with MnDOT was featured in the Star Tribune: https://www.startribune.com/roadside-fences-show-promise-for-reducing-minnesota-turtle-fatalities/600042873/?refresh=true
- In May, the Zoo's new quarterly Conservation Connection newsletter, which included a feature story about turtle conservation, was distributed to thousands of member and donor households. In honor of World Turtle Day, the newsletter also included a link to the Zoo's new short film about turtle conservation.
- Also in May, an article in the Dakota County Tribune detailed the Zoo's partnership with the DNR and our ongoing efforts to conserve Minnesota's wood turtles. https://www.hometownsource.com/zoo-continues-wood-turtle-conservation-project/article_01e3ebb4-be6a-11eb-ab1e-6f80732fd24c.html
- In June, journalists from PBS's "Prairie Sportsman" filmed elements of the wood turtle conservation work, including the release of head-started wood turtles earlier in the month. Additional filming will take place later this summer.
- Also in June, Zoo Conservation staff were filmed and interviewed by Morrie's Auto Group to highlight our partnership and share information about our conservation work.
- Finally, at the end of June, the Minnesota Zoo's turtle road mortality research project with MnDOT was featured in a short segment on WCCO-TV's evening and morning news. https://minnesota.cbslocal.com/2021/06/28/minnesota-zoo-mndot-partner-to-address-dwindling-blandings-turtle-population/

Seventh Update as of January 31, 2022

- In July 2021, the Minnesota Zoo became an official partner in the Association of Zoos and Aquariums (AZA) new SAFE American Turtle Program. The SAFE (Saving Animals From Extinction) program is designed to leverage the collective support and expertise of zoos and aquariums from across the country to coordinate efforts and implement strategic conservation actions to save wildlife.

- In September 2021, Dr. Markle gave a virtual presentation titled “Mitigating Small Animal Road Mortality” at the International Conference on Ecology and Transportation. A link to the recorded presentation is found **here.**
- Also in September, the Zoo’s quarterly Conservation Connection newsletter included a feature story about our road mortality mitigation project and partnership with the Minnesota Department of Transportation. In December 2021, the newsletter incorporated a “Science in Action” piece on our telemetry research.
- For Give to the Max Day (November 18, 2021) the Minnesota Zoo Foundation posted short video clips of interviews with Zoo Conservation staff on social media to highlight the Zoo’s field conservation efforts.
- In December 2021, Minnesota Zoo Conservation staff working on the turtle initiative were invited to join the Midwest Wood Turtle Working Group, which brings together researchers from across the Midwest to share current research efforts and coordinate conservation initiatives.

Final Update June 30, 2022

Highlights of media coverage and other dissemination outlets include:

- In March 2022, Dr. Markle gave a virtual presentation for the West Metro Chapter of the Minnesota Master Naturalists titled “Minnesota Turtle Conservation”.
- In April 2002, turtle conservation work in Minnesota was a feature story in PBS’s Prairie Sportsman in a segment called “Save the Turtles”. This piece originally aired on Pioneer PBS on April 17, 2022 and later aired on multiple PBS stations in Minnesota, Wisconsin and Iowa.
- Also in April, the Zoo’s Conservation Connection newsletter, distributed electronically to member and donor households, profiled turtle conservation activities planned during the 2022 field season.
- On May 23, 2022, the Minnesota Zoo promoted World Turtle Day by sharing turtle conservation messaging on social media platforms.
- Finally, in June 2022, the Zoo’s turtle conservation initiative was featured in a TV spot during a Minnesota Twins game; this segment was produced by the Minnesota Lottery to promote ENRTF supported projects.

Final Report Summary

Sharing information about the importance of turtles and their conservation was a key objective of this project. The Minnesota Zoo used a variety of platforms to disseminate significant findings and engage the general public in the conservation of Minnesota’s aquatic resources, ranging from informal talks, public and academic lectures and tabling events to media spotlights and distributing content on our social media channels. Relevant content also was disseminated via email to >40,000 Zoo member and donor households. Media highlights included features on PBS’s *Prairie Sportsman*, Kare 11’s *Minnesota Bound*, and a Minnesota Lottery commercial, and stories on a variety of other print and television media outlets such as the Fox 9 Morning Buzz, KSTP’s evening news, WCCO-TV’s evening and morning news, and newspaper articles in the Star Tribune and Dakota County Tribune. This video highlights the ecology and conservation of turtles in Minnesota. We also shared findings at scientific meetings including the National Spotted, Blanding’s and Wood Turtle Symposium and the International Conference on Ecology and Transportation.

V. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview: See attached budget spreadsheet

Explanation of Capital Expenditures Greater Than $5,000:

N/A

Explanation of Use of Classified Staff:
Two staff positions will be supported by these ENRTF funds. The Biologist position, which will be primarily funded by ENRTF (with supplemental funding received from another funding source), will be hired upon initiation of this project. The Principal Investigator / Project Manager is classified. S. Stapleton, current staff at the Zoo, has the necessary expertise to successfully oversee Activities 1, 2, and 3 as the PI / Project Manager. However, without the support of the ENRTF funding, he would not have the ability to work on this project and instead would need to focus on other position responsibilities. Incorporating existing expertise at the Zoo will be essential for the completion of this project.

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

Enter Total Estimated Personnel Hours: 5,928	Divide by 2,080 = TOTAL FTE: 2.85

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

Enter Total Estimated Personnel Hours: ~100	Divide by 2,080 = TOTAL FTE: ~0.02

B. Other Funds:

SOURCE OF AND USE OF OTHER FUNDS	Amount Spent	Status and Timeframe
Other Non-State $ To Be Applied To Project During Project Period:		
Minnesota Zoo Foundation; supplies, equipment and other expenditures in support of the Zoo's turtle conservation initiative. Estimate.	$ 20,000	FY19 – FY22
Other State $ To Be Applied To Project During Project Period:		
MN Zoo, General Operating Budget: Utilities and administrative costs, estimated at 15% of expended funds.	$ 42,100	FY19 – FY22
Minnesota Zoo's appropriation from State of Minnesota's Clean Water, Land and Legacy amendment. Additional costs associated with project implementation including equipment, supplies and staff time. Estimate.	$30,000	FY19 – FY21
Minnesota Department of Transportation, grant to MN Zoo for complementary work, entitled "Reduced vehicle-animal collisions with installation of small animal exclusion fencing."	$ 110,776	FY18 – FY22; Additional funding remained within MnDOT for installation of roadside exclusion fencing.

VI. PROJECT PARTNERS:

The Minnesota Zoo would be the sole recipient of ENRTF funds under this proposal. Zoo Conservation staff will plan and implement Activities 1 and 2 in partnership with MnDOT and DNR. Zoo Conservation and Education staff will jointly plan and implement Activity 3. We anticipate developing partnerships with other organizations, potentially including local governments and management authorities, universities, and NGOs, as work progresses.

A. Partners receiving ENRTF funding: N/A

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Chris Smith	Wildlife Ecologist, Protected Species Coordinator	Mn DOT	Key partner for implementation of Activity 1. Roles include technical advice on selection of roadways for study, coordination with road management authorities, selection and installation of mitigation mechanisms, and monitoring.
Peter Leete	Transportation Hydrologist (DNR – MnDOT Liason)	MN DNR	Key partner for implementation of Activity 1. Roles include technical advice on selection of roadways for study, coordination with road management authorities, selection and installation of mitigation mechanisms, and monitoring.
Elizabeth Brown	Environmental Program Specialist	Mn DOT	Key partner for implementation of Activity 1. Roles include technical advice on selection of roadways for study, coordination with road management authorities, selection and installation of mitigation mechanisms, and monitoring.
Carol Hall	Herpetologist	MN DNR	Key partner for implementation of Activity 2. Roles include selection of study sites, surveys for and capture of turtles to be outfitted with GPS transmitters, technical advice on nesting site selection for installation of predator exclusion fencing, and monitoring. Additional advice on site selection for Activity 1.
Krista Larson	Nongame Research Biologist	MN DNR	Key partner for implementation of Activity 2. Roles include selection of study sites, surveys for and capture of turtles to be outfitted with GPS transmitters, technical advice on nesting site selection for installation of predator exclusion fencing, and monitoring. Additional advice on site selection for Activity 1.
Jaime Edwards	Nongame Wildlife Specialist	MN DNR	Key partner for implementation of Activity 2. Roles include selection of study sites, surveys for and capture of turtles to be outfitted with GPS transmitters, technical advice on nesting site selection for installation of predator exclusion fencing, and monitoring. Additional advice on site selection for Activity 1.

Barb Perry	Natural Resources Technician	MN DNR	Key partner for implementation of Activity 2. Roles include selection of study sites, surveys for and capture of turtles to be outfitted with GPS transmitters, technical advice on nesting site selection for installation of predator exclusion fencing, and monitoring. Additional advice on site selection for Activity 1.

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

The goal of this project is to improve the conservation of Minnesota's imperiled turtles by mitigating two important sources of mortality. We will also promote public awareness about turtles and identify actions Minnesotans can take to benefit the conservation of our aquatic resources. This is particularly important at present, as both Blanding's and wood turtles are currently undergoing status reviews by the US Fish and Wildlife Service to determine whether they should be proposed for listing under the federal Endangered Species Act (ESA). Working proactively to improve the health of local turtle populations may avoid the regulatory burden and potential economic impacts associated with a possible listing under the ESA. Aspects of our work, such as reducing road mortality, will benefit other wildlife, including reptiles and amphibians. This project also meets an objective of the DNR's 2015 – 2025 Wildlife Action Plan, which calls for collecting data to update the status of wood turtles in Minnesota and inform the state's wood turtle conservation plan.

Evaluating and implementing strategies that improve the long-term viability of turtle populations may require several years. As such, we anticipate that the Zoo's activities to promote the conservation of turtles may continue beyond the scope of this grant. Hence, the Zoo will continue to explore non-ENRTF funding sources for this project and may submit a future proposal to fund this work.

VIII. REPORTING REQUIREMENTS:

- **The project is for 4 years, will begin on July 1, 2018, and end on June 30, 2022.**
- **Periodic project status update reports will be submitted January 31 of each year.**
- **A final report and associated products will be submitted between June 30 and August 15, 2022.**

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet
B. Visual Component or Map
C. Research Addendum

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2018 Budget Spreadsheet

Project Title: Conserving Minnesota's Nine Species of Freshwater Turtles
Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03k
Project Manager: Seth Stapleton
Organization: Minnesota Zoo
College/Department/Division: Conservation
M.L. 2018 ENRTF Appropriation: $300,000
Project Length and Completion Date: 4 years, June 30, 2022
Date of Report: June 30, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Revised Budget 2/8/2020	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$233,225	$233,225	$0
S. Stapleton, Principal Investigator / Project Manager. (1 person, 72% salary / 28% benefits), 0.05 FTE for 3 years - $16,225			
Biologist (to be determined). Research Analyst Intermediate or similar classification. (1 person, ~64% salary / 36% benefits). ~0.90 FTE for 3 years - $217,000			
Professional/Technical/Service Contracts			
Videographer contract to develop a short (3 - 5 min) video about Minnesota's turtles.	$5,000	$4,800	$200
Equipment/Tools/Supplies			
Road mortality mitigation measures, including traffic signs, lights, and road paint	$15,000	$4,480	$10,520
GPS transmitters to track movements of wood turtles (~$1,400 / unit; 16 total units for 2018, 2019, and 2020)	$22,500	$22,452	$48
Predator exclusion fencing and monitoring equipment (est. at $5,000 / unit, including hardware, fencing, batteries, and cameras; 4 units plus small contingency for additional supplies)	$11,775	$6,076	$5,699
Printing			
Printing of outreach materials, potentially including educational workbooks and / or booklets, that raise awareness and promote the conservation of turtles.	$7,500	$7,500	$0
Travel expenses in Minnesota			
Fuel / mileage and meals to travel to field sites in southern and central Minnesota: $1,000 / yr for 3 years. Reimbursement rates as allotted per the State of Minnesota travel regulations.	$3,000	$1,615	$1,385
Other			
Zoo-based turtle conservation educational and outreach, including photo licensing and interpretive signage and displays	$2,000	$568	$1,432
COLUMN TOTAL	**$300,000**	**$280,716**	**$19,284**

MINNESOTA ZOO

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

Mitigating Road Mortality

Road mortality is one of many threats faced by turtles in Minnesota. Although warning signs may be suitable in some circumstances, our research found that simple barriers are the most effective strategy for reducing turtle mortality.

MINNESOTA ZOO

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

Building Public Awareness

To raise awareness about the conservation of turtles, we developed educational materials including a durable, life-sized model of a snapping turtle, a video highlighting conservation efforts, and interpretive graphics. We also provided content for a children's book and disseminated printed copies during programming. On and off-campus programs provided the public with the opportunity to view turtles and other wildlife first-hand.

MINNESOTA ZOO

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

Tracking Imperiled Turtles

We attached radio and GPS transmitters to threatened wood turtles to improve our understanding of their habitat needs and inform turtle conservation in Minnesota. We also identified turtle nesting sites, allowing us to protect some nests with predator exclusion fencing and collect eggs from other nests to support head-starting efforts at the Zoo.