FINAL ENVIRONMENTAL ASSESSMENT

Field Evaluation of HOGGONE® Sodium Nitrite Toxicant Bait for Feral Swine

Prepared by:
United States Department of Agriculture
Animal and Plant Health Inspection Service
Wildlife Services

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LIST OF ACRONYMS AND ABBREVIATIONS

ADAI	Alabama Department of Agriculture and Industries
APHIS	Animal and Plant Health Inspection Service
AI	Active Ingredient
AVMA	American Veterinary Medical Association
CDC	Centers for Disease Control and Prevention
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO_2	Carbon Dioxide
EA	Environmental Assessment
EC_{50}	Half Maximal Effect Concentration
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
EUP	Experimental Use Permit
FAA	Federal Aviation Administration
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of no significant impact
FR	Federal Register
FY	Fiscal Year
IACRC	Invasive Animal Cooperative Research Center
IPM	Integrated Pest Management
IUCN	International Union for Conservation of Nature
ISSG	Invasive Species Specialist Group
LOED	Lowest observed effect dose
LOEL	Lowest observed effect level
MATC	Maximum Allowable Toxicant Concentrations
MOU	Memorandum of Understanding
NASS	National Agricultural Statistics Service
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NOEC	No observable effect concentration
NOED	No observed effect dose
NOEL	No observed effect level
NWDP	National Wildlife Disease Program
WS-NWRC	Wildlife Services - National Wildlife Research Center
OPP	Office of Pesticide Programs
PL	Public Law
SCWDS	Southeastern Cooperative Wildlife Disease Study
SOP	Standard Operating Procedure
SN	Sodium Nitrite
T&E	Threatened and Endangered
TDA	Texas Department of Agriculture
TPWD	Texas Parks and Wildlife Department
USC	United States Code
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Services
VS	Veterinary Services
WDM	Wildlife Damage Management
WS	Wildlife Services

1.0 NEED FOR ACTION AND SCOPE OF ANALYSIS

1.1 Introduction

Feral swine (Sus scrofa) are a destructive invasive species, they have been introduced into numerous countries, including the United States and Australia. Feral swine are rapidly expanding their geographic range and their population continues to increase in the United States (Waithman et al. 1999, Ballari and Barrios-Garcia 2013) because of their adaptability and high reproductive potential. However, recent range expansion is primarily due to humans transplanting them to new areas to increase hunting opportunities, either intentionally through release of animals into the wild, or unintentionally through escapes from hunting preserves (Waithman et al. 1999). Until the late 1980s, feral swine populations in the continental United States were primarily found in the southern states and on the west coast. In 1982, feral swine were thought to occur in only a small percentage of counties located in 17 states (Mayer and Brisbin 1991, Miller and Sweeney 2013, SCWDS 1982). Feral swine are now known to exist in at least 38 states (USDA 2015) (Figure 1).

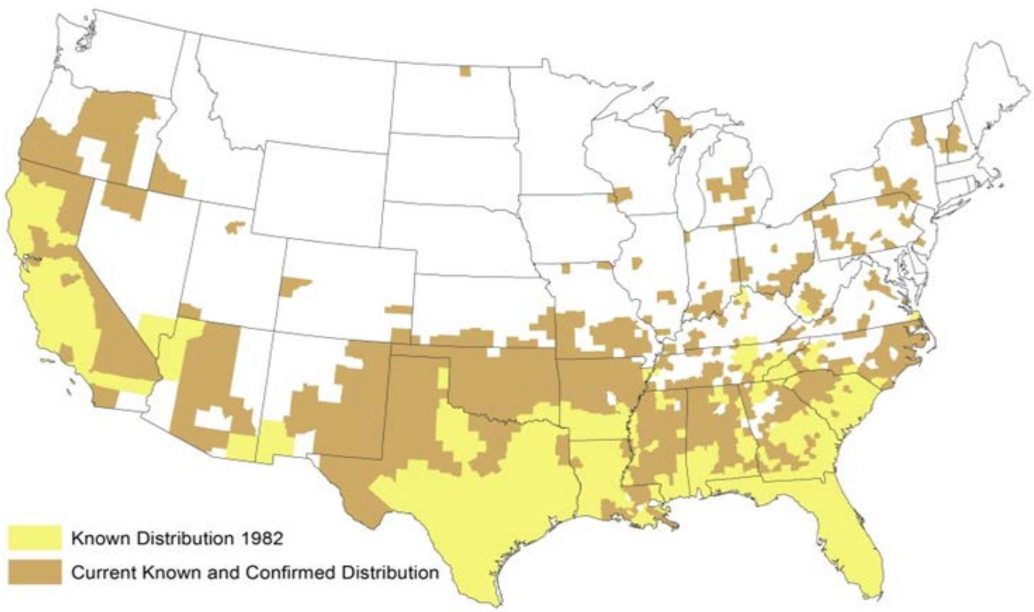

Figure 1. Known and confirmed feral swine range in (2012) compared with historic 1982 range. (Miller and Sweeney 2013, National Feral Swine Mapping System (http://swine.vet.uga.edu/nfsms/)).

Based on data from the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) Wildlife Services (WS), National Wildlife Disease Program (NWDP), the Southeastern Cooperative Wildlife Disease Study (SCWDS), and APHIS' Veterinary Services (APHIS-VS), feral swine are now present in approximately 40% of all counties in the United States (Figure 2). The national feral swine population is currently estimated to exceed more than 6 million individual animals (Mayer 2014).

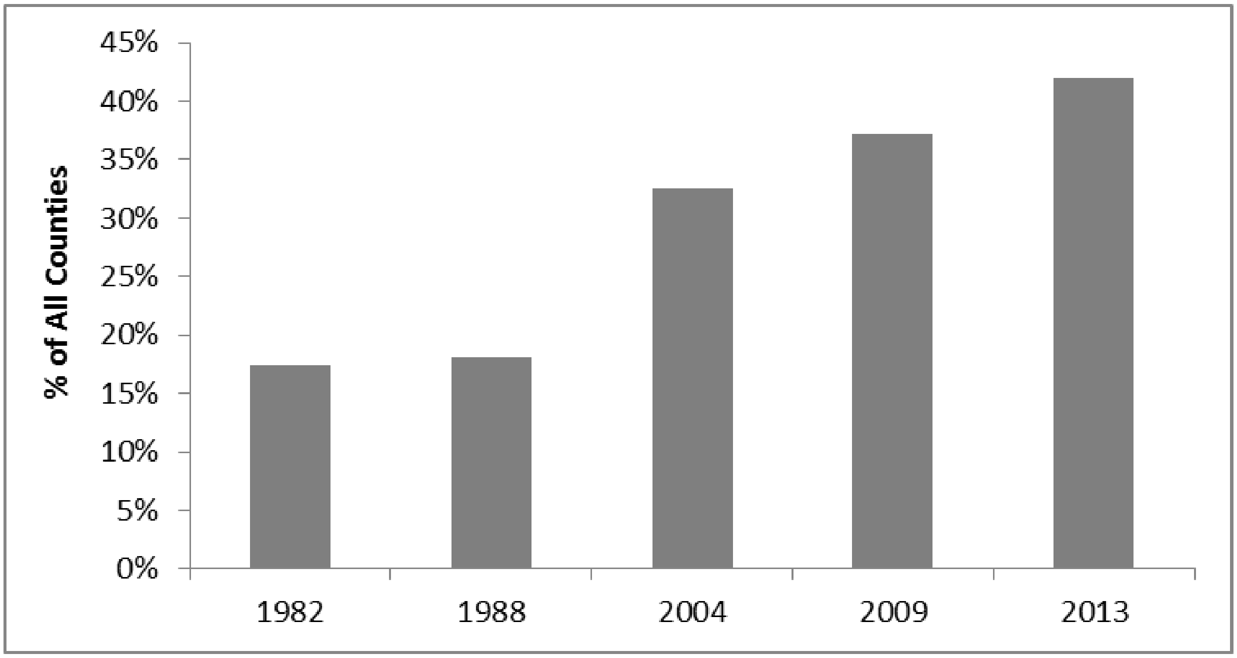

Figure 2. The percentage of counties in the United States with feral swine present from 1982 to 2013 (USDA 2015).

WS' National Wildlife Research Center (NWRC) is the largest facility in the world dedicated to researching methods and developing tools to help resolve human-wildlife conflicts, including those involving invasive species such as the rapidly expanding feral swine population. NWRC is the research arm of WS and has made feral swine research one of its highest priorities.

This Environmental Assessment (EA) describes and analyzes WS-NWRC's proposed involvement in testing and evaluating a toxicant bait for feral swine. More specifically, this EA is written to determine the environmental effects to inform a decision on whether or not research on a toxicant bait should be tested in the field for feral swine.

1.2 Need for Action

Feral swine can cause significant damage to agricultural, natural and cultural resources, property, and they pose risks to human and animal health. The International Union for Conservation of Nature (IUCN), Invasive Species Specialist Group (ISSG) has included feral swine in their listing of "100 of the World's Worst Invasive Alien Species" (Lowe et al. 2000). The damage from feral swine to natural and agricultural resources can be substantial (Seward et al. 2004). For example, Pimentel et al. (2000) conservatively estimated agricultural damage caused by feral swine in the United States to be $800 million/year or $200/animal/year. Pimentel (2007) later revised his estimates with a rapidly increasing feral swine population, estimating 5 million feral swine with increasing damages of approximately $300/animal/year resulting in approximately $1.5 billion in annual damages. Mayer (2014) provided the most recent population estimate, which exceeds 6 million animals. Using Pimentel's damage estimates of $300/animal/year, would indicate annual damages that now exceed $1.8 billion.

Feral swine also damage habitat and natural resources in many ways. They can consume large quantities of herbaceous vegetation (3–5% of their body weight daily) and have been linked to 95% declines of understory vegetation in some systems (Cole et al. 2012). They can consume large amounts of seeds, nuts and seedlings that may ultimately reduce the potential for forest regeneration (Campbell and Long 2009), and may influence future over-story composition and reduce tree diversity directly through consumption of seeds (Tolson and LaCour 2013).

Feral swine diets overlap with those of native wildlife, including threatened or endangered (T&E) species, which may result in competition for important and limited natural food supplies, although documentation of competition is limited (Mayer 2009, Ballari and Barrios-Garcia 2013). Mast crops are a preferred food of feral swine and also a critical food source for many native wildlife species. Consumption of seeds, seedlings, and other vegetation reduces availability for native species (Campbell and Long 2009, Mayer 2009).

Soil disturbance and vegetation loss associated with trampling, wallowing, and rooting by feral swine increases erosion and associated problems with water contamination and siltation. Siltation and water contamination in stream reaches and coastal areas with swine activity have contributed to declines in aquatic organisms, including freshwater mussels and insects (West et al. 2009). In some areas, feral swine have been implicated as the cause of elevated waterborne bacteria levels in streams, including levels which exceeded thresholds for the protection of human health (Kaller et al. 2007).

Feral swine foraging, rooting, and wallowing can also damage landscaping, golf courses, recreational fields, cemeteries, parks, and lawns. Rooting by feral swine likewise damages roadsides, dikes, and other earthen structures. Cultural sites impacted by feral swine have included national historic sites, tribal sacred sites and burial grounds, and archaeological sites and digs (Native American and European origin).

Feral swine can carry 30 viral and bacterial diseases, and nearly 40 parasites that may affect humans, domestic livestock, and wildlife species (Ruiz-Fons et al. 2008, Meng et al. 2009). Feral swine can also harbor the causative agents of important foodborne diseases (e.g., *Escherichia coli* (E. coli), toxoplasmosis, and trichinosis). Additionally, feral swine can transmit many of these diseases to pets, including pseudorabies. Dogs, particularly hunting dogs, become infected with pseuorabies after coming into contact with infected feral swine. Once a dog is infected, there is no treatment, and death typically occurs 48–72 hours after symptoms appear (HAID 2014).

Feral swine control efforts using traditional methods such as cage traps, snares, shooting, and aerial hunting have been successful in controlling and even eliminating small or isolated populations of feral swine in some states and islands (Richardson 2010, Knapp 2010). However, given the precipitous increase in abundance and distribution of feral swine across most of the U.S. (Dickson et al. 2001, Adams et al. 2006), additional methods to control feral swine damage or modifications to existing methods are needed to enhance current control methods (Sweeney et al. 2003).

Various toxicants to control feral swine have been used for decades in Australia (Hone et al. 1984). Furthermore, toxicants for feral swine are believed to have potential as a viable control method in the United States (Campbell et al. 2013), but until recently have never been registered in the U.S. Eason et al. (2010) suggests one reason for the lack of registration of vertebrate pesticides in the U.S. is because of the costly registration process. However, the Environmental Protection Agency (EPA) recently (January 2017) approved a warfarin based toxicant for feral swine in the U.S. but it has been considered and rejected for registration in several states. The future of this product is currently unknown.

Although warfarin, sodium fluoroacetate (1080) and yellow phosphorus (sold as CSSP) have been used in Australia for decades, they are not without disadvantages. Because of shortcomings with these toxicants and changing public attitudes about toxicants, Australia has led the challenge in researching an alternative that meets a multitude of criteria before considering it as a toxin for large mammals such as feral swine. Cowled et al. (2008) conducted a literature review of the various toxicants that have been used in Australia. The review recognized a number of criteria such as toxicity, acceptability to the target population, commercial availability, low cost, humaneness, species specificity, environmental soundness and human safety, among others, that should be considered when developing a feral swine toxicant. This review (Cowled 2008) identified sodium nitrite as meeting the majority of these standards. As a result, Australia has spent several years developing a sodium nitrite toxicant for feral swine.

In recent years, Australia has collaborated with researchers at WS-NWRC to explore sodium nitrite's potential use in the U.S. (Lapidge et al. 2012). A collaborative research effort among WS-NWRC, the Invasive Animal Cooperative Research Center (IACRC) from the University of Canberra, Australia, and the Texas Parks and Wildlife Department (TPWD) has developed HOGGONE® (Animal Control Technologies (Australia) Pty. Ltd., Somerton, Victoria, Australia) – an acute toxicant bait for feral swine in the United States.

WS-NWRC is proposing to conduct field trials in Alabama and Texas to test the feasibility and efficacy of HOGGONE® for feral swine in the United States. The Proposed Action (conduct the study) would build on previous work to develop and evaluate effective toxicant baits for feral swine (Campbell et al. 2006, Lapidge et al. 2012).

The goal of the field trials is to determine the effectiveness of HOGGONE® and its environmental effects as a feral swine toxicant for free ranging feral swine. Thus far, all research on the product in the U.S. has been conducted in controlled pen studies or in the laboratory. The proposed study would replicate how the toxicant would potentially be used in an operational capacity.

1.3 National Environmental Policy Act and WS-NWRC Decision-making

.This EA analyzes the impacts of a field trial (proposed action) on sodium nitrite (SN) HOGGONE® at two relatively small study sites in Alabama and Texas. WS-NWRC has prepared this EA to facilitate planning, interagency coordination, streamline field trial management, and clearly communicate with the public and regulators the analysis of potential cumulative impacts resulting from this research. The implementation of the proposed research constitutes a federal action subject to provisions of the National Environmental Policy Act (NEPA) of 1969, as amended. WS-NWRC is required to prepare an EA to analyze the effects on the human and natural environment and to document the findings. WS-NWRC will use this EA to determine if the Proposed Action is likely to result in significant impacts to the human and natural environment. If it is determined that there are no significant adverse impacts, WS-NWRC will issue a Finding of No Significant Impact (FONSI). If it is determined that significant adverse impacts might occur, the agency will be required to prepare an Environmental Impact Statement (EIS).

Depending upon the decision resulting from this EA, if the proposed field trial is selected and implemented, the research results may be used as part of an application to inform EPA in evaluating the pesticide for registration in the United States. The proposed study in this EA is designed to comply with EPA testing guidelines. Registration would be an EPA action involving its own scientific, legal and administrative processes, and would carry with it all attendant EPA NEPA and other environmental regulatory compliance requirements which cannot be assessed at this time.

1.4 Objectives

The objectives of the study are to analyze the effectiveness of the toxicant in a field setting, analyze and determine if there is a threat to non-target animals, particularly raccoons (*Procyon lotor*), and to continue evaluating the effectiveness of the prototype bait stations used to deploy the toxicant.

1.5 Scope of Analysis

The scope of the analysis includes a field study in two study sites in Texas and Alabama (Section 1.5.1). The analysis evaluates effects on humans and pets, terrestrial and aquatic environments, non-target and threatened and endangered species, and humaneness and ethics.

Actions outside the scope of this EA are those actions already taking place to reduce the feral swine population in the respective study sites in Texas and Alabama. Those actions which include traditional control measures such as trapping and aerial hunting are considered in other state environmental documents (USDA AL 2014, USDA TX 2014b).

1.5.1 Site-Specificity

WS-NWRC is proposing to evaluate the efficacy of HOGGONE® on free-ranging feral swine in 2 different climatic ecoregions of the United States. The first ecoregion, South-Central Semi-Arid Prairies, is part of the Tropical/Subtropical Steppe Ecosystem Division with a hot semiarid climate that rarely falls below freezing in the south-central part of the US (Archer, Baylor, Cottle, Foard, Hall, Knox, Motley, Wichita and Wilbarger counties of Texas) The second ecoregion, Southeastern U.S. Plains, is part of the Subtropical Ecosystem Division marked with high humidity and high temperatures during the summer and an absence of cold winters (Bailey 1998) in the south-eastern part of the U.S. (Bullock, Macon, and Montgomery counties in Alabama). These represent a range of climatic conditions and the geographic areas in which the majority of feral swine currently exist in the U.S.

While the proposed study sites have not yet been specifically identified, there are general criteria established for the selection of the sites. Within each of the 2 geographic locations, NWRC would target 3–9 unique sounders of feral swine for testing. Testing sites would be selected based on recommendation of experienced WS-TX and WS-AL operations personnel and the following criteria:

1. Contains a robust population of feral swine (e.g., presence of wallows, rooting, feces, and fresh tracks).
2. Landowners have granted USDA APHIS WS permission to access their land.
3. Low probability of interference from hunting or other public activities.
4. Few to no sensitive or protected habitats or species are present.
5. Separated by 1–2 km from other sounders of feral swine to reduce spatial dependency among sounders.

1.6 Agencies Involved in this EA and Their Roles and Authorities

<u>Lead Agency</u>

United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Wildlife Services (WS) National Wildlife Research Center (NWRC)

USDA is authorized by law to protect American agriculture and other resources from damage associated with wildlife (Act of March 2, 1931 (46 Stat. 1468; 7 U.S.C. 8351–8352) as amended, and the Act of December 22, 1987 (101 Stat. 1329–331, 7 U.S.C. 8352). Within the USDA, this authority has been delegated to the APHIS-WS program. APHIS-WS' mission, developed through its strategic planning process, is: 1) *"to provide leadership in wildlife damage management in the protection of America's agricultural, industrial and natural resources, and 2) to safeguard public health and safety."* APHIS-WS recognizes that wildlife is an important public resource greatly valued by the American people. By its very nature, however, wildlife is a highly dynamic and mobile resource that can cause damage to agriculture and property, pose risks to human health and safety, and affect industrial and natural resources. APHIS-WS conducts programs of research, technical assistance, and applied management to resolve problems that occur when human activity and wildlife conflict.

Consulting Agencies

United States Fish and Wildlife Service (USFWS)

USFWS has statutory authority to manage federally listed threatened and endangered species (T&E) through the Endangered Species act of 1973 (ESA) (16 U.S.C. 1531-1543, 87 Stat.884), as amended. The USFWS mission is to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. The Alabama Ecological Services Field Office located in Daphne, Alabama reviewed the T&E effect determinations for Alabama in this document and provided a letter of concurrence on April 27, 2017.

United States Environmental Protection Agency (EPA)

The EPA is responsible for implementing and enforcing the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which regulates the registration and use of pesticides, including repellents. The EPA provided input into the development of this document.

State agencies

The states involved in this proposed field study include Texas and Alabama. Each state has a state agency or agencies with authority under state law to manage, approve, conduct or coordinate various activities as they relate to wildlife, feral swine, agriculture, pesticides, etc. WS actions would only occur in complete cooperation with the appropriate state agency(ies) and in accordance with state authorities as identified by those agencies. A draft of this EA was provided to the Alabama Department of Conservation and Natural Resources, the Alabama Department of Agriculture and the Texas Parks and Wildlife Department.

1.7 Documents Related to this EA

Final Environmental Impact Statement – Feral Swine Damage Management: A National Approach

WS has prepared a programmatic feral swine environmental impact statement (EIS) to evaluate alternatives for a nationally coordinated feral swine damage management program in the U.S., American Samoa, Guam and the Commonwealth of the Northern Mariana Islands, U.S. Virgin Islands, and Puerto Rico (hereinafter USDA 2015). The Record of Decision (ROD), issued July 2015, selected a nationally coordinated, integrated Feral Swine Damage Management (FSDM) program. The selected alternative in the ROD incorporated all legally available FSDM methods and retained the flexibility to continue to work with local stakeholders under state or local level NEPA decisions, with local stakeholders to manage feral swine damage according to local feral swine management goals. This EA is consistent with the applicable findings, policies, and operational procedures evaluated in the Final EIS (FEIS). While the FEIS does not address the use of toxicants or repellants because they had not been developed at that time, it did identify research on sodium nitrite as a high priority to be conducted under the selected alternative of the FEIS.

Environmental Assessment – Mammal Damage Management in Alabama: WS has prepared an EA to evaluate the need to reduce damage and threats of damage associated with several species of mammals in Alabama (WS-Alabama), including feral swine (USDA 2014). The EA evaluates the potential effects associated with the alternative approaches and evaluates the need to manage damage associated with mammals in the State.

Environmental Assessment – Feral Swine Damage Management by the Texas Wildlife Services Program: The WS program in Texas (WS -Texas) has prepared an EA to evaluate the individual projects that could be conducted to manage damage and threats to agricultural resources, property, natural resources, and threats to people caused by feral swine (USDA 2014b).

Study protocol – Field Evaluation of HOGGONE® Sodium Nitrite Toxicant Bait for Feral Swine: WS-NWRC has prepared a detailed study protocol. This EA has incorporated all relevant information from this protocol as it relates to any potential environmental effects on the human environment. However, the study protocol incorporates specific details in regard to methodology that is not covered or applicable to this EA and therefore is not included in this document.

1.8 Public Involvement

As a part of the process for this proposed action, and as required by the Council on Environmental Quality (CEQ) and APHIS' NEPA implementing regulations, this document is being noticed to the public through legal notices published in local print media, through direct mailings to parties that have requested to be notified or have been identified to have an interest in WS-NWRC programs, and by posting the pre-decisional EA on the APHIS website at: http://www.aphis.usda.gov/wildlife_damage/nepa.shtml.

WS-NWRC will provide a 30-day comment period for the public and interested parties to provide new issues, concerns, and /or alternatives. Through the public involvement process, WS-NWRC will clearly communicate to the public and interested parties the analysis of potential environmental impacts on the quality of the human environment. New issues or alternatives identified from the public involvement process will be fully considered to determine whether the EA should be revisited and, if appropriate, revised prior to the issuance of a final EA and FONSI or the publication of a Notice of Intent to prepare an EIS.

1.9 Rational for Preparing an EA rather than an EIS

Based on guidance from APHIS NEPA implementing procedures, 7 CFR 372.5 States: Actions normally requiring environmental impact statements. Actions in this category typically involve the agency, an entire program, or a substantial program component and a significant impact on the human environment is anticipated. 7 CFR 372.6 States: Actions normally requiring environmental assessments. This category of actions is typically related to a more discrete program component but could be programmatic; however, the potential environmental impacts associated with the proposed action are not considered potentially significant at the outset of the planning process. An action in this category is typically characterized by its limited scope (particular sites, State-wide or district wide programs, specific or similar species, or particular activities). Actions normally requiring an environmental assessment, but not necessarily an environmental impact statement, include; (f) "Research or testing that will be conducted outside of a laboratory or other containment area."

Considering these guidelines, WS-NWRC believes the proposed action is limited in scope. The research is species-specific and involves only two isolated sites, specifically designated areas in Alabama and Texas.

As cited in 1.8 Public Involvement above, if new issues or alternatives are identified in the public involvement process or if the proposed action was determined to have significant impacts based on the context and intensity factors listed by the Council on Environmental Quality (CEQ) at 40 CFR 1508.27 it would require the preparation of an EIS. If this EA determines that an EIS is necessary, then WS-NWRC would issue a Notice of Intent to prepare an EIS.

1.10 Laws Related to this Discussion

National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.). All federal actions are subject to NEPA (42 U.S.C. §§ 4321 et seq.). WS-NWRC follows CEQ regulations implementing NEPA (40 CFR 1500 et seq.) and USDA (7 CFR 1b) and APHIS implementing regulation (7 CFR 372) as part of the decision-making process. These laws and regulations generally outline five broad types of activities to be accomplished as part of any project: public involvement, analysis, documentation, implementation, and monitoring. NEPA also sets forth the requirement that all major federal actions be evaluated in terms of their potential to significantly affect the quality of the human environment for the purpose of avoiding or, where possible, mitigating and minimizing adverse impacts.

Pursuant to NEPA and CEQ regulations, this EA documents the analysis for potential impacts of a proposed federal action, informs decision-makers and the public of reasonable alternatives capable of avoiding or minimizing adverse impacts, and serves as a decision-aiding mechanism to ensure that the policies and goals of NEPA are infused into federal agency actions. This EA was prepared by integrating as many of the natural and social sciences as warranted, based on the potential effects of the proposed action. The direct, indirect, and cumulative impacts of the proposed action are analyzed.

Endangered Species Act (ESA) (16 U.S.C. 1531 et seq.). It is federal policy, under ESA, that all federal agencies shall seek to conserve threatened and endangered (T&E) species and shall utilize their authorities in furtherance of the purposes of the Act (Sec.2(c)). For actions that “may affect” listed species, APHIS-WS conducts Section 7 consultations with the U.S. Fish & Wildlife Service (USFWS) to ensure that "any action authorized, funded or carried out by such an agency . . . is not likely to jeopardize the continued existence of any endangered or threatened species . . . Each agency shall use the best scientific and commercial data available" (Sec.7(a)(2)).

National Historic Preservation Act (NHPA) of 1966 as amended (16 U.S.C. § 470). NHPA and its implementing regulations (36 CFR 800) require federal agencies to: 1) determine whether activities they propose constitute “undertakings” that can result in changes in the character or use of historic properties and, 2) if so, evaluate the effects of such undertakings on such historic resources and consult with the State Historic Preservation Office regarding the value and management of specific cultural, archaeological, and historic resources, and 3) consult with appropriate American Indian Tribes to determine whether they have concerns for traditional cultural properties in areas of these federal undertakings.

The Proposed Action would not cause major ground disturbance, does not cause any physical destruction or damage to property, would not cause any alterations of property, wildlife habitat, or landscapes, and does not involve the sale, lease, or transfer of ownership of any property. In general, such methods in the proposed action also do not have the potential to introduce visual, atmospheric, or audible elements to areas in which they are used that could result in effects on the character or use of historic properties. Therefore, the methods that would be used under the Proposed Action are not generally the types of activities that would have the potential to affect historic properties. If an individual activity with the potential to affect historic resources is planned under an alternative selected as a result of a decision on this EA, then site-specific consultation as required by Section 106 of the NHPA would be conducted as necessary.

Executive Order on Environmental Justice. Executive Order (EO) 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations requires federal agencies to analyze disproportionately high and adverse environmental effects of proposed actions on minority and low-income populations. APHIS-WS-NWRC has analyzed the effects of the proposed action and determined that implementation would not have adverse human health or environmental impacts on low-income or minority populations.

Executive Order on Protection of Children from Environmental Health and Safety Risks. Executive Order 13045 was passed to help protect children who may suffer disproportionately from environmental health and safety risks for many reasons. The analysis in Section 3.2.1 of this EA supports a conclusion of very low to no risk of adverse effects on human health and children from the Proposed Action. Implementation of the Proposed Action would not increase environmental health or safety risks to children.

Invasive Species - Executive Order 13112

Executive Order 13112 establishes guidance to federal agencies to prevent the introduction of invasive species, provide for the control of invasive species, and to minimize the economic, ecological, and human health impacts that invasive species cause. The Order states that each federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law: 1) reduce invasion of exotic species and the associated damages, 2) monitor invasive species populations and provide for restoration of native species and habitats, 3) conduct research on invasive species and develop technologies to prevent introduction, and 4) provide for environmentally sound control and promote public education of invasive species. WS Directive 2.320 provides guidelines for WS' actions in the management of invasive species in fulfillment of Executive Order 13112.

The Native American Graves and Repatriation Act of 1990

The Native American Graves Protection and Repatriation Act (Public Law 101-106, 25 USC 3001) requires federal agencies to notify the Secretary of the Department that manages the federal lands upon the discovery of Native American cultural items on federal or tribal lands. Federal agencies are to discontinue work until the agency has made a reasonable effort to protect the items and notify the proper authority. The Proposed Action is not occurring on federal or tribal land.

Federal Insecticide, Fungicide, and Rodenticide Act

FIFRA and its implementing regulations (Public Law 110-426, 7 USC 136 et. seq.) require the registration, classification, and regulation of all pesticides used in the United States. The EPA is responsible for implementing and enforcing FIFRA. The EPA and the Texas Department of Agriculture (TDA) and the Alabama Department of Agriculture and Industries (ADAI) regulate chemical methods that could be available to manage damage associated with feral swine in each state.

2.0 ISSUES AND ALTERNATIVES

NEPA requires consideration of reasonable alternatives, including a No Action Alternative to be used for comparison purposes. For the purpose of this environmental assessment, there are two alternatives, the

Proposed Action to conduct the study and the No Action alternative is to not conduct the study. The alternatives are evaluated to determine what, if any significant impacts they may have on the environment.

2.1 Introduction to issues and Alternatives

This chapter describes and identifies the issues and the alternatives that will be analyzed in this environmental assessment. The following issues will be evaluated in detail for their potential environmental, social, and human health impacts as appropriate in Chapter 3, Environmental Effects. These issues have been identified based on WS-NWRC's experience, and previous EAs and public comments on those EAs.

2.1.1 Issues Considered in Detail

<u>Effects on Human Health and Pet Safety</u>

<u>Impacts on Terrestrial and Aquatic Environments</u>

<u>Effects on Non-Target and T&E Species</u>

<u>Humaneness / Ethics</u>

2.1.2 Issues Not Considered in Detail with Rationale

<u>Effects on Target Species</u>

The goal of the study is to uniquely mark 30 feral swine in each geographic location. However, a minimum of 15 will be acceptable with a maximum of 60 feral swine being marked in each location. This would be a total (combined Alabama and Texas) of 120 marked feral swine or less that could be euthanized in the effort to determine the effectiveness of HOGGONE® on free-ranging feral swine. Mayer (2014) estimates there are 6 million feral swine in the U.S. Based on the proposed use of HOGGONE® in the study, WS-NWRC could remove a combined total of approximately 300-400 feral swine from the study sites. Both Texas and Alabama have robust feral swine populations and removing roughly 150-200 feral swine from each location will have little to no effect on the local population and no effect on the national population of feral swine.

<u>Impacts on Odor / Air Quality</u>

Odor associated with feral swine or raccoon carcasses for this study would represent at most a small scale project with short term, temporary odor effects. Odor from feral swine is not considered a health risk. WS-NWRC would only leave feral swine carcasses on site where land uses, agreements with landowners and land managers, and local regulations allow. Carcass odor is also a temporary issue and would not contribute to significant direct, indirect or cumulative air quality or odor issues.

<u>Impacts on Hunting / Recreation</u>

Feral swine are not categorized as a game animal in Texas or Alabama. There is no season or bag limits for feral swine in either state. Although feral swine hunting is popular in both states, the number of feral swine that would potentially be removed as a result of this study from either local area would be insignificant relative to the population. Furthermore, the lands that WS-NWRC would be conducting the field trials on are private and the land owners have requested WS assistance to conduct feral swine damage management. These properties are not accessible to local hunters and therefore the study would not impact hunting or recreation in Texas or Alabama. Section 3.2.1 does however provide a human exposure assessment. The analysis looks at a scenario where an individual hunter could trespass on the property where the study is being conducted. Although highly unlikely, it is addressed in Section 3.2.1.

Effects of Socio Cultural Resources

As described in 1.12, the proposed action would not cause major ground disturbance, does not cause any physical destruction or damage to property, would not cause any alterations of property, wildlife habitat, or landscapes, and does not involve the sale, lease, or transfer of ownership of any property. In general, such methods in the proposed action also do not have the potential to introduce visual, atmospheric, or audible elements to areas in which they are used that could result in effects on the character or use of historic properties. Furthermore, feral swine do not have traditional or cultural value in Texas or Alabama and are not expected to adversely affect any tribes, traditional cultures or ceremonial values in either study location.

Cost Effectiveness

Although this study does not specifically address the cost effectiveness of HOGGONE®, it is conceivable that the method (if ultimately registered with the EPA) could be more cost effective than some of the currently available methods to control feral swine, especially in particular situations. Its potential cost effectiveness as an additional tool for feral swine control is one of the motivations for the proposed study. Opponents may argue that recreational hunting of feral swine is more cost effective than a toxicant or other state/government organized control efforts because the service is provided "free" by hunters and states can generate income from selling licenses to harvest feral swine. It is true that some states do generate some revenue and feral swine can provide some recreational opportunities, however, each management situation needs to be evaluated independently to determine if public hunting is a viable option to meet management objectives. In most situations, public hunting does not control the population adequately and has been documented to promote the spread of feral swine (Richardson et al. 1995, Bevins et al. 2014) and generally does not meet management objectives.

Although cost effectiveness is always an important issue to consider when analyzing control techniques, it is not analyzed here in detail because this EA only considers the immediate issues within the confines of the proposed study and the small scale of the study does not warrant a cost effective analysis.

Economic Impacts

Like cost effectiveness, it is not relevant to analyze the economic impacts of this study because it is of such a small scale and it is not within the scope of this EA. As mentioned, the total number of feral swine that would potentially be removed from this study is insignificant in terms of economics.

2.2 Study Protocol

The goal of this proposed study will be to expose feral swine from uniquely identified sounders to HOGGONE® sodium nitrite bait using anticipated application methods in field conditions. Lethal control of feral swine is hypothesized as most efficient when entire sounders (*i.e*., social group containing several adults and piglets) are removed from an area (Sparklin et al. 2009). Sounders of feral swine generally consist of 3–9 animals, although 2–30 are commonly reported (Mayer and Brisbin 2009). Failing to remove only a few animals may allow feral swine to become quickly re-established given their high reproductive capacity. Bait stations (Appendix B) designed to allow multiple feral swine (including piglets) to feed at once, and keep non-target species from accessing the toxic bait will be used to apply the bait. Secondly, the study will assess the risk that HOGGONE® poses to non-target species when applied in these bait stations. The study will also sample HOGGONE® for consistent concentrations of SN in the toxic bait and lack thereof in the placebo HOGGONE® baits. Lastly, the study will test feral swine carcasses for SN residue and monitor their fate at each study site.

2.2.1 Product Description

HOGGONE® is comprised of the active ingredient, sodium nitrite (SN), within a bait matrix of black-colored peanut paste and crushed grains. WS-NWRC studies have identified that free-ranging feral swine exhibited no shyness to a black-colored bait matrix of peanut paste and crushed grains. The SN is concealed from detection by feral swine by a micro-encapsulation coating over the SN. The coating consists of an inert food-grade polymer (Connovation Ltd., Manukau, NZ) designed to dissolve in the high pH environment of the stomachs of feral swine. Pen studies at WS-NWRC recently identified that a single micro-encapsulation coating over the SN at 10% concentrations within the bait matrix is lethal to feral swine.

The mode of lethality of HOGGONE® is caused by its direct impacts on hemoglobin. Hemoglobin is a protein in blood responsible for transporting oxygen throughout the body. Sodium nitrite converts hemoglobin to methemoglobin (MtHb). Higher than normal levels of nitrite leads to methemoglobinemia which quickly leads to loss of consciousness and then death from the rapid depletion of oxygen to the brain and vital organs. The severity of methemoglobinemia depends on the balance between MtHb formation and its reduction or reversal back to hemoglobin by a protective enzyme called MtHb reductase. This naturally occurring enzyme catalyzes the reduction of MtHb back to hemoglobin to protect red blood cells against oxidative damage.

Different species have varying levels of the enzyme MtHb reductase resulting in varying levels of sensitivity to sodium nitrite. Feral swine have relatively low levels of the enzyme and so they are susceptible to nitrite-induced methemoglobinemia (Lapidge and Eason 2010). Snow et al. (2017a) showed a 95% mortality rate for captive feral swine in 2-choice laboratory efficacy tests with HOGGONE®. Studies have also demonstrated that 400 mg/kg of SN per body weight produced 100% mortality in feral swine within 2.5–4 hours of consumption and the Institute of Medical and Veterinary Science (2010) considers SN a humane toxicant for feral swine. Furthermore, Lapidge and Eason (2010) also demonstrated that MtHb reductase levels had a positive correlation to lethality in several different mammalian species suggesting that MtHb reductase levels could be used to estimate lethality for other mammalian species where toxicity data is unknown for sodium nitrite.

Figure 3. A sample of toxic HOGGONE® bait. Bait will likely be packaged in pre-mixed buckets and scooped directly into the bait stations.

2.2.2 Description of Study

This study is designed to test the efficacy of HOGGONE® for sounders of feral swine at bait sites located on a single property or adjacent properties, because this is the geographic scale at which WS feral swine control typically occurs, and therefore, represents how HOGGONE® would likely be applied if it were to be registered and used operationally by WS. In an analysis of sounders across the U.S., sounders separated by >2 km rarely came into contact (Pepin et al. 2016). Therefore, WS-NWRC expects sounders visiting bait sites separated by 1–2 km on a single or adjacent properties will be largely spatially and behaviorally independent during the duration of the study.

Trapping efforts will be conducted in specific areas (*e.g.,* 500 meter (m) radius). Within the concentrated areas, corral traps, box traps, drop traps, air-cannon nets, and drop nets could potentially be used to capture sounders of feral swine. Traps will be monitored using remote cameras (Reconyx PC900, Holmen, WI, USA) to identify the number of feral swine visiting the traps daily. Initially, all traps will be pre-baited and left unset to determine the number of feral swine visiting the traps. Once regular visits by feral swine are identified and the approximate number of feral swine per sounder is determined, an attempt to capture ≥75% of the animals observed within the target sounders will be made. Handling of captured feral swine will be conducted with the aid of chemical immobilization drugs (3.3 mg/kg body weight of Telazol® plus 1.6 mg/kg body weight of xylazine) or immobilization devices (e.g., squeeze chute) in order to humanely and safely attach the transmitters. Animals will be equipped with GPS/VHF transmitting collars or ear tags, and uniquely identifiable ear tags (3-star All American® ear tags, Y-Tex® Corporation, Cody, WY, USA) onto both ears of each feral swine. The goal will be to uniquely mark 30 feral swine in each geographic location. However, a minimum of 15 will be acceptable with a maximum of 60 feral swine being marked in each location.

Snow et al. (2016) identified that white-tailed deer (*Odocoileus virginianus*) and raccoons were the most frequently observed non-target species that visited placebo HOGGONE® without using bait stations in Texas. Previous studies identified raccoons as the primary non-target species accessing predecessor prototypes of bait stations for feral swine (Long et al. 2010, Campbell et al. 2011, Campbell et al. 2013). Given these findings, the study will focus on raccoons as the primary non-target species at potential risk from direct exposure to toxic HOGGONE® in bait stations.

To test effects on non-target species, WS-NWRC will live capture and uniquely mark 15 raccoons in each geographic location near the placement of the feral swine bait stations. However, a minimum of 6 and a maximum of 30 raccoons at each geographic location will be acceptable. Raccoons will be marked with GPS/VHF transmitting collars. Live capture of raccoons will be conducted primarily using cage traps (Tomahawk Live Trap, Hazelhurst, WI, USA) at night. Handling of raccoons will be conducted with the aid of chemical immobilization drugs (20 mg/kg body weight of ketamine plus 4 mg/kg body weight of xylazine, or 3 mg/kg body weight of Telazol® plus 2 mg/kg body weight of xylazine) in order to humanely and safely attach the transmitters. All non-targets will be released.

After marking feral swine and raccoons in each geographic location, a ≥2 week acclimation period will be initiated for the marked animals to recover from capture stress. During this period, exploratory baiting will be conducted using whole kernel corn to identify potential bait sites for deploying bait stations. Bait sites will be monitored using remote cameras to determine which bait sites marked animals are visiting and consuming bait. After the acclimation period, bait stations will be deployed at those bait sites with the highest visitation rate by feral swine. At each bait site, 1 bait station (Appendix B) will be deployed per 5–10 feral swine that visit the location.

Pre-baiting the bait stations will begin immediately after being deployed. Snow et al. (2016) found that refreshing the placebo HOGGONE® daily at bait sites produced consistent and increasing visitation by feral swine over a period of at least 10 days. Bait stations will be monitored with 2 remote cameras. Initially the bait stations will be pre-baited with whole-kernel corn and transitioned to placebo HOGGONE® (same bait matrix but without active ingredient sodium nitrite) as feral swine regularly access the bait station. Bait stations will then be transitioned from having the lids propped completely open, to slightly open, to closed without resistance, and lastly to closed with 13.6 kg (30 lbs.) of magnetic resistance. All bait stations targeting a unique sounder will transition throughout the steps simultaneously. The transition between steps will be made as feral swine appear to regularly access the bait station at the previous stage. Once feral swine are observed regularly accessing the bait station with the lid closed with 13 kg magnetic resistance and consuming placebo HOGGONE® for 2 consecutive nights, the bait site is considered ready for a toxic HOGGONE® application.

For toxicant application, each side of the bait station is designed to hold 10 kilogram (kg) of the pre-mixed toxic HOGGONE®. The bait stations have two sides, therefore each station will contain 20 kg of HOGGONE® and will be applied for 2 consecutive nights. Fresh bait will be placed in the bait stations in the afternoons or early evenings. Remote cameras will be used to identify which marked animals accessed the bait station (*i.e.*, they were observed with their head under a lid of the bait station) and were exposed to the toxic HOGGONE®.

Following 2 nights of toxicant baiting, 2 nights of post-baiting using placebo HOGGONE® will be initiated to observe if any marked feral swine continue to visit the bait station. If marked feral swine are observed visiting the bait station during this time, another 2-night period of toxic HOGGONE® baiting will be initiated. This procedure will continue for up to 3 rounds per bait station, after which WS-NWRC will consider any remaining visiting or unaccounted for marked feral swine to have survived the study.

2.2.3 Study Assessment and Data Analyses

Sodium nitrite is an acute toxicant, thus death from hypoxia occurs rapidly after ingestion of toxic HOGGONE® if a sufficient methemoglobin level is reached. The time to death was also identified to be ≤4 hours in multiple pen studies with toxic HOGGONE® (Snow et al. 2017a). Feral swine that fail to consume a lethal dose of HOGGONE® over a short-enough period of time will quickly convert the SN-induced methemoglobin back to hemoglobin via methemoglobin reductase. Thus, feral swine will either die within 4 hours from the time-of-last-visit to a bait station or survive because it did not consume a lethal dose. Therefore, WS-NWRC will use 4 hours as the time point to begin looking for carcasses. WS-NWRC will measure the following metrics of mortality for HOGGONE® on free-ranging feral swine and raccoons.

GPS/VHF transmitters

GPS/VHF transmitters equipped with mortality sensors will be used to identify and locate any dead feral swine or raccoons. The transmitters will be used in conjunction with remote cameras to determine whether the marked animals are visiting the bait stations. Mortality sensors on the transmitters will determine whether the animals are alive both pre- and post- toxic HOGGONE® application. Mortalities will be identified by using these sensors, and they will assist with locating carcasses. Finally, the distance from the last bait station the animal visited will be recorded in order to measure the minimum distance traveled between ingestion of toxic HOGGONE® and death.

Remote Cameras

Each bait station will be monitored using 2 remote cameras. The first camera will be mounted 5 m from the bait station and 1.5 m above the ground on a T-post or tree. This camera will be set to record 1 time-lapse image of the bait station every 5 minutes (i.e., 288 images per day). From these images, WS-NWRC will record daily indices of visitation by all species that visit the bait site. These indices will be used to compare visitation pre- and post-toxicant deployment. Any reduction in visitation will be attributed to mortality from the toxic HOGGONE®.

The second camera will be mounted on the opposite side of the bait station from the first camera, 3 m from the bait station and 1 m above the ground. This camera will be used to record motion activated images in bursts of 3 images at 5 second intervals per trigger. Motion activated trigger events will be separated by 10 second intervals. From these images, uniquely marked animals (identified from collars, ear tags, and unique markings) will be confirmed visiting and accessing the bait station. This information will be used to estimate the proportion of the population exposed to toxic HOGGONE®. Animals will be recorded as accessing the bait station if their head is observed under a lid of the bait station. Unique feeding bouts for each animal will be considered as any feeding event that occurs ≥30 minutes from a previous feeding event for that animal. For all other non-target species, the species and whether or not the species accessed the bait station will be recorded.

All images from the remote cameras will be assessed following previously established techniques (Snow et al. 2016) using the Colorado Parks and Wildlife (CPW) Photo Database for image processing (Newkirk 2014, Ivan and Newkirk 2015). A single-observer technique will be used to identify and count the number of species in each image. The total number of feral swine and the total number of adult feral swine (i.e., estimated as >20 kg body weight) will be counted. Weight estimation will be standardized among observers using example images prior to image processing and knowledge of weights from captive feral swine. All non-target species will be recorded separately, with the exception of combining all birds under one category, except for wild turkeys (*Meleagris gallopavo*), combining cottontail rabbits (*Sylvilagus* spp.) and black-tailed jackrabbits (*Lepus californicus*), and combining all rodents, except for squirrels (*Sciurus* spp.).

Bait Consumption and Spillage

All bait will be weighed after each baiting period to measure the amount of bait consumed. This will include the 2-night pre-baiting periods, the 2-night toxicant periods, and the 2-night post-baiting periods. The bait stations and the surrounding area will also be examined for bait spillage, any spilled bait will be weighed and removed. Bait consumed, pre- and post-toxicant deployment will be compared. Any reduction in consumption between the pre-baiting and post-baiting period will be attributed to mortality from the toxic HOGGONE®.

Systematic Transects

Following each 2-night deployment of toxic HOGGONE®, systematic transects will be walked near the bait stations to search for and document locations of carcasses of feral swine and non-target species. A search will also be conducted to locate any regurgitated bait from feral swine. Snow (2017b) found that 70% of feral swine regurgitated before death after consuming a lethal dose of toxic HOGGONE® bait. The search area will cover a 400 m × 400 m area surrounding the bait stations, divided into 50 m transects (Figure 4). Species, location of the carcass or regurgitated bait, and distance from the nearest bait station will be recorded.

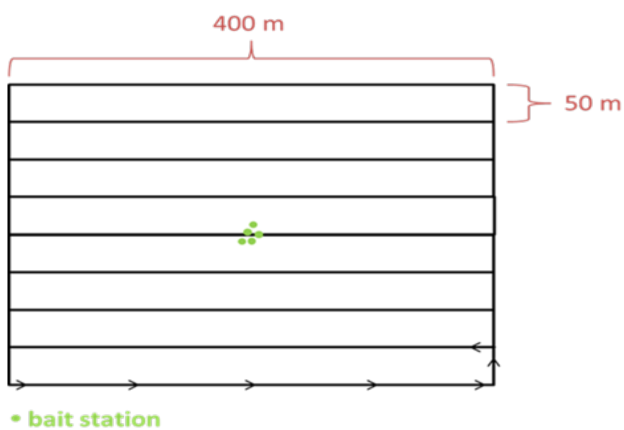

Figure 4. Diagram of hypothetical transects to be walked after each 2-night application of toxic HOGGONE®

Postmortem Examination of Carcasses

Carcasses will be examined for evidence of death from consuming toxic HOGGONE® bait. An obvious symptom of methemoglobinemia caused by SN toxicity is the resulting darkening of blood to a chocolate-brown color from high levels of methemoglobin. The mouth, esophagus, or stomach will be examined for any signs of toxic HOGGONE® that was consumed prior to death (e.g., residual HOGGONE® is found in the digestive tract). Any carcasses with evidence of consuming toxic HOGGONE® bait will be considered dead as a result of consuming a lethal dose of HOGGONE® unless an alternative cause of death is evident from the carcass (e.g., the animal was shot).

Statistical Analysis and Reporting

Descriptive statistics will be used to calculate the number of nights of pre-baiting required and visitation rates per species for each bait station. Reports will describe and compare the metrics of efficacy for feral swine and the non-target risk to raccoons separately for each geographic location. The proportion of marked feral swine per sounder and raccoons that succumb to toxic HOGGONE® after being exposed (i.e., visiting the bait station) will provide a robust estimate of mortality rates for exposed populations of these species. Overall mortality rates and conditional mortality rates will be recorded for each repeated application of the toxic HOGGONE® bait. Any reductions in visitation to the bait stations and in bait consumption will provide relative indices for population reduction pre- and post-toxicant deployment. The counts of carcasses found during transects will provide a ratio of feral swine to non-target species that were killed by the toxicant. From the motion-activated camera data, the proportion of marked animals that access the bait stations will be identified.

For comparison of metrics within and between the two geographic locations, generalized linear mixed-effects models will be used with package lme4 in Program R (v3.1.1; R Development Core Team). Each sounder will be treated as a random effect. For all statistical tests, significant differences will be considered at the level of $\alpha = 0.05$, and where 95% confidence intervals of parameter estimates do not overlap zero.

2.3 Standard Operating Procedures

WS-NWRC has a number of standard operating procedures (SOPs) and operational policies. In addition to operating policies and SOPs, the study protocol follows an Experimental Use Permit (EUP) label for the HOGGONE® product that has directions and use restrictions. The following, in no particular order are the SOPs, operational policies, study protocols, EUP label requirements that will be followed for this proposed study.

- WS-NWRC personnel would operate in accordance with WS Directive 2.210 (Compliance with federal, state and local laWS-NWRC and regulations) and WS Directive 2.450 (Traps and trapping devices). Personnel would check live-capture methods in accordance with Alabama / Texas laws and regulations. This would help ensure that WS-NWRC' personnel could release non-target species in a timely manner.
- WS-NWRC personnel would use immobilizing drugs and euthanasia chemicals according to the United States Drug Enforcement Administration and United States Food and Drug Administration guidelines, along with WS-NWRC' directives and procedures.
- WS-NWRC personnel would only use controlled substances registered with the United States Drug Enforcement Administration or the United States Food and Drug Administration.
- WS-NWRC personnel that use controlled substances receive training and certification to use those substances.
- Pesticide and controlled substance use, storage, and disposal would conform to (draft) label instruction and other applicable laws and regulations, and Executive Order 12898.
- As appropriate, capture devices would be equipped in such a manner to reduce the potential of capturing non-target animals.
- WS-NWRC personnel employees would release non-target animals live-captured in traps unless it was determined that the animal would not survive and/or that the animal could not be released safely.
- Remote cameras will be used to monitor bait stations and if a T&E or other protected species is found accessing the bait station, baiting will be discontinued.

- Any spilled bait will be cleaned up and disposed of every day when bait stations are checked.
- Bait stations will not be placed closer than 25 feet from permanent water bodies or water wells.
- Bait stations will not be placed any closer than 300 meters from property lines unless permission is obtained from the adjoining property owner. A warning sign will also be placed at the bait stations.
- GPS/VHF transmitters will be equipped with mortality sensors to quickly identify and locate dead feral swine or raccoons.
- Systematic transects will be walked near the bait stations immediately after a toxic baiting to search for any carcasses of feral swine and non-target species (not equipped with transmitters). The search area will cover a 400 m × 400 m area surrounding the bait stations, divided into 50 m transects. Species, location of the carcass or regurgitated bait, and distance from the nearest bait station will be recorded.
- WS-NWRC personnel would dispose of carcasses retrieved in accordance with WS Directive 2.515.
- WS-NWRC personnel would keep their presence at sites to a minimum to reduce disturbance to the area.

2.4 Alternatives Considered in Detail

The following alternatives were developed to meet the objectives for a field trial.

Alternative 1 – No Action – No Study

The no action alternative is the status quo. Under this alternative, a research study on the effectiveness of HOGGONE® sodium nitrite bait to control feral swine would not be conducted. The No Action alternative is required for comparative evaluation in an EA.

Alternative 2 – Proposed Action – Conduct the Study

This alternative consists of conducting a study to determine the effectiveness and environmental effects of HOGGONE® as a toxicant bait for feral swine as described in Sections 2.2.1, 2.2.2, 2.2.3.

2.5 Alternatives and Strategies Not Considered in Detail

Australia has collaborated with researchers at WS-NWRC to explore the potential use of a sodium nitrite product to control feral swine for several years. Literature reviews (Cowled et al. 2008) have shown that sodium nitrite has the potential to meet high standards in regard to a potential feral swine toxicant. Research has been on-going for several years developing acceptable bait formulas and delivery systems. Recently, the EPA (January 2017) approved a warfarin-based toxicant for feral swine in the U.S. An alternative strategy would be to discontinue the current research on sodium nitrite and the proposed field study and pursue using the warfarin product.

Initially, this may appear to be a viable alternative given the fact that the EPA registration process can be costly (Eason et al. 2010). However, as discussed briefly in 1.2, warfarin and other toxicants have been used in Australia for decades and those toxicants have been shown to have shortcomings (Cowled 2008). Previous research has shown that sodium nitrite meets a multitude of criteria to include; toxicity to the target population, commercial availability, low cost, humaneness, environmental soundness and human safety. These criteria, among others, are important considerations when developing a vertebrate toxicant. WS-NWRC believes it is important to continue research on sodium nitrite despite the recent EPA registration of a warfarin product. This alternative would not meet the objective of studying the efficacy of sodium nitrite bait and delivery system in a field setting and evaluating its effects on non-target animals, particularly raccoons.

Another alternative would be to conduct the proposed study at alternate sites. Texas is believed to harbor approximately one third of the 6 million feral swine in the United States. Alabama also has a robust and expanding population of feral swine. The two locations are thought to represent habitat that is similar to over three quarters of the total feral swine population in the U.S. These locations are also within close proximity to WS-NWRC staff therefore making the study more cost effective. Using the criteria established in section 1.5.1 for final site selection would limit the potential for adverse effects on the environment and minimize the need for alternative locations.

3.0 ENVIRONMENTAL EFFECTS

This chapter discusses the beneficial and adverse environmental impacts of the Proposed Action and the No Action Alternative on environmental, human health and safety and threatened and endangered species. Each section includes information on existing conditions of the resource and the expected consequences or impacts of the alternatives. Impacts include direct impacts from the proposed study, indirect and cumulative impacts that could occur at a later point in time. Impacts are described as either beneficial or adverse and are quantified where possible. When it is not possible to quantify, impacts are qualitatively described as no effect, minor, insignificant, discountable, moderate, or major. They are also described as short-term, long-term or cumulative whenever possible.

3.1 Ability of Alternatives to meet Management Objectives

As described in 1.4, the proposed action objectives are to analyze the effectiveness of the toxicant to adequately control free-ranging individual sounders (groups) of feral swine, analyze and determine if there is a threat to non-target animals, particularly raccoons, and to continue evaluating the effectiveness of the prototype bait stations used to deploy the toxicant.

This section reviews each alternative to determine if the alternative could be successful in meeting the objectives. The evaluation is distinct from the environmental impacts analyses in 3.2. Sections 3.1.1, 3.1.2 summarize the ability of each alterative to meet the management objectives, and will aid the decision maker in making a well informed decision.

3.1.1 Alternative 1 – No Action – No Study

The No Action Alternative is a procedural NEPA requirement (40 CFR 1502) and serves as a baseline for comparison with the other alternatives. The No Action Alternative can be defined as “no change” from the status quo, which means a research study on the effectiveness of HOGGONE® sodium nitrite bait to control feral swine would not be conducted. Without the study, there is no way to establish the effectiveness of a sodium nitrite toxicant for feral swine or its effects on non-target raccoons through testing of the prototype bait stations.

3.1.2 Alternative 2 – Proposed Action – Conduct the Study

The proposed action is to conduct the sodium nitrite toxicant study. Conducting the study would meet the objectives and allow WS-NWRC to determine the efficacy of sodium nitrite baits in a filed setting, and provide data and information on risks to non-target species and the design of the bait stations.

3.2 Issues Considered in Detail and Their Associated Impacts.

The issues identified in chapter 2 are addressed here in detail for each alternative. This section analyzes the environmental consequences of the No Action Alternative for the identified issues and compares these impacts with the projected environmental impacts of the Proposed Action. The environmental baseline, or status quo of the No Action Alternative, for this EA provides the necessary benchmark to determine if the real or potential impacts of the Proposed Action are greater, lesser or the same for each of the issues. This section considers direct, indirect and cumulative impacts on the resources.

3.2.1 Effects on Human Health and Pet Safety

It is important to evaluate the effects of the proposed study on human health and pet safety. WS-NWRC believes any risks to humans or pets associated with the study would be minimal, however, in order to reduce any potential effects, WS-NWRC will follow the study protocol, EUP product label and a number of SOPs put in place to mitigate any potentially negative effects on humans or pets.

<u>Alternative 1 – No Action - No Study</u>

Under this alternative, there would be no direct effect on human health and pet safety. Field trials to test the effectiveness of a feral swine toxicant would not be conducted.

<u>Alternative 2 – Proposed Action – Conduct the Study</u>

Under this alternative, WS-NWRC would conduct the study to test the effectiveness of a feral swine toxicant on free-ranging feral swine in Alabama and Texas. The details of the study are outlined in 2.2 through 2.3.

The proposed study would be conducted on private land at both sites. Access to the study sites in Alabama and Texas would only be granted to WS-NWRC personnel and there would be no public access. Any direct impacts to public human health and safety or pets would be eliminated unless the public were trespassing on private land and pets were free-roaming and in violation of leash laws. Based on this assessment, it is unlikely that humans or pets would be exposed to sodium nitrite during this proposed study. However, since trespassing could be an issue, a human exposure assessment along with some unlikely scenarios are discussed below.

<u>Human Exposure Assessment</u>

Due to the use of sodium nitrite as a food preservative, a large amount of data exists on its metabolism in humans as well as numerous other species. Exposure assessments evaluate the potential exposure risks to humans by first accessing any exposure pathways to sodium nitrite. The exposure assessment begins with the use and application method of the sodium nitrite product. An identified exposure pathway for sodium nitrite includes (1) a release from a sodium nitrite source, (2) an exposure point where contact can occur, and (3) an exposure route such as ingestion, inhalation, or dermal contact by which contact can occur (USEPA 1989). Exposures for the identified human populations are qualitatively evaluated for each identified exposure pathway.

(1) A release from a sodium nitrite source. To evaluate this potential exposure route, the application method is accessed. As described in 2.3.2, and pictured in figure 3, the baits will be contained in an enclosed bait station (Appendix B). Based on the application method, the greatest chance for human exposure to sodium nitrite would be from WS-NWRC' employees who handle and load the bait stations. Exposure to employees while transporting the bait is unlikely since the bait comes in

sealed containers. The bait is pre-packaged and no mixing is required, reducing the potential to expose employees while loading the bait station. In addition, following label directions including the proper use of personal protective equipment (PPE) will minimize exposure to employees. Otherwise, once the bait is contained in the bait stations there is not a pathway to human or pet exposure except for accidental spills or bait that is dropped from feral swine during feeding. Effects of spilled bait is addressed in 3.2.3 Impacts on Terrestrial and Aquatic environments.

(2) An exposure point where contact can occur. Besides the direct exposure potential from loading the bait stations or from spilled bait discussed above, the only other plausible exposure would be from secondary exposure from a carcass that has consumed sodium nitrite. This scenario is discussed below when addressing possible exposure to hunters.

(3) An exposure route such as ingestion, inhalation or dermal contact. Of these exposure routes, only ingestion has a viable pathway for exposure and would still be considered highly unlikely. Potential ingestion via water contamination is also addressed in 3.2.2 Impacts on Terrestrial and Aquatic environments. Inhalation and dermal exposure is also expected to be insignificant due to the anticipated formulation as a paste bait. In addition, sodium nitrite is not considered to be volatile further reducing the potential for exposure from inhalation.

<u>Exposure to Hunters</u>

The potential exposure of hunters to feral swine with a lethal dose of sodium nitrite shot while or after feeding at a bait station could occur if a hunter ignores the placarding (warning signs) and trespasses to gain access to one of the sites. In the rare event that this were to happen and a hunter shot a feral swine at a bait station containing bait with sodium nitrite, or just after feeding at one, the hunter would typically clean the animal in the field discarding the stomach and other abdominal contents. These items are typically discarded during the field dressing process along with any meat that may have come in contact with stomach or intestinal contents may also get cut out and thrown away. Therefore, the potential exposure for a hunter to receive a significant dose of sodium nitrite through consumption of hunted feral swine is low. In addition, the potential exposure of sodium nitrite through dermal contact is low because many hunters wear protective gloves when cleaning feral swine. Hunters that harvest feral swine at a bait station likely are aware that they are trespassing or have seen the signage and should be aware of the potential for feral swine being treated with a toxicant which should discourage them from such areas.

Another possible scenario would be a hunter that shot a feral swine that may have received a sublethal dose of sodium nitrite. The sodium nitrite concentrations consumed from hunted sublethal exposed feral swine are not expected to be high because a) sub lethal doses are rapidly eliminated (nitrite plasma half-life is 29 to 62 minutes in rats, humans, sheep, dogs and horses), b) most nitrite was converted during the toxicosis process, and c) a dose to cause fatal methemoglobinemia is difficult to extract quickly in meat (Lapidge et al. 2012). Snow et al. (2017b) found residual SN in muscle, liver and eye tissue to be very low (average 3.2 mg/kg). Previous residue testing from pen and field-poisoned feral swine show that nitrite residues in thigh muscle, eye, liver, and small intestine were less than 100mg/kg (Lapidge et al. 2012). By comparison, the U.S. Food and Drug Administration regulates that no more than 200 mg/kg of sodium nitrite can be used as a preservative in meat products. Snow et al. (2017b) and (Lapidge et al. 2012) both reported nitrite concentrations that were considerably higher in undigested stomach contents or vomitus and could be a concern for scavengers that consume stomach contents such as canids and vultures, but not for humans. This issue will be addressed in 3.2.3, effects on non-target species.

Exposure to Feral Swine Meat Markets

For the purpose of the study, WS-NWRC will conduct the study on large private properties and will not place bait stations any closer than 300 meters from any adjoining property line unless WS-NWRC also has an agreement with the adjoining property owner. This will insure that no feral swine are likely to leave the study area before succumbing to the lethal effects of sodium nitrite.

Texas has approximately one hundred feral swine "buying stations" around the state. These stations are essentially wholesaler operations that buy live feral swine from private trappers at a per-pound price. Feral swine are held in holding pens at these buying stations until the wholesaler has enough to transport to a processing plant where they are held to USDA pre- and post-slaughter inspections and can then be marketed for sale for human consumption. The meat is marketed as "wild boar" mostly to European restaurants but is also sold to some domestic U.S. markets as well.

As discussed in 2.3.1, the mode of lethality of HOGGONE® is caused by its direct impacts on hemoglobin. Sodium nitrite converts hemoglobin to methemoglobin (MtHb). Higher than normal levels of nitrite leads to methemoglobinemia which quickly leads to loss of consciousness and then death from the rapid depletion of oxygen to the brain and vital organs. This has been shown to occur when feral swine consume a lethal dose in 2-4 hours (Snow 2017a). Data from Australia on free-ranging feral swine show that swine traveled a maximum of 230 meters from the nearest bait station after consuming a lethal dose of HOGGONE®.

Furthermore, in the unlikely event that a feral swine were to consume a sub-lethal dose of sodium nitrite, travel to an adjacent property, be trapped and transported to a buying station, then transported to a processing facility (several hours and likely days later), there would be no excess nitrite or residue in the blood or tissue due to the reversal of MtHb back to hemoglobin from the protective enzyme called MtHb reductase. This naturally occurring enzyme catalyzes the reduction of MtHb back to hemoglobin to protect red blood cells against oxidative damage and ultimately death. Death only occurs when swine consume excess nitrites and hemoglobin is converted to MtHb faster than MtHb reductase can reverse its effects. Sodium nitrite does not bio-accumulate and sub-lethal doses are expected to be completely metabolized in a matter of hours with no evidence of residual sodium nitrite and no debilitating effects to the swine (Snow et al. 2017b).

Due to the processing requirements (swine must be alive for pre-slaughter inspections), the amount of time it would take to bring feral swine to a processing facility and the toxicosis process of sodium nitrite, WS-NWRC believes there is no plausible way that a feral swine could consume a lethal dose of sodium nitrite from a bait station, travel to an adjacent property and be trapped, transported to a buying station, held for several hours and more likely days, and finally transported to a processing facility before succumbing to the effects of sodium nitrite or completely recovering from a sub-lethal dose. Therefore, for the size and scale of the proposed study, HOGGONE® would have no effect on the feral swine meat market and no risk of exposing sodium nitrite to the human food chain through the commercial processing of feral swine in Texas.

3.2.2 Impacts on Terrestrial and Aquatic Environments

The public, regulatory agencies and WS-NWRC are concerned about the toxic effects of using a chemical could have on the environment. The evaluation of sodium nitrite on terrestrial and aquatic environments is described and analyzed in this Section.

Alternative 1 – No Action - No Study

Under this alternative, there would be no direct impacts on the terrestrial and aquatic environment. There would be no study to test the effectiveness of a feral swine toxicant.

Alternative 2 – Proposed Action – Conduct the Study

The proposed action to conduct the study would determine the effectiveness of SN to control free-ranging feral swine at two field sites and also assess the effectiveness of the bait stations to exclude raccoons and other non-target wildlife. From existing data, WS-NWRC believes the proposed action would have the following effects on the terrestrial and aquatic environment if the decision is made to conduct the study.

Environmental Fate of Sodium Nitrite

In order to assess rather or not the proposed study would have any effects on the terrestrial or aquatic environment, WS-NWRC will first analyze how the product HOGGONE® will specifically be used and what potential there is for the active ingredient sodium nitrite to enter the environment and to discuss the environmental fate of sodium nitrite.

The environmental fate describes the processes by which sodium nitrite moves and transforms in the environment. The environmental fate processes include: 1) mobility, persistence, and degradation in soil, 2) movement to air, 3) migration potential to groundwater and surface water, and 4) plant uptake.

The soil environment is composed of organic and inorganic material as well as air and water. Sodium nitrite does not adhere well to soil particles. Sodium nitrite remains as a particulate in the air pockets in soil because it is not volatile. In the air (both above the soil and within the soil) sodium nitrite gradually oxidizes to nitrate. However, in the presence of water, sodium nitrite immediately dissociates into sodium and nitrite ions. In water, the nitrite ions easily oxidize to nitrate, and nitrate is the more predominant compound of the two detected in groundwater (OECD 2005). Nitrate and nitrite are likely to remain in water until consumed by plants or other organisms (USEPA 2006). Biodegradation of nitrite in the environment occurs when bacteria (such as members of genus *Nitrobacter*) oxidize nitrites to nitrates. Then, anaerobic bacteria present in soil and sediment reduce nitrates to nitrogen, which is then absorbed into the nitrogen cycle. Bioconcentration or bioaccumulation of nitrite is not expected for residues that could occur in aquatic systems. Nitrite is highly soluble which is not typical for compounds that may accumulate in aquatic biota (OECD 2005). A low estimated bioconcentration factor (BCF) of 3.162 and the metabolism of nitrite by fish further supports the lack of potential for bioconcentration or bioaccumulation in aquatic habitats.

Aquatic Exposure Assessment

The anticipated use of the sodium nitrite product HOGGONE® will significantly reduce the possibility of any exposure to aquatic environments. The use of baits that are contained within a bait station will virtually eliminate the potential for off-site transport of sodium nitrite from drift and significantly reduce the potential for any runoff to aquatic systems. The possibility does however exist that some runoff could occur if baits are dropped or spilled on the ground during feeding. The amount of runoff from this type of scenario is expected to result in very low estimated residues. Most bait will be consumed in the bait station. Baits dropped on the ground by feeding swine will likely be consumed by feral swine or other animals, thereby, decreasing the probability baits would stay on the ground for a sufficient amount of time to allow for degradation and be susceptible to runoff.

To estimate what the risks would be in a typical baiting situation, WS-NWRC characterized potential residues in various sized water bodies using several conservative assumptions. The total amount of bait in a bait station is 20 kg with 10 percent of the material by weight (10% concentration) containing sodium nitrite. This is the maximum amount of bait that would be in an individual bait station. Based on observed removal efficiencies of the bait noted in previous unpublished pen studies the total amount that could end up on the ground was estimated to be 0.1 to 1.0%. The amount of material susceptible to runoff was set at 10 percent based on maximum runoff values for conventionally applied liquid pesticides. This value is conservative since it assumes that feral swine or non-target mammals and birds would remove none of the material on the ground, and that all of the sodium nitrite would be susceptible to runoff instantaneously. Baits will degrade at different rates depending on the environmental conditions and nitrite leaching and movement will occur slowly at varying rates instead of one large single runoff event indicative of broadcast liquid pesticide applications.

Residues from the above exercise were calculated for three different aquatic habitats: a wetland, small pond and drinking water reservoir. The dimensions of these water bodies are based on USEPA default assumptions for each habitat type. The water bodies are assumed to be static with no inflow or outflow and residues are considered instantaneous with no degradation or partitioning. This is also a very conservative assumption since nitrite in runoff would be susceptible to a variety of transformation processes to less toxic forms of nitrogen or assimilation by terrestrial or aquatic plants, or partitioning to soil/sediment (Bowden 1987). Residues were also assumed to be instantaneously distributed throughout the water column, as opposed to a chemical gradient with higher residues adjacent to the point source as observed under normal field conditions. Potential residues into flowing aquatic habitats were assumed to be captured by the use of the three static water bodies that were used in this exposure assessment. Instantaneous surface water concentrations ranged from 0.003 parts per billion (µg/L) or .000003 (mg/L) in a wetland habitat to 2.47 X 10^{-5} µg/L in a small pond. These are considered very conservative estimates of potential aquatic residues and highly unlikely to occur, but can be used for screening level purposes to compare to available aquatic effects data and determine the potential for risk to aquatic biota.

<u>Risks to Aquatic Vertebrates</u>

The below section provides a summary of available nitrite toxicity data for aquatic vertebrates. Nitrite toxicity varies considerably between different fish species, ranging from highly toxic to practically non-toxic (Figure 5). Cold tolerant freshwater species such as salmonids appear to be the most sensitive fish species with median lethality concentrations (LC50) in the low part per billion (µg/L) range while marine fish and cyprinids appear to be more tolerant to sodium nitrite exposure with median lethality values greater than 100 parts per million (mg/L).

Sublethal acute and chronic effects have also been noted in fish species at concentrations below median lethality values (Jensen 2003, Kroupova et al. 2005, Jensen 2007, Russo 2006). Nitrite at sublethal concentrations can result in methemoglobinemia as well as affect the gill, brain and liver, where it can accumulate (Margiocco et al. 1983). Effects on swimming performance, food consumption and growth, ability to survive hypoxic conditions and increased pathogen susceptibility have been reported in acute sublethal dosing studies (Eddy and Williams 1987, Carballo and Munoz 1991, Carballo et al. 1995, Russo et al. 1981). These types of effects result in decreased fitness, reducing reproduction potential and predator avoidance as well as increased susceptibility to other natural and anthropogenic stressors. Acute sublethal responses that have been observed in fish exposed to sodium nitrite have also been observed in chronic studies. Hilmy et al. (1987) noted effects on erythrocyte (red blood cell) count, hemoglobin content and hematocrit (percentage of red blood cells) counts during a six month exposure to nitrite at 1/10 (2.8 mg/L), the median lethal concentration for the African mudfish, *Clarias lazera*. In another long-term exposure study, steelhead trout (*Onchorhynchus mykiss*) were exposed to sodium nitrite concentrations ranging from 0.015 to 0.060 mg/L for six months. Methemoglobinemia was slightly elevated compared to controls observed at each test concentration; however, no effects on growth or other hematological abnormalities were noted at concentrations ranging up to 0.030 mg/L. The highest test concentration (0.060 mg/L) resulted in hypertrophy, hyperplasia, and lamellar separation in the gill epithelium (Wedemeyer and Yasutake 1978).

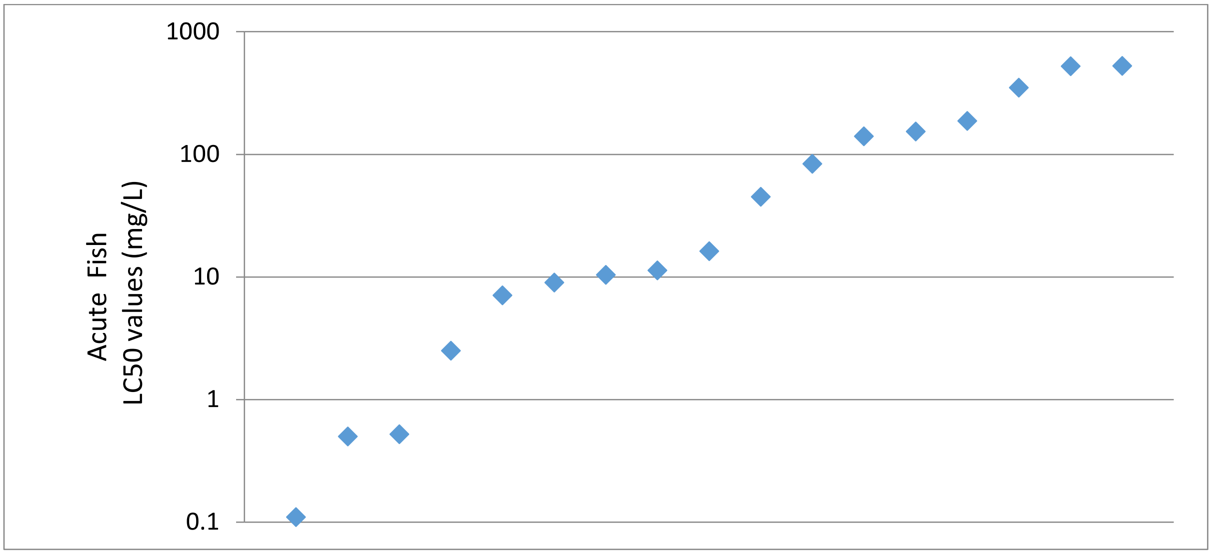

Figure 5. Distribution of acute nitrite sensitivity to freshwater and marine fish species.

Amphibian sensitivity to nitrite is comparable to the range of sensitivities reported for acute lethal exposures to fish. Marco et al. (1999) reported 96-hr median lethality values ranging from 0.59 mg/L for the northwestern salamander (*Ambystoma gracile*) to greater than 5.0 mg/L for the Oregon spotted frog (*Rana pretiosa*), the northern red-legged frog (*R. aurora*), and the Western toad (*Bufo boreas*). In another study using small-mouthed larval salamanders (*A. texanum*), the 96-hr LC_{50} value was reported as 1.09 mg/L suggesting that larval salamander species may be more sensitive than tadpole species (Huey and Beitinger 1980a). Shinn et al. (2008) reported five and six-day median lethality values of 127.6 and 116.4 mg/L for larval Perez's frog (*Pelophylax perezi*) and Mediterranean tree frog (*Hyla meridionalis*). Sensitivity was shown to increase with longer exposure time, which is typical for most chemicals.

Smith (2007) reported no lethal or sublethal effects of nitrite concentrations ranging up to 20 mg/L for the wood frog (*R. sylvatica*). A similar lack of lethal or sublethal effects has also been noted in the bullfrog (*R. catesbiana*) at concentrations up to 10 mg/L (Huey and Beitinger 1980b; Smith et al. 2004). However, sublethal effects have been noted in other amphibian species at lower test concentrations. Marco and Blaustein (1999) documented developmental and behavioral effects at a concentration of 3.5 mg/L for the Cascades frog (*R. cascadae*) resulting in increased susceptibility to predation. Griffis-Kyle (2005, 2007) reported sublethal effects on growth and development in 30-day exposures using embryos and larvae of wood frogs and eastern tiger salamanders (*A. tigrinum tigrinum*) at concentrations ranging from 0.3 to 6.0

mg/L. This variability, even within the *Rana* genus, is due to the type of endpoint measured, water chemistry during the test exposures, and potential differences in physiological adaptation related to lower ion uptake or a more effective methemoglobin (metHb) reductase enzyme system for those species and life stages that are less sensitive.

Risks to Aquatic Invertebrates

Aquatic invertebrate acute toxicity to sodium nitrite ranges from highly toxic to nearly non-toxic with median lethality values ranging from approximately 1.0 mg/L to greater than 500 mg/L (Figure 6).

Chronic toxicity of nitrite has also been evaluated in different aquatic invertebrate species. Water chemistry, in particular chloride levels, can also influence the effect on toxicity of nitrite to aquatic invertebrates with increasing chloride concentrations reducing toxicity (Lin and Chen 2003, Russo 2006, Alonso and Camargo 2007). Chen and Chen (1992) reported Maximum Allowable Toxicant Concentrations (MATC) of 4, 2 and less than 2 mg/L in 10, 30 and 60 day exposures for the marine shrimp (*Penaeus monodon*) and reported EC50 values at 60 days for length and weight were 26.20 and 22.45 mg/L. Armstrong et al. (1976) found larval giant Malaysian prawn (Macrobrachium rosenbergii) to have LC50 values of 6-12 mg/L. Kelso et al. (1999) in a reproductive study using the freshwater cladoceran, (*Daphnia magna*), reported a significant linear negative impact on length and weight of adult cladocerans as well as reproduction at concentrations ranging from 2.5 to 40 mg/L. Dave and Nilsson (2005) reported nitrite-related reproductive and adult effects in a chronic study using another freshwater cladoceran (*Ceriodaphnia dubia*) at the lowest test concentration 0.0157 mM (converted to 1.08 mg/L by multiplying the molecular weight of sodium nitrite 68.9953 g/mole). Chen et al. (2011) demonstrated impacts on growth and reproduction in a twelve-day exposure for the freshwater rotifer (*Brachionus calyciflorus*) at 10 mg/L nitrite but not at 3 and 6 mg/L suggesting a No Observable Effect Concentration (NOEC) of 6 mg/L.

Mollusks have been shown to have much higher tolerances to nitrates and nitrites than crustaceans and aquatic insects (Soucek and Dickinson 2012). Soucek and Dickinson 2012 also conducted a review of the literature that found five species of mollusks to have LC_{50} for nitrite that ranged from 15.6 mg/L to 535 mg/L. Epifanio and Srna (1975) found tolerance levels of 330-736 mg/L in juveniles and adults in the clam (*Mercenaria mercenaria)* and the oyster (*Crassostrea virginica)*. Widman and Meseck (2008) found bay scallops (*Argopectien irradians irradians)* to have LC_{50} levels at 345.13 mg/L. Furthermore, considering that most nitrite would likely oxidize to nitrate in water, increasing those tolerances substantially anywhere from 2 to 10 times higher depending on the species (Soucek and Dickinson 2012).

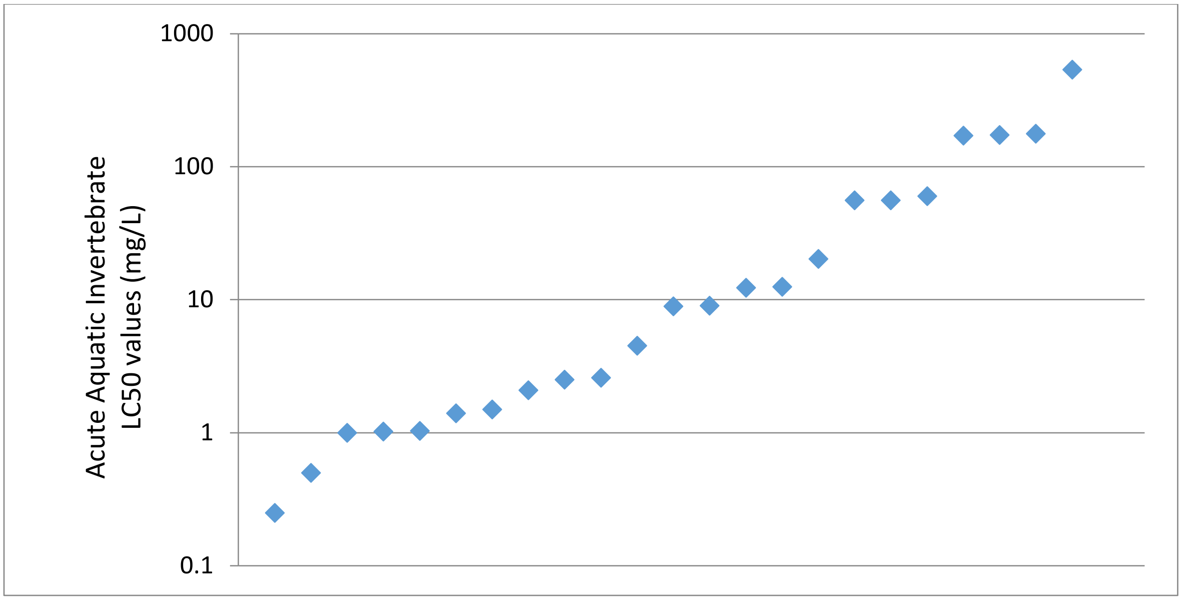

Figure 6. Distribution of acute median lethality concentrations (LC_{50}) for nitrite toxicity to freshwater and marine aquatic invertebrates.

Risks to Aquatic plants

Available toxicity data for aquatic plants is limited primarily to algal species. Algal sensitivity to sodium nitrite is low with a reported 72-hr EC_{50} value for the green algae (*Scenedesmus subspicatus*) of greater than 100 mg/L. No sublethal effects were noted at the highest test concentration used in the study resulting in a NOEC of 100 mg/L. Comparative experiments using several species of green and blue-green algae suggest that blue green algae are more sensitive based on photosynthesis inhibition when exposed to 1.0 mM (68.9 mg/L) nitrite (Wodzinski et al. 1978). Risk to aquatic plants from nitrite would also be negligible based on the available toxicity data endpoint of a NOEC of 100 mg/L. Toxicity to aquatic plants is several orders of magnitude above any of the residues that would be expected in various water bodies.

Summary of Aquatic Risks

The risk of nitrite exposure from HOGGONE® applications was evaluated by comparing the estimated residues in a typical wetland and pond to the range of acute and chronic toxicity data for aquatic vertebrates and invertebrates and is summarized in Figure 7.

All acute and chronic toxicity endpoints were several orders of magnitude above the range of estimated acute aquatic concentrations suggesting a lack of risk to aquatic fauna. As previously stated, the estimated aquatic values for nitrite are conservative since they would decrease rapidly due to degradation and uptake from other biota. The estimate of aquatic residues in this assessment also assumed that baiting stations would be established adjacent to aquatic habitats. A setback buffer of 25 feet from aquatic habitats is required under the current EUP HOGGONE® label and will further reduce the potential for acute or chronic nitrite exposure to aquatic organisms.

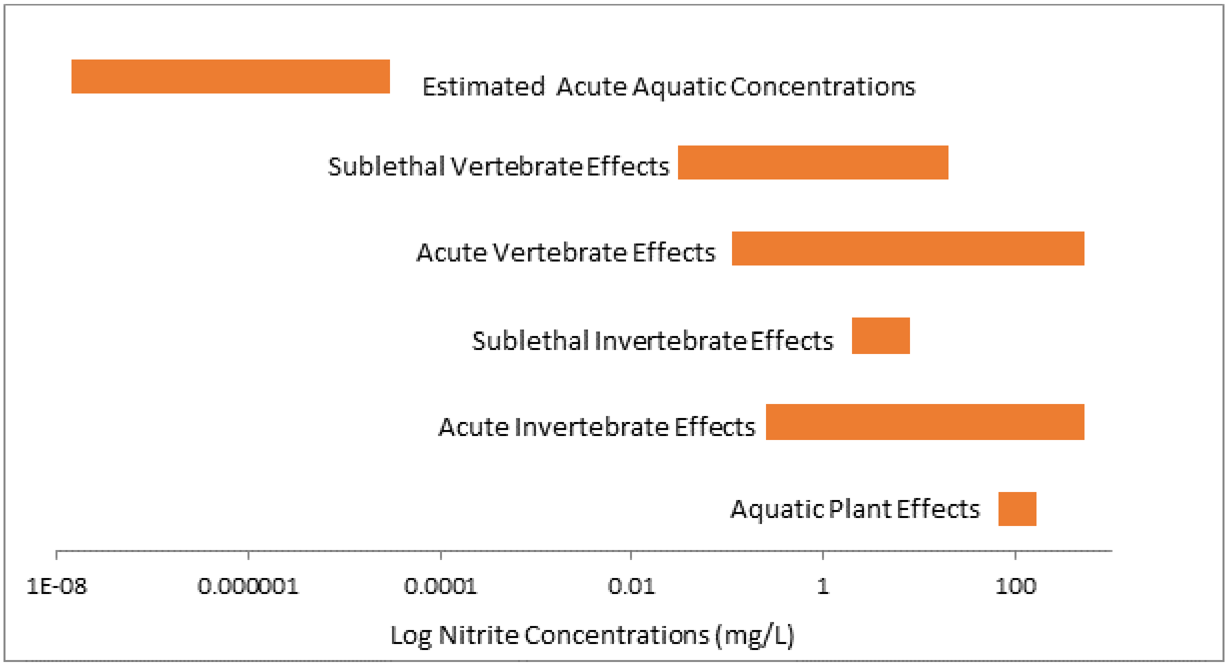

Figure 7. Aquatic vertebrate and invertebrate risk characterization for nitrite.

It is anticipated that toxic baiting in most situations would be for two days. It may be necessary to reapply a toxic bait after two days for an additional two days if it is found that some feral swine did not receive a toxic dose. Therefore, WS-NWRC does not expect there to be any chronic nitrite exposure due to a short application period. Furthermore, referring back to figure 7, there are still wide margins of safety between the estimated acute residues and the chronic toxicity data. The available data for aquatic vertebrates, invertebrates and plants demonstrate that the estimated residues of HOGGONE in aquatic habitats presents risks to these organisms that are insignificant and discountable. This includes direct risk from exposure to nitrite as well as any indirect risk to available food items and habitat.

Terrestrial Exposure Assessment

The primary exposure pathway to terrestrial wildlife will be via the dietary route. Exposure may occur for those animals that can access bait from the bait station itself or from bait that falls on the ground during feeding events. As mentioned above in the aquatic assessment, it is anticipated that no more than 0.1 – 1.0% of sodium nitrite would end up on the ground for any terrestrial wildlife to consume directly. That is the equivalent of 2 – 20g (approximately .64 ounce, about the size of a small salt shaker) of active ingredient. A detailed analysis of the potential effects these concentrations may have on non-target and threatened and endangered terrestrial wildlife is addressed below in 3.2.3.

Risk to Terrestrial Vertebrates

Sensitivity of different mammalian species to sodium nitrite is correlated to levels of MtHb reductase which converts methemoglobin to hemoglobin. Lapidge and Eason (2010) demonstrated the relationship between MtHb reductase and lethality for several mammal species in Figure 8. A statistically significant positive correlation was observed between MtHb reductase levels and lethality suggesting that reductase levels can be used to estimate lethality for other mammal species where toxicity data is unknown for sodium nitrite. The correlation between lethal doses and data regarding MtHb reductase levels demonstrates that domestic animals such as dogs and some livestock are particularly sensitive to the effects of sodium nitrite toxicity.

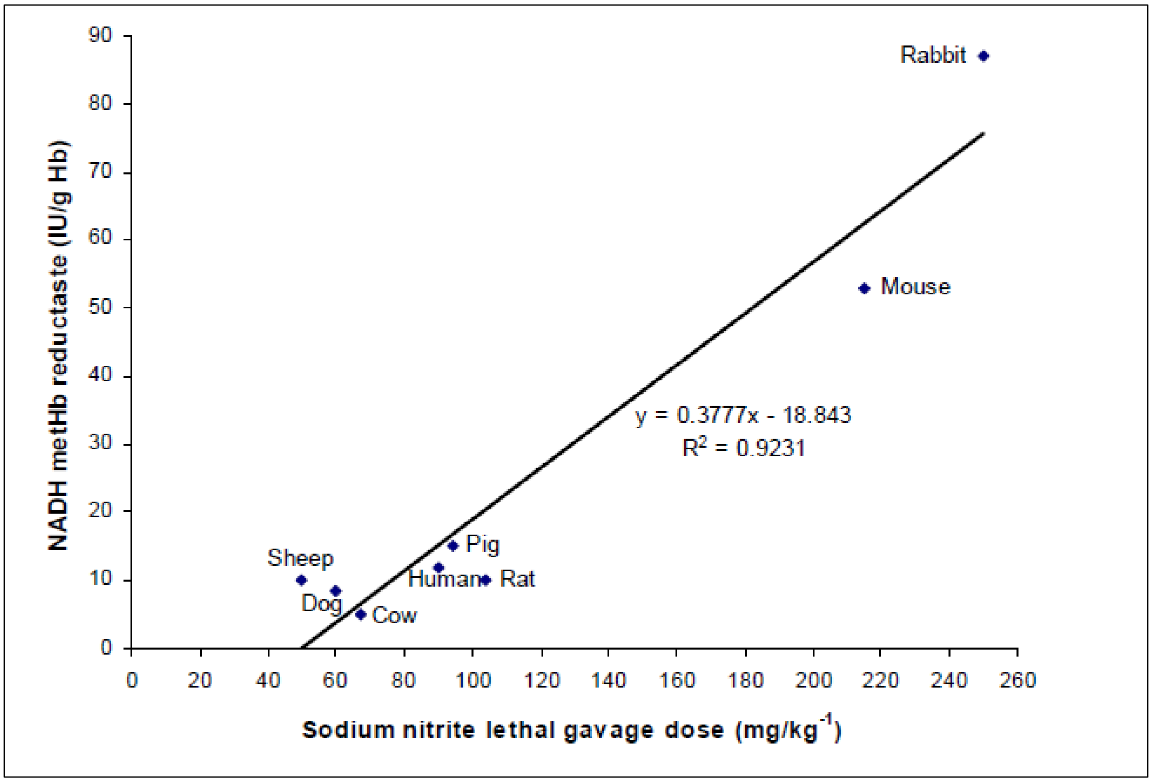

Figure 8. Regression between sodium nitrite lethal doses and NADH (Nicotinamide Adenine Dinucleotide (NAD^+) reduced by oxidization) MtHb reductase levels in various mammal species (from Lapidge and Eason 2010)

Lethality in mammals can occur when methemoglobin levels exceed 70 percent; however, many sublethal responses may occur at lower levels and may be ecologically relevant. Clinical signs of nitrite exposure can appear in some species of mammals when methemoglobin levels reach 20 percent (Bruning-Fan and Kaneene 1993). Ataxia (lack of coordination), dyspnea (shortness of breath) and general weakness are some of the typical signs of nitrite toxicosis and could impact the ability of non-target mammals to avoid predation as well as impact other behavioral and physiological responses. However, any potential sub-lethal effects are expected to be short-lived based on the rapid metabolism of sodium nitrite observed in various mammals. Lapidge and Eason (2010) summarized data from previous studies in the rat, sheep, dog and horse and observed the elimination half-life ($T_{1/2}$) of sodium nitrite in plasma to range from 29 to 62.5 minutes based on a range of doses.

Chun-Lap Lo and Agar (1986) compared MtHb reductase levels in erythrocytes (red blood cells) from eleven newborn and adult mammal species and found that with the exception of the rabbit and humans, levels were higher in newborns when compared to adults of the same species. These results are consistent with previous work with the exception of cattle and pigs which demonstrated that newborns were shown to have less MtHb reductase levels compared to adults (Agar and Harley 1972).

Dietary exposure may also occur from consumption of potentially contaminated drinking water. Strnad and Persin (1983) reported average methemoglobin levels of 16.5 percent in fourteen-day old ring-necked pheasant (*Phasianus colchicus*) chicks exposed to 15 mg/L of sodium nitrite in drinking water; liver and kidney dysfunction were also reported at this exposure. Other studies exposing birds to a range of nitrite concentrations in drinking water have demonstrated similar impacts to those observed from feeding studies in various test species at concentrations of 200 mg/L (Bruning-Fan and Kaneene 1993). However, this exposure pathway is anticipated to be insignificant or discountable since conservative estimated aquatic residues presented above in the aquatic assessment are well below concentrations that would be expected to result in adverse effects.

No nitrite toxicity data appears to be available for reptiles and the terrestrial phase for amphibians. USEPA Office of Pesticide Programs (OPP) assumes that bird sensitivity to pesticides is representative of the potential effects to reptiles, however, some uncertainty is presumed with this assumption. Differences in metabolism and other physiological adaptations and life history traits are unique to reptiles and not shared with birds. Uncertainty regarding nitrite sensitivity of reptiles compared to birds and other non-target vertebrates can be addressed by assessing available information regarding MtHb reductase levels. Reductase levels are equal to, or greater in reptiles than to birds suggesting sensitivity to the effects of nitrite poisoning would be similar, or less, for reptiles (Board et al. 1977). A similar trend was also observed when comparing MtHb reductase levels in nucleated erythrocytes (red blood cells) between birds and the adult bullfrog suggesting similar sensitivity between terrestrial phase amphibians and birds (Ito et al. 1984).

Risk to Terrestrial Invertebrates

Acute exposure data using the earthworm demonstrates moderate toxicity with a 48-hr LC_{50} ranging from 100 to 1000 $\mu g/cm^3$ (Roberts and Dorough 1984). Elevated soil nitrite concentrations impact soil microorganisms responsible for methanogenesis and other degradation processes (Banihani et al. 2009, O'Reilly and Colleran 2005). Other studies have shown some nitrite-related impacts to soil-borne terrestrial invertebrates, but these studies are typically conducted with sewage sludge and contain other pollutants that could be responsible for adverse impacts; thus, these studies would have limited ecological relevance in evaluating the impacts of the use of sodium nitrite as a feral swine toxicant. Some nitrite toxicity information is available for non-soil-borne terrestrial invertebrates. Sarikaya and Cakir (2005) conducted feeding studies using the larval fruit fly, (*Drosophila melanogaster*), and found no effects on survival when exposed to 25 mM sodium nitrite until pupation. Ionescu et al. (1990) reported 100 percent mortality to honey bees (*Apis mellifera*) when exposed to a 1 percent solution of sodium nitrite with a maximum allowable concentration of 1 mg/L. More recently, Leonard (2016) evaluated the effects of SN on honey bees and found a NOED of 100µg (0.1 mg/L) and a LOED of 400µg (0.4 mg/L).

Most recently, Shapiro et al. (2017) evaluated the primary and secondary poisoning risks to several surrogate species in New Zealand when exposed to a new SN toxicant registered in New Zealand for brushtail possums (*Trichosurus vulpecula)* and feral swine that has a very similar formulation as HOGGONE®. Shapiro evaluated the risks to the cave weta (Family: Rhaphidophoridae) a common native New Zealand invertebrate similar to a grasshopper or cricket. These invertebrates were commonly found sheltering in bait stations and could potentially access and consume baits that could cause direct mortality or consume sub-lethal amounts of bait and then be eaten by other non-targets such as birds.

Shapiro et al. (2017) collected sixteen cave weta and allowed them direct access to bait for a two week period. All cave weta were alive after the trial suggesting there was no primary poisoning. Following the direct exposure trial, cave weta were euthanized and assayed to determine if any trace of SN could be detected. One cave weta was found to have SN residue of 10 μg suggesting the potential for bioaccumulation and secondary poisoning is extremely low. Furthermore, this concentration was just above the minimum detection level and the author suggests it could have been the result of some bait material contaminating the weta when collected at the conclusion of the trial. The authors go on to suggest that based on the dietary LD_{50} calculated for chickens, a 1 kg chicken would need to consume over 25,000 weta (each with a residue of 10μg) in quick succession to receive an LD_{50} dose.

<u>Risk to Terrestrial Plants</u>

Available toxicity data for terrestrial plants suggested effects can occur when nitrite soil or soil water concentrations exceed 1.0 mg/L. Effects on root and shoot growth, dry matter yield and chlorosis have been observed in crops such as lettuce, tomato and tobacco (Phipps and Cornforth 1970, Hamilton and Lowe 1981, Hoque et al. 2007). Wheat seedlings exhibited nitrite related effects to root growth in exposures to 1 mM (68.9 mg/L) sodium nitrite (Tari and Csiszar 2003).

As discussed above, the amount of sodium nitrite that could inadvertently end up on the ground as a result of spillage from a bait station would be minimal. Predicted values would still be far below the 1.0 mg/L concentration that have been shown to have negative effects on plants. It should also be noted that sodium nitrite would also be susceptible to degradation to other forms such as nitrogen that are less toxic and can be assimilated by plants. Similar to soil invertebrates the risk to terrestrial plants is low and would only occur in areas where bait contacts the ground and decomposes. However, due to degradation of the bait and sodium nitrite, extremely low concentrations and low bioavailability, potential effects would be transient and specific to soil under, and immediately adjacent to, any spilled bait. The removal of spilled bait as required by the label would further reduce the availability of sodium nitrite to terrestrial plants.

<u>Summary of Terrestrial Risks</u>

Overall, risks to terrestrial vertebrates, invertebrates and plants are expected to be minimal based on the proposed use and available effects data. Some terrestrial vertebrates and invertebrates may be attracted to spilled bait as a food source but any potential risk would be limited to individuals actively feeding on the bait and would not result in population level impacts. A more detailed analysis of non-target mammals and birds is presented below in 3.2.3. The lack of toxicity at relevant doses to pollinators such as the honey bee and the low potential for exposure to pollinators suggests they would not be at risk from the proposed use of sodium nitrite. The risk to soil-borne invertebrates would be possible if bait was left on the ground and allowed to degrade in place adding sodium nitrite levels to the soil resulting in exposure. However, current SOPs and the proposed product label would prevent that much bait from ending up on the ground and therefore WS-NWRC does not believe this to be an exposure risk. Any dietary exposure to vertebrates from contaminated water is shown to be insignificant based on the estimated aquatic residues presented above. These levels are also shown to be insignificant for terrestrial plants as well.

Other indirect effects of this study that may affect the terrestrial environment such as trails accessing bait sites or other human activities were also considered. Bait sites will be visited daily most likely via a 4x4 vehicle or an ATV. Access on private land would be from established trails or roads and access off of those trails would either be by an ATV or by foot. Any foot traffic or ATV traffic off of established trails would be minimal. It would not only be desirable to leave a "minimal footprint" to prevent any environmental damage such as trampling of vegetation, erosion from new trails etc., it would also likely be beneficial to the effectiveness of the control program and the study so that feral swine are not disturbed or frightened from the area, so, all efforts will be made to keep disturbances in the area to a minimum.

3.2.3 Effects on Non-target and T&E Species

A common concern among members of the public and wildlife professionals, including WS-NWRC personnel is the impact of any wildlife damage management action on the target species, non-target species and T&E species. This Section analyzes those potential effects by alternative.

Alternative 1 – No Action - No Study

Under this alternative, there would be no direct effects on non-target or T&E species. Field trials to test the effectiveness of a feral swine toxicant would not be conducted.

Alternative 2 – Proposed Action – Conduct the Study

The proposed action to conduct the study would determine the effectiveness of SN to control free-ranging feral swine at two field sites and also assess the effectiveness of the bait stations to exclude raccoons and other non-target wildlife. Under this alternative, WS-NWRC would be able to continue researching and assessing the effects of SN on non-target wildlife. From existing data, WS-NWRC believes the following effects on non-target and T&E species would result if the decision is made to accept the Proposed Action to conduct the study.

Impacts on Threatened and Endangered Species

WS-NWRC reviewed the status, critical habitats designations, and current known locations of all species listed as threatened, endangered, or candidates within the counties where the two study sites in Alabama and Texas would be selected. Species effects determinations were made for each study location and where applicable, were submitted to the USFWS for concurrence pursuant to Section 7 of the Endangered Species Act. In Alabama, WS-NWRC considered three counties (Bullock, Mason and Montgomery) for the study site and these species listed in those counties.

Species listed as threatened, endangered, or candidate in three Alabama counties.

Common Name	Scientific Name	Status†	Determination‡
ANIMALS			
Snails			
Tulotoma snail	*Tulotoma magnifica*	T	MANLAA
Mussels			
Choctaw bean	*Villosa choctawensis*	E	MANLAA
Finelined pocketbook	*Hamiota altilis*	T	MANLAA
Fuzzy pigtoe	*Pleurobema strodeanum*	T	MANLAA
Narrow pigtoe	*Fusconaia escambia*	T	MANLAA
Oval pigtoe	*Pleurobema pyriforme*	E	MANLAA
Ovate clubshell	*Pleurobema perovatum*	E	MANLAA
Round ebonyshell	*Fusconaia rotulata*	E	MANLAA
Southern clubshell	*Pleurobema decisum*	E	MANLAA
Southern kidneyshell	*Ptychobranchus jonesi*	E	MANLAA
Southern sandshell	*Hamiota australis*	T	MANLAA
Tapered pigtoe	*Fusconaia burkei*	T	MANLAA
Stirrup Shell	*Quadrula stapes*	E	MANLAA
Reptiles and Amphibians			
Gopher tortoise	*Gopherus polyphemus*	C	MANLAA
Birds			
Wood stork	*Mycteria americana*	E	MANLAA
Red-cockaded woodpecker	*Picoides borealis*	E	MANLAA
PLANTS			
Flowering Plants			
Alabama canebrake pitcher-plant	*Sarracenia rubra* ssp. *alabamensis*	E	MANLAA
American chaffseed	*Schwalbea Americana*	E	MANLAA
Georgia rockcress	*Arabis georgiana*	T	NE
Little Amphianthus	*Amphianthus pusillus*	T	NE
Relict trillium	*Trillium reliquum*	E	MANLAA

†T=Threatened; E=Endangered; C=Candidate; PT=Proposed Threatened
‡NE=No effect; MANLAA=May affect, not likely to adversely affect

The USFWS has also designated critical habitat in Alabama for some of the species listed as threatened or endangered. Below is a list of those species with critical habitat designated in Bullock, Macon and Montgomery counties in Alabama along with a summary of WS-NWRC' effects determination.

Common Name	Scientific Name	Status†	Determination‡
Mussels			
Choctaw bean	Villosa choctawensis	CH	MANLAA
Finelined pocketbook	Hamiota altilis	CH	MANLAA
Fuzzy pigtoe	Pleurobema strodeanum	CH	MANLAA
Narrow pigtoe	Fusconaia escambia	CH	MANLAA
Oval pigtoe	Pleurobema pyriforme	CH	MANLAA
Ovate clubshell	Pleurobema perovatum	CH	MANLAA
Round ebonyshell	Fusconaia rotulata	CH	MANLAA
Southern clubshell	Pleurobema decisum	CH	MANLAA
Southern kidneyshell	Ptychobranchus jonesi	CH	MANLAA
Southern sandshell	Hamiota australis	CH	MANLAA
Tapered pigtoe	Fusconaia burkei	CH	MANLAA
PLANTS			
Flowering Plants			
Georgia rockcress	Arabis georgiana	CH	NE

WS-NWRC' provided a review of the proposed study and these effect determinations in the form of a Biological Assessment (BA) on March 16, 2017 to the USFWS Alabama Ecological Services Field Office located in Daphne, Alabama. The USFWS provided a letter of concurrence on April 27, 2017.

In Texas, WS-NWRC considered nine counties (Archer, Baylor, Cottle, Foard, Hall, Knox, Motley, Wichita and Wilbarger) for the study site and the T&E species in those counties.

Species listed as threatened, endangered or candidate in nine Texas counties.

Common Name	Scientific Name	Status†	Determination‡
ANIMALS			
Clams			
Texas fawnsfoot	*(Truncilla macrodon)*	C	NE
Birds			
Whooping crane	*(Grus Americana)*	E	NE
Red knot	*(Calidris canutus rufa)*	T	NE
Piping Plover	*(Charadrius melodus)*	T	NE
Least tern	*(Charadrius melodus)*	E	NE
Black-capped vireo	*(Vireo atricapilla)*	E, PD	NE
Golden-checked warbler	*(Dendroica chrysoparia)*	E	NE
Fish			
Smalleye Shiner	*(Notropis buccula)*	E	NE
Sharpnose Shiner	*(Notropis oxyrhynchus)*	E	NE

†T=Threatened; E=Endangered; C=Candidate; PT=Proposed Threatened; PD=Proposed Delisting

‡NE=No effect; MANLAA=May affect, not likely to adversely affect

WS-NWRC' provided a review of the proposed study and these effect determinations in a letter to the USFWS Texas Ecological Services Field Office located in Arlington, TX on June 5, 2017.

Dissimilarities of Threatened and Endangered Species between Study Sites

The following is a brief discussion and rationale for WS-NWRC' different endangered species "effect" determinations between the two study sites. As discussed in 1.10, this proposed study consists of two study sites and field trials will be conducted at different times but within 6 months of each other.

Threatened and endangered species effects and determinations must be treated and analyzed separately between study sites. The primary reason for this is the variability between the species analyzed, their biology, and habitat. Although the study intends to replicate the exact trial in each location (i.e. same SN concentrations and amounts deployed, etc.), the trials will take place at different times of the year, in different habitat types, and involve different T&E species. Therefore, even if a T&E species appears to be similar at each site, the effects determination can be very different because of these variables. For example, the wood stork (in Alabama) could be considered similar to the whooping crane (in Texas). They are both large birds that feed primarily on aquatic vertebrates and therefore it is plausible to assume the effect determinations may be similar for the two species. Conversely, WS-NWRC determined there would be "no effect" to the whooping crane and a "may effect, not likely to adversely affect" determination was made for the wood stork.

These different determinations are explained by what WS-NWRC would reasonably expect the presence or absence of these two birds at the proposed study sites along with other variables. In the case of the wood stork in Alabama, this species has not been documented to nest in the state, but juvenile birds have been documented dispersing up the coastal rivers of lower Alabama and could potentially take up a semi-residence near a study location. Based on the data provided in this document, WS-NWRC believes the study would have no effect on the wood stork, but recognizes it is possible for a wood stork to be present during the time of the proposed study and the study site may be located in or near favorable wood stork habitat. Therefore, WS-NWRC has taken a conservative approach and given the wood stork a "may effect, but not likely to adversely affect" determination.

Whooping cranes breed in Canada during the summer months and spend the winters on the Texas coast near Rockport, TX. Whooping cranes only migrate through the proposed study site counties in Texas and would likely only stop briefly (if at all) as they migrate to the coast. Furthermore, study site locations would not likely be located in whooping crane habitat and WS-NWRC does not anticipate any whooping cranes to be present during the study time frame. Therefore, given very different variables from those of the wood stork, WS-NWRC has made a "no effect" determination for the whooping crane.

Another significant difference between study sites involves annual average rainfall. The study site in Alabama receives about 53 inches of rainfall annually and the study site in Texas receives about 24 inches. This is a significant difference when considering the effect determinations of aquatic species such as fish and mussels. Data estimates presented here show there is no risk to aquatic organisms because any predicted residues that could leach into water sources from spilled bait would be miniscule and well below minimum tolerance levels to aquatic species. However, WS-NWRC also recognizes that the Alabama study site receives more than double the amount of annual rainfall than the Texas site and therefore runoff risk may be slightly higher in Alabama. Again, taking a conservative approach, WS-NWRC determined "may effect, not likely to adversely affect" for aquatic species in Alabama but made "no effect" determinations in Texas due to the substantially lower risk of runoff and the other EUP restrictions.

<u>Alabama Species</u>

Below is brief summary and rational for the effects determinations WS made for the T&E species in Alabama. Aquatic species and their critical habitat were closely evaluated because excess nitrite in aquatic systems can be very detrimental to aquatic species. The direct, indirect and cumulative effects were analyzed. This detailed analysis of aquatic impacts is discussed in Section 3.2.2 and also provided in the March 16, 2017 Biological Assessment. The risk of nitrite exposure from HOGGONE® applications was evaluated by comparing the estimated residues in a typical wetland and pond to the range of acute and chronic toxicity data for aquatic invertebrates and vertebrates. In all estimates, sodium nitrite concentrations were orders of magnitude below the range of estimated acute aquatic concentrations for aquatic species suggesting a lack of risk to aquatic fauna.

Available data for aquatic vertebrates and invertebrates and estimated residues of HOGGONE® in aquatic habitats demonstrates that the risk to listed freshwater mussels and snails is insignificant and discountable. This includes direct risk from exposure to nitrite as well as any indirect risk to available food items and habitat.

WS believes that any other operational activities including trapping, handling of animals, euthanasia, transporting equipment and carcass disposal for this study will have no effect or insignificant effects on aquatic species that may be found in or near the potential study sites in Alabama because the activities would not modify habitats, occur in waterways, or affect individual animals. Therefore, the USFWS concurred with WS' determination that the proposed action is not likely to adversely affect the Tulotoma snail, Choctaw bean, the ovate clubshell, southern clubshell, round ebonyshell, southern kidneyshell, fuzzy pigtoe, narrow pigtoe, oval pigtoe, finelined pocketbook, southern sandshell, yellow blossom and the stirrup shell or their critical habitat.

Alabama has five threatened and endangered plants. Two of those plants, the Georgia rockcress and the little amphianthus exist on steep rocky bluffs or small depressions in granitic rock outcrops. WS would not deploy the bait stations for feral swine in these habitats, therefore WS believes the proposed study or activities would have no effect on these species or their critical habitat.

Feral swine inhabit a variety of habitat types and they are often found in low land moist environments because it is generally more suitable for rooting up plants and invertebrates. Therefore it would be possible to find feral swine inhabiting suitable habitat that could support the Alabama canebrake pitcher-plant, the American chaffseed and the relict trillium.

Available toxicity data for terrestrial plants suggested effects can occur when nitrite soil or soil water concentrations exceed 1.0 mg/L. As discussed in the aquatic and terrestrial risk sections above, the amount of sodium nitrite that could inadvertently end up on the ground as a result of spillage from a bait station would be minimal. Predicted values would still be far below the 1.0 mg/L concentration that have been shown to have negative effects on plants.

Other indirect effects of this study such as trails accessing bait sites or other human activities were also considered and believed to be insignificant. For all these reasons, the USFWS concurred with WS' determination that the proposed action would not be likely to adversely affect the Alabama canebrake pitcher-plant, the American chaffseed and the relict trillium.

Alabama has two federally threatened and endangered birds. The wood stork (discussed above), and the red-cockaded woodpecker. It is not anticipated that the wood stork or the red-cockaded woodpecker would feed directly on any spilled bait on the ground near the bait stations due to their feeding habits. The wood stork forages in a variety of shallow wetlands and feeds almost exclusively on fish. The red-cockaded woodpecker feeds primarily on arthropods on the outer bark of live pines and in dead branches of live pines. The foraging behavior of both species makes it highly unlikely that either species would opportunistically feed on any spilled bait and therefore be directly exposed to the bait.

Indirect effects for these two species was also analyzed in detail. The risks to aquatic and terrestrial vertebrates and invertebrates (these species' forage base) is outlined in Section 3.2.2 and shows those risks to be insignificant. Based on this analysis, USFWS concurred with WS' determination that the proposed study would not be likely to adversely affect the wood stork or the red-cockaded woodpecker.

Lastly, the gopher tortious is listed as a candidate species in Alabama. Gopher tortoises primarily consume plants and fleshy fruits. Based on the foraging behaviors of the gopher tortoise it is possible that a tortoise could pick up and eat some spilled bait at a bait station but based on their food preferences, it is not likely. Indirect effects on plants (potential gopher tortoise forage) was also analyzed and shown to be insignificant. Therefore USFWS concurred with WS' determination that the proposed study would not be likely to adversely affect the gopher tortoise.

Texas Species

Texas has nine federally listed T&E species occurring in counties where the proposed study may occur. Three are aquatic species (2 fish and 1 mussel) and six are birds. As discussed above for aquatic species in Alabama and based on the analysis in 3.2.2, WS believes any effects on the aquatic environment to be insignificant. In Texas, because of significantly less annual precipitation and likely locations of bait stations, WS determined to have no effect on aquatic species.

Of the six bird species, WS also made no effect determinations. Rationale for the whooping crane determination was already discussed above. Rationale for the red knot, piping plover and the least tern are similar in that WS does not anticipate the species to be present during the time of the proposed study. It is also not likely that any bait stations would be located in preferred habitat of these species. The black-capped vireo and the golden cheeked warbler are known to feed almost exclusively above ground foraging on small invertebrates and are therefore not anticipated to feed on any spilled baits from bait stations and so were also given no effect determinations.

Direct Impacts on Non-target Mammals and Birds

Direct exposure refers to the ability of a non-target animal to directly access and consume bait either directly from the bait station or from spilled bait on the ground next to the bait station. Non-targets represents any animal other than the target species (feral swine). The primary exposure pathway to terrestrial non-target wildlife will be via the dietary route. Evaluation of potential bait formulations in the United States have demonstrated that a variety of non-target organisms may be attracted to bait stations (Campbell and Long 2007, Campbell and Long 2009, Campbell et al. 2011, Long et al. 2010). This includes wild species and domestic animals, similar observations were also noted outside of the United States (Massei et al. 2010).

Snow et al. (2016) identified that white-tailed deer and raccoons were the most frequently observed non-target species that visited placebo HOGGONE® without using bait stations in Texas. Foster (2011) also found that raccoons and deer were very susceptible to SN and therefore would be a serious non-target concern. Previous studies also identified raccoons as the primary non-target species accessing predecessor prototypes of bait stations for feral swine (Long et al. 2010, Campbell et al. 2011, Campbell et al. 2013). Given these findings, the proposed study will focus on raccoons as the primary non-target species at potential risk from direct exposure to toxic HOGGONE® in bait stations.

As mentioned above in 2.2.2, the bait station (Appendix B) lids will have 13.6 kg (30 lbs) of magnetic pressure holding the lids shut ensuring that only larger animals such as feral swine would have direct access when the sodium nitrite bait is deployed. This bait station delivery device will significantly decrease the potential for exposure to the majority of non-target organisms. Snow et al. (2017c) found that 13.6 kg of magnetic pressure excluded raccoons but allowed access to 75% of feral swine to the bait station. Therefore, it is assumed that all non-target birds and mammals smaller than a raccoon will be completely excluded from the bait station.

To ensure there is no direct exposure to any non-target animals such as black bears, large dogs or any other large non-target animal that may be capable of opening a 30 lb. lid, each bait station will be monitored with remote cameras. If any non-target animal is detected during the pre-bait or any baiting period, baiting will be discontinued (also required by the EUP label). By monitoring the bait stations remotely, risk of use by non-target wildlife will be minimized. Both the Alabama Department of Conservation and Natural Resources and the Texas Parks and Wildlife Department acknowledge that the black bear's range in each state does not include the proposed study sites.

The only other possible direct exposure route for non-target wildlife would be from spilled bait around the bait stations. As discussed in detail in 3.2.2, the Environmental Fate section, it is anticipated that no more than 0.1 – 1.0% of sodium nitrite would end up as spillage on the ground for any non-target animals to consume directly. That is the equivalent of 2 – 20g (approximately .64 ounce) of active ingredient. All species have varying degrees of sensitivity to SN, therefore, acute oral dosing studies have been conducted with several test species with values demonstrating moderate to high toxicity from sodium nitrite exposure (Table 1).

Table 1. Acute oral median lethality values for various mammals to sodium nitrite.

Test Species	Test	Toxicity Values (mg/kg)	Reference
Brushtail possum (*Trichosurus vulpecula)*	Acute Dietary Toxicity	122	Shapiro 2016
Raccoon (*Procyon lotor*)	Acute Oral Toxicity	58	Foster 2011
New Zealand rabbit (*Oryctolagus cuniculus*)	Acute Oral Toxicity	124	Dollahite and Rowe 1974
White-tailed deer (*Odocoileus virginianus*)	Acute Oral Toxicity	154	Foster 2011
Feral swine (*Sus scrofa*)	Acute Oral Toxicity	133	Foster 2011

Available acute oral dosing studies show moderate toxicity of sodium nitrite to birds. Acute dietary testing have shown some mixed results, Stafford (2011a,b,c) using the northern bobwhite and mallard demonstrates that sodium nitrite is practically non-toxic to surrogate bird species representing upland game birds and waterfowl. No toxicity or sublethal effects were noted at the highest test concentration (Table 2). However, more recently, Shapiro (2017) dosed domestic chickens and mallards with SN paste bait registered for brushtail possums in New Zealand and found dietary LD_{50} values to be approximately 254.6 mg/kg for both species. Soniat (2012) and Stafford (2011a) showed sodium nitrite LD_{50} toxicity values for red-winged blackbird to be 119.8 mg/kg and the Northern bobwhite to be 619 mg/kg. Ley (1986) reported an LD_{50} value of 588 mg/kg for the domestic turkey testing a nitrite based fertilizer. Sublethal effects and measured methemoglobin levels were consistent with nitrite being the causal agent for mortality.

Table 2. Standardized acute avian toxicity values for sodium nitrite.

Test Species	Test	Toxicity Values	Reference
Red-winged blackbird (*Agelaius phoeniceus*)	Acute Oral Toxicity	LD_{50}:< 119.8mg/kg LOEL: 119.8 mg/kg NOEL: 71.1 mg/kg	Soniat (2012)
Turkey Vulture (*Cathartes aura*)	Acute Oral Toxicity	LC_{50}: 663 mg/kg NOEL: 75 mg/kg	Foster (2017)
Northern Bobwhite (*Colinus virginianus*)	Acute Oral Toxicity	LD_{50}: 619 mg/kg LOEL: 418 mg/kg NOEL: 251 mg/kg	Stafford (2011a)
Domestic chicken *(Gallus gallus domesticus)*	Acute Dietary Toxicity Acute Oral Toxicity	LC_{50}: 254.6 mg/kg LC_{50}: 68.5 mg/kg	Shapiro (2017)
Domestic Mallard *(Anas platyhynchos domesticus)*	Acute Dietary Toxicity Acute Oral Toxicity	LC_{50}: 254.6 mg/kg LC_{50}: 68.5 mg/kg	Shapiro (2017)
Mallard (*Anas platyhynchos*)	Acute Dietary Toxicity	LC_{50}: > 5000 ppm LOEL: undetermined NOEL: > 5000 ppm	Stafford (2011b,c)
Northern Bobwhite (*Colinus virginianus*)	Acute Dietary Toxicity	LC_{50}: >5000 ppm $LOEL_{(BW)}$: 5000 ppm $NOEL_{(BW)}$: 2995 ppm	Stafford (2011a)

Available sublethal feeding studies using domestic and wild bird species show multiple physiological endpoints that may be impacted by sodium nitrite. Atef et al. (1991) dosed cockerels (immature male chickens) for four weeks at a dose of 1.7 g sodium nitrite/kg feed. Significant negative effects were seen on weight gain, erythrocyte (red blood cell) counts and glutamic pyruvic transaminase. Creatinine and urea levels suggested immune, liver and kidney impacts. No NOEC was determined since only one dose was tested. Average (±SD) percent methemoglobin levels were 25.6 percent (±4.0) in sodium nitrite exposed birds which was statistically significant from control birds at 1.1percent (±0.5).

It is not anticipated that the majority of non-target birds and mammals would feed directly on any spilled bait on the ground near the bait stations due to the low amounts of spilled bait that has been observed at the stations. However, it is possible to take a very small number of non-targets with the maximum amount of predicted spillage (0.1 - 1.0% or 2 – 20g of active ingredient, 200g (20 x 10% AI) or 7 oz. of total bait on the ground). For example, a 4 kg raccoon would need to eat 232 mg (58mg/kg x 4 kg) of active ingredient or 2.32 g (232 X 10%) of bait. This would appear that 20 g of SN would take several raccoons but in reality, raccoons eat 5% of their body weight per day, approximately 200 g (4 kg = 4000 g x .05% = 200) and therefore one raccoon could easily consume all of the spilled bait resulting in the death of one or maybe two raccoons.

In the case of birds, red-winged blackbirds were tested to be relatively sensitive to SN compared to other birds at LD_{50} of about 120 mg/kg. An average red-winged blackbird weighs about 56 g, therefore they would need to eat approximately 6.7mg (120mg/kg x .056kg) of SN or about 67mg (6.7x 10%) of bait to receive a lethal dose. They likely consume about 4 grams of food per day. This indicates that it would be possible to take 50 (200 g bait divided by 4 grams per bird) red-winged black birds if they were to feed on the precise amount of spilled bait. Realistically, this would be extremely unlikely due to the foraging behavior of most birds and the fact that the bait will not be widely scattered and evenly distributed. A more realistic estimate may be 5-10 non-target black birds could be taken as a result of intensively feeding on spilled bait.

These estimates would be considered worst case scenarios. Furthermore, the study protocol and the EUP label requires any spilled bait to be removed each day when the bait stations are checked to minimize any direct feeding on spilled bait. Although there is a slight chance to expose some non-target birds and mammals directly to spilled bait, WS-NWRC believes the risk is minor and short-term and would not result in any chronic exposure effects. Overall, some non-targets may be attracted to the bait as a food source but any potential risk would be limited to individuals actively feeding on the bait and would not result in any population level impacts.

Indirect Impacts to Non-Target Mammals and Birds

Indirect impacts to mammals or birds primarily refers to secondary poisoning concerns. WS-NWRC analyzed the possibility and the effects of an animal consuming another animal, insects or plants that may have been exposed to sodium nitrite and other potential secondary or indirect effects. WS-NWRC identified four possible routes of secondary exposure to SN. First, and probably the least likely concern is exposure via the consumption of contaminated drinking water. As noted above in 3.2.2., the estimated aquatic residues are orders of magnitude below any effects data for all aquatic species and are also far below safe drinking water standards. There is virtually no risk of secondary exposure to SN via drinking water to non-target wildlife. Secondly, the consumption of vertebrates, invertebrates or plants that may have been exposed to SN is considered. The impacts of SN exposure to plants and invertebrates is also discussed above in 3.2.2. The effects to aquatic plants and invertebrates, terrestrial plants and invertebrates were shown to be minuscule and insignificant. Furthermore, due to the biological process in which SN converts hemoglobin to methemoglobin (MtHb) and the protective enzyme MtHb reductase quickly reverses the de-oxidizing effects of nitrite, no bioaccumulation of nitrite occurs. Lapidge and Eason (2010) summarized data from previous studies in the rat, sheep, dog and horse and observed the elimination half-life ($T_{1/2}$) of sodium nitrite in plasma to range from 29 to 62.5 minutes based on a range of doses.

Also noted above in 3.2.2, Shapiro et al. (2017) evaluated the risks to the cave weta (Family: Rhaphidophoridae) a common native New Zealand invertebrate similar to a grasshopper or cricket. One out of 16 wetas collected and analyzed was found to have a SN residue of 10 µg suggesting the potential for bioaccumulation and secondary poisoning is extremely low. Shapiro et al. (2017) goes on to suggest that based on the dietary LD_{50} calculated for chickens, a 1 kg chicken would need to consume over 25,000 weta (each with a residue of 10µg) in quick succession to receive an LD_{50} dose. Therefore it is highly unlikely that there would be any secondary exposure effects to an animal that may consume a plant or animal that could have received a sub-lethal dose of SN.

Another potential route of secondary exposure identified was the possible exposure to feral swine vomitus (vomited material) to non-target wildlife. Pen studies have shown that 70% of feral swine vomited after consuming a lethal dose of HOGGONE®. Snow et al. (2017b) evaluated the potential risks of vomitus (vomit) to non-targets and found that residual SN in vomitus degraded quickly in a hot humid environment. Residual SN was found to have decreased by 50% in less than 4 days and had nearly completely degraded in 25 days. The authors also noted that vomitus was difficult to accurately weigh and collect because it primarily had a liquid consistency and that undigested bait was usually found in scarce amounts. Vomitus would also likely be randomly distributed making it difficult for non-target animals to find. In addition, the residual SN in vomitus is exposed to the digestive tract and therefore the micro-encapsulation would have been dissolved, giving the vomitus a strong salty taste that is likely aversive to scavengers or non-target wildlife. Given these parameters, WS-NWRC believes it would be highly unlikely that non-target wildlife would find and consume enough vomitus to receive a lethal dose.

Lastly, and likely the most probable concern would be for non-target or scavenger species that may consume carcasses of feral swine that have consumed a lethal dose of SN. This concern is discussed in detail below.

<u>Indirect Impacts on Scavenging Species</u>

The potential for scavenging species such as predators, free-ranging dogs, vultures, raptors and any other non-target animal that may consume carcasses has been analyzed. Sodium nitrite is metabolized quickly by feral swine that consume the product with negligible residues reported in muscle tissue. Lapidge et al. (2012) and (Snow et al. 2017b) found residual SN in muscle, liver and eye tissue to be very low (average 3.2 mg/kg). The U.S. Food and Drug Administration regulates that no more than 200 mg/kg of sodium nitrite can be used as a preservative in meat products.

Risk estimates for non-target animals such as the bald eagle show they would need to consume greater than 300 times their daily food consumption rate to exceed an acute oral dose of sodium nitrite based on residues that could occur in muscle tissue. Similar estimates of low risk have also been shown for other scavengers (Snow et al 2017b). An unpublished pen study with coyotes from WS-NWRC found no observable effects to coyotes when allowed to feed freely on SN dosed feral swine carcasses for 24 hours. Sixteen coyotes were given feral swine carcasses, 8 coyotes were given SN dosed feral swine carcasses and 8 coyotes were given placebo dosed carcasses. There were no mortalities and no difference in the consumption rates for each group. In another study that is currently being conducted by TPWD assessing the secondary effects of SN on Turkey vultures (*Cathartes aura*), it has been shown SN from carcasses is a minimal to no risk to vultures (Foster 2017). TPWD dosed 4 feral pigs at 600 mg/kg of SN (one and a half times the lethal dose) and presented them to 4 groups of 5 vultures (3 treatments and 1 control group).

Vultures fed freely on the carcasses for one week. The entire carcasses were consumed (with the exception of the hair and bones) by vultures and no effects were observed.

Despite the extremely low residues found in muscle tissue and the apparent lack of risk, the digestive tract (stomach, stomach contents and the small intestines) showed elevated levels of SN and hence a greater risk of exposure to scavengers. However, Snow et al. (2017b) found that approximately 90% of sodium nitrite residues in the stomach of feral swine are lost within three hours due to metabolism and degradation. These residues in the stomach contents are susceptible to environmental degradation reducing the time for exposure to scavenging non-target animals. Estimates assuming that scavengers only feed on undigested stomach contents show potential acute risk (Snow et al 2017b). However, these estimates are conservative since they don't assume any degradation of sodium nitrite and scavengers would preferentially feed only on undigested stomach contents. Shapiro et al. (2016) cited that SN has an aversive taste and therefore it must be encapsulated to mask the taste. Once the SN has been consumed and the encapsulation removed by the acidic stomach, it again, becomes very unpalatable to potential scavengers. Wade and Brown (1982) also suggest that many predator/scavengers will choose to consume rumen or stomachs last and that bald eagles typically do not eat the stomachs.

Muscle tissue that makes up a larger percentage of biomass from a feral swine would also be present for scavenging and with negligible sodium nitrite concentrations. In most cases scavengers would preferentially consume muscle tissue over stomach contents reducing the exposure of sodium nitrite to non-target wildlife. Evidence of this was seen in the unpublished coyote study mentioned above when only 2 of the 16 coyotes consumed stomachs. Those 2 were also in the placebo group meaning there was no SN in the stomach. Of the 8 coyotes that were feed SN dosed carcasses, none consumed stomachs. Scavengers would also have to consume stomach contents quickly to receive a lethal dose since consuming it over a longer period of time would allow metabolism of sodium nitrite, reducing the potential for acute risk (Snow et al 2017b).

In an ongoing study, TPWD fed HOGGONE® *ad libitum* to four pigs, the stomach and upper intestines were harvested. Only the stomachs and upper intestine (1 pair/cage) were presented to 3 groups of 5 Turkey vultures and a control with 2 vultures. Birds were monitored visually and with remote camera for 24 hrs. Stomachs and tissues were nearly completely consumed, only a portion of the food bolus from stomachs were not consumed. The remaining contents were removed at 24 hours to avoid forced consumption of the food bolus. No mortalities or effects have been observed. Although the residual concentrations of SN in the stomach and intestines are high enough to be lethal to vultures, it is hypothesized that the vultures are not able to consume them fast enough to produce any observable effects (Foster 2017). In summary, there are some minimal risks to scavenging species but given the biological properties of SN and the available data, these risks are very minor and short term.

3.2.4 Humaneness / Ethics

Many people are concerned with the humane treatment of animals. The issue of humaneness and other sociological issues including ethical perceptions pertaining to wildlife damage management can be interpreted in a variety of ways depending upon individual perspectives, philosophies and experience. This Section reviews the varying perspectives on the issue relative to the Proposed Action.

Alternative 1 – No Action - No Study

Under the no action alternative, no study would be conducted and therefore no feral swine or raccoons would be euthanized and consequently humaneness would not be an issue.

Alternative 2 – Proposed Action – Conduct the Study

Under this alternative, the proposed study may be viewed by some persons as inhumane because it could be perceived that feral swine and or raccoons could suffer after eating a lethal dose of HOGGONE® before succumbing to death. The issue of humaneness, as it relates to the killing or capturing of wildlife is an important but complex concept. Schmidt (1989) indicated that vertebrate pest control for societal benefits could be compatible with animal welfare concerns, if *". . . the reduction of pain, suffering, and unnecessary death is incorporated in the decision making process.".* Suffering has been described as a *" . . . highly unpleasant emotional response usually associated with pain and distress*." However, suffering *" . . . can occur without pain . . .* ," and *". . . pain can occur without suffering . . ."* (American Veterinary Medical Association (AVMA) 1987, 2001, 2007).

Defining pain as a component of humaneness may be a greater challenge than that of suffering. Pain obviously occurs in animals. Altered physiology and behavior can be indicators of pain, and the causes that elicit pain responses in humans would *" . . . probably cause pain in other animals..."* (AVMA 1987). Suffering, generally would imply there is a time frame and when death occurs quickly, suffering is minimized.

Pain and suffering as it relates to tools used to capture animals, is often interpreted differently by professional wildlife biologists and the general public. In addition, individuals that receive feral swine damage or threats of damage may perceive humaneness differently. Some individuals may have resources being damaged such as pets or livestock being injured or killed by feral swine while others may have no conflicts with feral swine and therefore view the situation very differently.

The issue of humaneness therefore, in part, appears to be a person's perception of pain and suffering. Different people may perceive the humaneness of an action differently based on that person's past experiences (Broom 1999). The challenge in coping with this issue remains how to achieve the least amount of suffering within the constraints imposed by current technology, funding, workforce, and social concerns. The decision-making process involves tradeoffs between the aforementioned aspects of pain from damage management activities and the needs of humans to reduce wildlife damage. An objective analysis of this issue must consider not only the welfare of wild animals but also the welfare of humans and prey animals if damage and losses are not stopped. The proposed study is intended to evaluate and develop a humane damage control method that may ultimately help curtail damage and loses by feral swine.

The Institute of Medical and Veterinary Science (2010) reported on the efficacy and humaneness of SN as a potential toxicant for feral swine. Pen trials lead by the Invasive Animals Cooperative Research Centre (CRC) in 2006 conducted on domestic pigs in a controlled environment concluded that SN was efficient and produced a humane death. Four of the five animals in these initial trials died in less than two hours after consuming SN bait, the fifth animal consumed the least amount of bait died within three hours. Animals were closely monitored for clinical signs of distress and physiological changes (respiration, hematology, biochemistry, cortisol and lactate and methemoglobin levels). Biochemical changes other than the rise of lactate and cortisol were not different between test and control animals. The rise in blood lactate is consistent with methemoglobinemia. Lactate at 25 mM/L is not in itself associated with pain or discomfort.

The authors suggest that the development of methemoglobinemia resulting from SN ingestion leads to a state of unconsciousness without a prolonged preliminary excitatory state. This behavioral evidence suggests that death from SN intoxication is an acceptable humane method for damage management of feral swine.

Subsequent studies have shown similar results, Snow et al. (2017a) showed a 95% mortality rate for captive feral swine in 2-choice laboratory efficacy tests with HOGGONE®. Studies have also demonstrated that 400 mg/kg of SN per body weight produced 100% mortality in feral swine within 2.5–4 hours of consumption. Typical symptoms included lethargy, un-coordination, labored breathing, loss of consciousness and death.

WS-NWRC also follows the Animal Welfare Act and its associated regulations. This act sets the standards for humane care and treatment for certain animals that are exhibited to the public, bred for commercial sale, used in medical research, or transported commercially. Research is continuing to bring new findings and products into practical use. Until new findings and products are found practical, a certain amount of animal suffering could occur when some feral swine damage management methods are used in situations where nonlethal damage management methods are not practical or effective.

3.3 Issues Not Considered for Comparative Analysis

The following resource values within Alabama and Texas are not expected to be significantly impacted by any of the alternatives analyzed: geology, minerals, floodplains, visual resources, air quality, or prime and unique farmlands. In addition, no irreversible or irretrievable commitments of resources are expected by implementation of the proposed action.

3.4 Summary of Impacts

This study will likely only result in the removal of approximately 200 feral swine from each study site in Texas and Alabama. An improvement in habitat conditions in the immediate area where swine are removed could be expected. This improvement would be a result of less habitat destruction from feral swine. Although the removal of approximately 200 feral swine at each study site would likely be beneficial, it would still be considered minor and insignificant due to the small scale of the study.

The analysis suggests that based on the methodology of the study, the amounts or concentrations of sodium nitrite used and its potential exposure to the terrestrial and aquatic environment, any direct or indirect effects would be insignificant or discountable. Due to the short term time frame of this study (approximately 6 months in each location), any cumulative effects are expected to be insignificant.

WS-NWRC recognizes that registration of the product HOGGONE® could be considered a cumulative effect of the study. However, registration is not certain but could be a reasonably foreseeable future action providing the study results were positive. This study is designed with EPA guidelines to provide the required efficacy data for EPA registration. The registration of a product necessitates several data requirements that include but are not limited to: product chemistry, toxicology (human), ecological effects, environmental fate, residue chemistry (for food use), and product performance (lab and field studies, i.e. Proposed Action)

A considerable amount of these data requirements have not been completed. Therefore, due to the complexity and the potential timeframe of the registration process (2-3 years), the other data requirements for EPA registration that are not yet complete, and the unknown results of this proposed study, WS-NWRC believes any cumulative effects analysis of registration would be premature and inappropriate at this time due to the lack of completed data that could be used in a meaningful analysis.

Based on the analysis in this EA, WS-NWRC has determined that the Proposed Action is not expected to have significant or adverse impacts to human health and pet safety, the terrestrial and aquatic environment, non-target and T&E wildlife or the humaneness of research activities. Based on experience, the methods and strategies considered in this document are limited in nature and any reasonably foreseeable future actions from this Proposed Action will not result in cumulatively significant environmental impacts.

3.4.1 Summary Tables

Table 3: Summary of Environmental Effects Analyzed in Detail

Environmental Resource	Alternative 1: No Action No Study	Alternative 2: Proposed Action Conduct Study
Human Health and Safety	No Effect	Insignificant Effects
Impacts on the Terrestrial Environment	No Effect	Insignificant and discountable effects.
Impacts on the Aquatic Environment	No Effect	Insignificant and discountable effects.
Impacts to Non-Target Wildlife	No Effect	No Effect to insignificant and discountable effects.
Impacts to Threatened and Endangered species	No Effect	No Effect to insignificant and discountable effects.
Humaneness/Ethics	No Effect	No Effect, SN is considered humane.

Table 4: Summary of Environmental Effects Not Analyzed in Detail

Environmental Resource	Proposed Action Conduct Study
Impacts to Feral Swine	No Effect, insignificant, local small scale feral swine removal.
Impacts to Air Quality	No Effect, small number of feral swine carcasses, short term nuisance odor.
Impacts on Hunting/Recreation	No Effect, study would be conducted on private land with no public hunting access.
Effects on Socio Cultural Resources	No Effect
Cost Effectiveness	Not analyzed due to small scale of project.
Economic Impacts	Not analyzed, not in the scope or scale of the project.
Impacts to the Feral Swine meat market	No Effect

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APPENDIX A. Literature Cited

Adams, C. E., K. J. Lindsey, and S. J. Ash. 2006. Urban wildlife management. CRC Press, Boca Raton, FL, USA.

Agar, N. S. and J. D. Harley. 1972. Erythrocytic methaemoglobin reductases of various mammalian species. Experientia 15(10):1248-1249.

Alonso, A. and J. A. Camargo. 2007. Ameliorating effect of chloride on nitrite toxicity to freshwater invertebrates with different physiology: a comparative study between amphipods and planarians. Arch. Environ. Contam. Toxicol. 54:259–265.

American Veterinary Medical Association (AVMA). 1987. Panel Report on the Colloquium on Recognition and Alleviation of Animal Pain and Distress. J. Amer. Vet. Med. Assoc. 191:1186-1189.

American Veterinary Medical Association (AVMA). 2001. 2000 Report of the AVMA panel of Euthanasia. J. Amer. Veterinary Med. Assoc. 218: 669-696.

American Veterinary Medical Association (AVMA). 2007. AVMA guidelines on euthanasia (formerly report of the AVMA panel on euthanasia), June 2007. J. Amer. Veterinary Med. Assoc., Schamburg, Ill. 36 pp.

Armstrong, D.A., Stephenson, M.J. and Knight, A.W., 1976 Acute toxicity of nitrite to larvea of the giant Malaysian prawn, *Macrobrachium rosenbergii.* Aquaculture, 9: 39-46.

Atef, M., Abo-Norage, M.A.M., Hanafy, M.S.M. and A.E. Agag. 1991. Pharmacotoxicological aspects of nitrate and nitrite in domestic fowls. British Poultry Sci. 32:399-404.

Bailey, R. G. 1998. Ecoregions, the ecosystem geography of the oceans and continents. Second edition. Springer-Verlag, New York, USA.

Ballari, S. A., and M. N. Barrios-Garcia. 2013. A review of wild boar *Sus scrofa* diet and factors affecting food selection in native and introduced ranges. Mammal Review 44:124-134.

Banihani, Q., R. Sierra-Alvarez and J. A. Field. 2009. Nitrate and nitrite inhibition of methanogenesis during denitrification in granular biofilms and digested domestic sludges. Biodegradation 20:801–812.

Bevins, S. N., K. Pedersen, M. W. Lutman, T. GidleWS-NWRCki, and T. J. Deliberto. 2014. Consequences associated with the recent range expansion of nonnative feral swine. BioScience Online 64:291-299.

Board, P. G., N. S. Agar, M. Gruca and R. Shine. 1977. Methaemoglobin and its reduction in nucleated erythrocytes from reptiles and birds. Comp, Biochem. Physiol. 57(B):265-267.

Bowden, W. B. 1987. The biogeochemistry of nitrogen. Biogeochem. 4(3):313-348.

Broom, D.M. 1999. The welfare of vertebrate pests in relation to their management. In: Advances in Vertebrate Pest Management, ed. P.D. Cowan and C.J. Feare, 309-329.

Bruning-Fann, C.S. and J.B. Kaneene. 1993. The effects of nitrate, nitrite, and N-nitroso compounds on animal health. Vet. Human Toxicol. 35(3):237-53.

Carballo, M., M. J. Munoz, M. Cuellar and J. V. Tarazona. 1995. Effects of waterborne copper, cyanide, ammonia, and nitrite on stress parameters and changes in susceptibility to saprolegniosis in rainbow trout (*Oncorhynchus mykiss*). App. Env. Microbiol. 61(6):2108-2112.

Carballo, M. and M. J. Munoz. 1991. Effect of sublethal concentrations of four chemicals on susceptibility of juvenile rainbow trout (*Oncorynchus mykiss*) to saprolegniosis. App. Env. Microbiol. 57(6):1813-1816.

Campbell, T. A., S. J. Lapidge, and D. B. Long. 2006. Using baits to deliver pharmaceuticals to feral swine in southern Texas. Wildlife Society Bulletin 34:1184-1189.

Campbell, T. A., and D. B. Long. 2007. Species-specific visitation and removal of baits for delivery of pharmaceuticals to feral swine. Journal of Wildlife Diseases 43:485-491.

Campbell, T. A., and D. B. Long. 2009. Feral swine damage and damage management in forested ecosystems. Forest Ecology and Management 257:2319-2326.

Campbell, T. A., D. B. Long, and G. Massei. 2011. Efficacy of the Boar-Operated-System to deliver baits to feral swine. Preventive veterinary medicine 98:243-249.

Campbell, T. A., J. A. Foster, M. J. Bodenchuk, J. D. Eisemann, L. Staples, and S. J. Lapidge. 2013. Effectiveness and target-specificity of a novel design of food dispenser to deliver a toxin to feral swine in the United States. International Journal of Pest Management 59:197-204.

Chen, J.C. and S.F. Chen. 1992. Effects of nitrite on growth and molting of Penaeus monodon juveniles. Comp. Biochem. Physiol. Vol. 101C(3): 453-458.

Chen, W., H. Liu, Q. Zhang and S. Dai. 2011. Effects of nitrite and toxic *Microcystis aeruginosa* PCC7806 on the growth of freshwater rotifer *Brachionus calyciflorus*. Bull. Environ. Contam. Toxicol. 86:263–267.

Chun-Lap Lo, S. and N.S. Agar. 1986. NADH-methemoglobin reductase activity in the erythrocytes of newborn and adult mammals. Experientia 42: 1264-1265.

Cole, J. R., C. M. Litton, M. J. Koontz, and R. K. Loh. 2012. Vegetation recovery 16 years after feral pig removal from a wet Hawaiian forest. Biotropica 44:463-471.

Cowled, B. D., P. Elsworth, and S. J. Lapidge. 2008. Additional toxins for feral pig (Sus scrofa) control: identifying and testing Achilles' heels. Wildlife Research 35:651-662.

Dave G. and E. Nilsson. 2005. Increased reproductive toxicity of landfill leachate after degradation was caused by nitrite. Aquat. Toxicol. 73: 11–30.

Dickson, J. G., J. J. Mayer, and J. D. Dickson. 2001. Wild hogs. Pages 191-208 *in* J. G. Dickson, editor. Wildlife of southern forests: habitat and management. Hancock House Publishers, Blaine, WA, USA

Eason, C. T., K. A. Fagerstone, J. D. Eisemann, S. Humphrys, J. R. O'Hare and S. Lapidge. 2010. A review of existing and potential New World and Australasian vertebrate pesticides with a rationale for linking use patterns to registration requirements. International Journal of Pest Management. Vol. 56, No. 2, April-June 2010, 109-125.

Eddy, F.B. and E.M. Williams. 1987. Nitrite and freshwater fish. Chem. and Ecol. 3:1-38.

Epifanio, C.E. and Srna, R.F., 1975. Toxicity of ammonia, nitrite ion, nitrate ion, and orthophosphate to Mercenaria mercenaria and Crassostrea virginica. Mar. Biol., 33: 241-246.

Foster J. A. 2011. Effects of sodium nitrite on feral swine and non-targets. Performance report for Texas Parks and Wildlife Department as required by Federal Aid in Wildlife Restoration Act. Federal Aid Grant No. W-132-R-9. 11 p.

Foster J. A. 2017. Secondary effects of sodium nitrite on Turkey Vultures. Personal communication, Texas Parks and Wildlife Department, on-going study.

Griffis-Kyle K.L. 2005. Ontogenetic delays in effects of nitrite exposure on tiger salamanders (*Ambystoma tigrinum tigrinum*) and wood frogs (*Rana sylvatica*). 24:1523–1527.

Griffis-Kyle, K.L. 2007. Sublethal effects of nitrite on eastern tiger salamander (*Ambystoma tigrinum tigrinum*) and wood frog (*Rana sylvatica*) embryos and larvae: implications for field populations. Aquat. Ecol. 41:119–127.

HAID (Hawaii Animal Industry Division), Animal Disease Control Branch. 2014. Pseudorabies. Retrieved on January 14, 2014 from http://hdoa.hawaii.gov/ai/ldc/pseudorabies/.

Hamilton, J.L. and R.H. Lowe. 1981. Organic matter and N effects on soil nitrite accumulation and resultant nitrite toxicity to tobacco transplants. Agron. J. 73: 787-790.

Hilmy, A.M., N.A. El-Domiaty and K. Wershana. 1987. Acute and chronic toxicity of nitrite to *Clarias lazera*. Comp. Biochem. Physiol. 86(2):241-253.

Hone, J., R. Kleba. 1984. The Toxicity and Acceptability of Warfarin and 1080 Poison to Penned Feral Pigs. Aust. Wildl. Res., 11: 103-111.

Hoque, M.M., H.A. Ajwa and R. Smith. 2007. Nitrite and ammonium toxicity on lettuce grown under hydroponics. Comm. Soil Sci. Plant Anal. 39(1-2): 207-216.

Huey, D.W. and T.L. Beitinger. 1980a. Toxicity of Nitrite to Larvae of the Salamander *Ambystoma texanum*. Bull. Environ. Contam. Toxicol. 25:909-912.

Huey, D.W. and T.L. Beitinger. 1980b. Hematological Responses of Larval *Rana catesbiana* to Sublethal Nitrite Exposures. Bull. Environ. Contam. Toxicol. 25:74-577.

Institute of Medical and Veterinary Science. 2010. Assessing the humaneness and efficacy of a new feral pig bait in domestic pigs. Pages 11pp *in*, Report for the Australian Government Department of the Environment, Water, Heritage and the Arts. Canberra, Australia.

Ionescu, D., M. Mircea and E. Bursuc. 1990. Researches regarding the toxicity of nitrates and nitrates to honeybees. *In*: Proceedings of the fourth international symposium on harmonization of methods for testing the toxicity of pesticides to bees. Pp. 136-140.

Ito, T., K. Mezawa, T. Okazaki and R. Shukuya. 1984. NADH and NADPH- dependent reduction of methemoglobin in the nucleated erythrocytes from hen and bullfrog. Comp. Biochem. Physiol. 78B(3):683-686.

Ivan, J. S., and E. S. Newkirk. 2015. Cpw Photo Warehouse: a custom database to facilitate archiving, identifying, summarizing and managing photo data collected from camera traps. Methods in Ecology and Evolution In press.

Jensen, F.B. 2003. Nitrite disrupts multiple physiological functions in aquatic animals. Comparative Biochemistry and Physiology Part A 135: 9–24.

Jensen, F.B. 2007. Nitric oxide formation from nitrite in zebrafish. The Journal of Experimental Biology 210:3387-3394.

Kaller, M. D., J. D. Hudson III, E. C. Achberger, and W. E. Kelso. 2007. Feral hog research in western Louisiana, expanding populations and unforeseen consequences. Human-Wildlife Conflicts 1:168-177.

Kelso, B.H.L., D.M. Glass and R.V. Smith. 1999. Toxicity of nitrite to freshwater invertebrates. *In*: Managing risk of nitrates. Pub. No. 237 Ch. 12. Pp. 175-188.

Knapp, J., N.L. MacDonald, K.N. Walker, S.A. Morrison, A recipe for successful pig control: lessons from the third largest island pig eradication. Proceedings from: 2010 International Wild Pig Conference, Science and Management, Pensacola, Florida, USA.

Kroupova, H., J. Machova and Z. Svodova. 2005. Nitrite influence on fish: a review. Vet. Med. 50(11): 461-471.

Lapidge, S. J. and C.T. Eason. 2010. Pharmacokinetics and methaemoglobin reductase activity as determinants of species susceptibility and nontarget risks from sodium nitrite manufactured feral pig baits. Report for the Australian Government, Department of the Environment, Water, Heritage and the Arts.

Lapidge, S., J. Wishart, L. Staples, K. Fagerstone, T. Campbell, and J. Eisemann. 2012. Development of a feral swine toxic bait (Hog-Gone®) and bait hopper (Hog-Hopper™) in Australia and the USA. WIldlife Damage Management, Internet Center for Publications.

Leonard, J. 2016. An acute contact toxicity study to determine the effects of Sodium Nitrite on the honey bee (*Apis mellifera*). Final Report. SynTech Research Laboratory Services, LLC. 17745 S. Metcalf Ave., Stilwell, KS 66085, USA.

Ley, D. H. 1986. Nitrite poisoning in herring gulls (*Larus argenta tus*) and ring-billed gulls (*Larus dela warensis*). J. Wild. Dis. 22(3):381-384.

Lin, Y.C. and J.C Chen. 2003. Acute toxicity of nitrite on *Litopenaeus vannamei*(Boone) juveniles at different salinity levels. Aquaculture 224:193–201.

Long, D. B., T. A. Campbell, and G. Massei. 2010. Evaluation of feral swine-specific feeder systems. Rangelands 32:8-13.

Lowe, S., M. Browne, and S. Boudjelas. 2000. 100 of the world's worst invasive alien species : A selection from the global invasive species database. Invasive Species Specialist Group, Auckland, New Zealand.

Massei, G., J. Coats, R. Quy, K. Storer and D.P. Cowan. 2010. The Boar-Operated-System: a novel method to deliver baits to wild pigs. J. Wild. Mgt. 74(2):333-336.

Mayer, J. J., and I. L. Brisbin, Jr. 1991. Wild pigs in the United States: Their history, comparative morphology, and current status. The University of Georgia Press, Athens, GA. 313 pp.

Mayer, J. J. 2009. Overview of wild pig damage. Pages 221-246 *in* J. J. Mayer and I. L. Brisbin, Jr. eds. Biology, damage control techniques and management. SRNL-RP-2009-00869. Savannah River National Laboratory. Aiken, SC.

Mayer, J., and I. L. Brisbin, editors. 2009. Wild pigs: biology, damage, control techniques and management. Savannah River National Laboratory, Aiken, South Carolina, USA.

Mayer, J. J. 2014. Estimation of the number of wild pigs in the United States. SRNL-STI-2014-00292, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken South Carolina. 8 pp.

Marco, A. and A.R. Blaustein. 1999. The effects of nitrite on behavior and metamorphosis in Cascades frogs (*Rana cascadae*). Env. Toxicol. Chem. 18(5): 946–949.

Marco, A., C. Quilchano and A.R. Blaustein. 1999. Sensitivity to nitrate and nitrite in pond-breeding amphibians from the Pacific Northwest, USA. Env. Toxicol. Chem. 18(12):2836-2839.

Margiocco, C., A. Arillo, P. Mensi and G. Schenone. 1983. Nitrite bioaccumulation in *Salmo gairdneri* Rich, and hematological consequences. Aq. Toxicol. 3:261-270.

Meng, X.J., D.S. Lindsay, and N. Sriranganathan. 2009. Wild boars as sources for infectious diseases in livestock and humans. Philosophical Transactions of the Royal Society B: Biological Sciences 364:2697-2707.

Miller, R. S., and S. J. Sweeney. 2013. *Mycobacterium bovis* (bovine tuberculosis) in North American wildlife: current status and opportunities for mitigation of risks of further infection in wildlife populations. Journal of Epidemiology and Infection. 141(7):1357-70.

Newkirk, E. S. 2014. CPW Photo Database. Colorado Parks and Wildlife, Fort Collins, CO, USA.

OECD. 2005. Sodium Nitrite (CAS No. 7632-00-0). UNEP Publications. Available at: http://www.inchem.org/documents/sids/sids/7632000.pdf.

O'Reilly, C. and E. Colleran. 2005. Toxicity of nitrite toward mesophilic and thermophilic sulphate-reducing, methanogenic and syntrophic populations in anaerobic sludge. J. Ind. Microbiol. Biotechnol. 32: 46–52.

Pepin, K. M., A. J. Davis, J. Beasley, R. Boughton, T. Campbell, S. M. Cooper, W. Gaston, S. Hartley, J. C. Kilgo, S.,M. Wisely, C. Wyckoff, and K. C. VerCauteren. 2016. Contact heterogeneities in feral swine: implications for disease management and future research. Ecosphere 7(3):e01230. 10.1002/ecs2.1230

Phipps, R.H. and I.S. Cornforth. 1970. Factors affecting the toxicity of nitrite nitrogen to tomatoes. Plant and Soil. 33:457-466.

Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2000. Environmental and economic costs of nonindigenous species in the United States. BioScience 50:53-65.

Pimentel, D. 2007. Environmental and Economic Costs of Vertebrate Species Invasions into the United States. Managing vertebrate invasive species: proceedings of an international symposium. USDA/APHIS Wildlife Services, National Wildlife Research Center, Fort Collins, Colorado, USA.

Richardson, C.D., P.S. Gipson, D.P. Jones, and J.C. Luchsinger. 1995. Extirpation of a recently established feral pig population in Kansas. Proceedings of the Eastern Wildlife Damage Management Conference 7:100-103.

Richardson, C.D. 2010. Aerial hunting feral hogs in non-traditional areas. Proceedings from: 2010 International Wild Pig Conference, Science and Management, Pensacola, Florida, USA.

Roberts, B.L. and H.W. Dorough. 1984. Relative toxicities of chemicals to the earthworm *Eisenia foetida.* Env.Toxicol. Chem. 3: 67-78.

Ruiz-Fons, F., J. Segales, and C. Gortazar. 2008. A review of viral diseases of the European wild boar: Effects of population dynamics and reservoir role. Veterinary Journal 176:158-169.

Russo, R. C., R.V. Thurston and K. Emerson. 1981. Acute toxicity of nitrite to rainbow trout (Salrno gaidneri): effects of pH, nitrite species, and anion species. Can. J. Fish. Aquat. Sci. 38:387-393.

Russo, R. C. 2006. Nitrite toxicity to fishes. Pp. 73-89. *In:* Fish Physiology, Toxicology, and Water Quality Proceedings of the Ninth International Symposium, Capri, Italy, April 24-28, 2006. EPA/600/R-07/010.

Sarikaya, R. and S. Cakir. 2005. Genotoxicity testing of four food preservatives and their combinations in the *Drosophila* wing spot test. Env. Toxicol. Pharmacol. 20:424–430.

Schmidt, R. 1989. Wildlife management and animal welfare. Trans. N. America Wildl. 54:468-475.

SCWDS (Southeastern Cooperative Wildlife Disease Study). 1982. Feral/wild swine populations 1982. SCWDS, Athens Georgia. Map. 1 pp.

Seward, N. W., K. C. VerCauteren, G. W. Witmer, and R. M. Engeman. 2004. Feral swine impacts on agriculture and the environment. Sheep & Goat Research Journal 19:34-40.

Shapiro, L., C. Eason., C. Bunt., S. Hix., P. Aylett., D. MacMorran. 2016. Encapsulated sodium nitrite as a new toxicant for possum control in New Zealand. New Zealand Journal of Ecology, 40(3): 381-385. DOI: 10.20417/nzjecol.40.36.

Shapiro, L., P. Aylett, D. Arthur, C. Eason. 2017. Primary poisoning risk for encapsulated sodium nitrite, a new tool for pest control. New Zealand Journal of Zoology, DOI: 10.1080/03014223.2016.1264979.

Shinn, C., A. Marco and L. Serrano. 2008. Inter- and intra-specific variation on sensitivity of larval amphibians to nitrite. Chemosphere 71:507–514.

Snow, N. P., J. M. Halseth, M. J. Lavelle, T. E. Hanson, C. R. Blass, J. A. Foster, S. T. Humphrys, L. D. Staples, D. G. Hewitt, and K. C. VerCauteren. 2016. Bait preference of free-ranging feral swine for delivery of a novel toxicant. PloS one 11:e0146712.

Snow, N. P., M. A. Jarzyna, K. C. VerCauteren. 2017. Interpreting and predicting the spread of invasive wild pigs. J. of Applied Ecology. Doi: 10.1111/1365-2664.

Snow, N. P., J. A. Foster, J. C. Kinsey, S. T. Humphrys, L. D. Staples, D. G. Hewitt, K. C. Vercauteren. 2017a. Development of Toxic Bait to Control Invasive Wild Pigs and Reduce Damage. In Press.

Snow, N. P., J. A. Foster, E. H. Van Natta, K. E. Horak, S. T. Humphrys, L. D. Staples, D. G. Hewitt, and K. C. VerCauteren. 2017b. Evaluation of Potential Secondary Poisoning Risks from Sodium Nitrite Toxic Bait for Invasive Wild Pigs. In Press.

Snow, N. P., M. J. Lavelle J. M. Halseth, M., C. R. Blass, J. A. Foster, S. T. and K. C. VerCauteren. 2017c. Strength testing of raccoons and invasive wild pigs for a species-specific bait station. Wildl. Soc. Bull.. doi:10.1002/WS-NWRCb.756.

Soniat, M. 2012. Avian Single-Dose Oral Toxicity Test with Sodium Nitrite in Red-winged Blackbirds *(Agelaius phoeniceus).* Unpublished Report HG 2011/005, Genesis Laboratories, Inc., Wellington, CO, 73p.

Soucek, D.J. and A. Dickinson. 2012. Acute toxicity of nitrate and nitrite to sensitive freshwater insects, mollusks, and a crustacean. Arch. Environ. Contam. Toxicol. 62:233–242.

Sparklin, B. D., M. S. Mitchell, L. B. Hanson, D. Jolley, and S. S. Ditchkoff. 2009. Territoriality of feral pigs in a highly persecuted population on Fort Benning, Georgia. The Journal of Wildlife Management 73:497-502.

Smith, G.R., D.A. Vaala, D.A., H.A. Dingfelder and K.G. Temple. 2004. Effects of nitrite on bullfrog (*Rana catesbeiana*) tadpoles from central Ohio, USA. Bull. Environ. Contam. Toxicol. 72:1012–1016.

Smith, G.R. 2007. Lack of effect of nitrate, nitrite, and phosphate on wood frog *(Rana sylvatica)* tadpoles. Appl. Herp. 4: 287-291.

Stafford, J. 2011a. Northern Bobwhite (*Colinus virginianus*) Acute Oral Toxicity (LD50) Test with Sodium Nitrite. Unpublished Report No. 998.4100, Smithers Vicient, Snow Camp, NC, 81p.

Stafford, J. 2011b. Mallard (*Anas platyhynchos*) Dietary Toxicity Test (LC50) with Sodium Nitrite. Unpublished Report No. 13998.4103, Smithers Vicient, Snow Camp, NC, 78p.

Stafford, J. 2011c. Mallard (*Anas platyhynchos*) Dietary Toxicity Test (LC50) with Sodium Nitrite. Unpublished Report No. 13998.4102, Smithers Vicient, Snow Camp, NC, 81p.

Strnad, Z. and M. Persin. 1983. Experimental poisoning of pheasant chicks with nitrates and nitrites in drinking water. Vet. Med. 28(9):541-547.

Sweeney, J. R., J. M. Sweeney, and S. W. Sweeney. 2003. Feral hog. *Sus scrofa*. Pages 1164-1176 *in* G. A. Feldhamer, B. C. Thompson, andJ. A. Chapman, editors. Wild mammals of North America: biology, management, and conservation. Johns Hopkins University Press, Baltimore, Maryland, USA.

Tari, I. and J. Csiszar. 2003. Effects of NO2 or NO3 supply on polyamine accumulation and ethylene production of wheat roots at acidic and neutral pH: implications for root growth. Plant Growth Regulation 40:121–128.

Tolson, K. M., and J. M. LaCour. 2013. The reproductive potential of feral hogs in Louisiana and their impact on forestry and agronomic activities. Pages 47-56 *In* T.F. Shupe and M.S. Brown, eds. Proceedings of the Louisiana Natural Resources Symposium. Louisiana State University AgriCenter. Baton Rouge, LA.

USDA (United States Department of Agriculture). 2014. Environmental Assessment: Mammal Damage Management in Alabama. USDA/APHIS Wildlife Services. Auburn, Alabama

USDA (United States Department of Agriculture). 2014b. Environmental Assessment: Feral Swine Damage Management by the Texas Wildlife Services Program. UDSA/APHIS Wildlife Services, San Antonio, Texas.

USDA (United States Department of Agriculture) 2015. Final Environmental Impact Statement: Feral Swine Damage Management: A National Approach. United States Department of Agriculture, Animal Plant Health Inspection Service, Wildlife Services, Washington, D.C., USA.

USDA (United States Department of Agriculture) 2017. Study Protocol: Field Evaluation of Hoggone® Sodium Nitrite Bait for Feral Swine, National Wildlife Research Center, Ft. Collins, CO.

USEPA. 1989. Risk assessment guidance for Superfund volume I, human health evaluation manual (Part A). interim final. Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-89/002 December 1989.

USEPA. 2006. Nitrates and Nitrites, Toxicity and Exposure Assessment for Children's Health (TEACH) Chemical Summary. Available at: http://www.epa.gov/teach/chem_summ/Nitrates_summary.pdf.

Wade, D. and J. Browns. 1982. Proceedures for evaluating predation on livestock and wildlife. Texas Agricultural Extension Service, Texas A&M University, San Angelo; Bulletin No. B-1429:42 pp.

Waithman, J. D., R. A. Sweitzer, D. V. Vuren, J. D. Drew, A. J. Brinkhaus, I. A. Gardner, and W. M. Boyce. 1999. Range expansion, population sizes, and management of wild pigs in California. The Journal of Wildlife Management 63:298-308.

Wedemeyer, G.A. and W. T. Yasutake. 1978. Prevention and treatment of nitrite toxicity in juvenile steelhead trout (Salmo gairdneri). J. Fish. Res. Board Can. 35:822-827.

West, B. C., A. L. Cooper, and J. B. Armstrong. 2009. Managing wild pigs: A technical guide. Human-Wildlife Interactions Monograph 1:1-55.

Widman, J.C., S.L. Meseck, G. Sennfelder, D.J. Veilleux. 2008. Toxicity of Un-ionized Ammonia, Nitrite, and Nitrate to Juvenile Bay Scallops, *Argopecten irradians irradians.* Arch Environ Contam Toxical 54: 460-465.

Wodzinski, R.S., D.P Labeda and M. Alexander. 1978. Effects of low concentrations of bisulfite-sulfite and nitrite on microorganisms. Appl. Envir. Micro. 35(4):718-723.

APPENDIX B. Bait Station Specifications

Specifications of a feeding device for safe and efficient delivery of sodium nitrite exclusively to Feral Swine

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Description:

The feeding device is constructed from marine-grade High Density Polyethylene (HDPE) components cut from ¼", ½", ¾", and 1"-thick sheets. HDPE is an extremely strong, non-porous material approved by the Food and Drug Administration (FDA) for food storage and packaging as well as many industrial uses. Marine-grade HDPE has a UV inhibitor to insure long-life despite harsh environmental conditions. The device is assembled using 2 and 3 inch coated decking screws (Deck Mate, Phillips Screw Company, Holyoke, MA, USA) in pre-drilled pilot holes. The lids are mounted with standard 3 ½ inch door hinges (Everbuilt, Home Depot, Atlanta, GA, USA). Lid resistance (30 lbs.) to exclude non-target species is achieved using internally mounted magnets (Master Magnets, Inc., Castle Rock, CO, USA) and magnetic plates (i.e., hot rolled mild steel; 2.54 × 0.32 cm). The feeding device is comprised of two modular halves that can be used separately or quickly secured together as one cohesive unit. The device is weather resistant to precipitation events.

Specifications:

Whole unit- 36"x 54"x 6.5"/116 lbs. --Half unit-18"x 54"x 6.5"/58 lbs.

(upper left)-Complete feeding device. Note the handles also serve as 'stoppers' to prevent the lids from remaining open once feeding ceases. **(upper right)**- Frontal view of the device with the lid propped open. **(lower left)**- Two halves of the feeding device. **(lower right)**- Example of the magnetic locking mechanism.

APPENDIX C: Responses to public Comments

There were a total of 88 comment letters submitted during the public comment period. These comments have been summarized into 18 topics and are addressed below. The number of comments received are in parenthesis for each topic. Some commenters expressed more than one topic in their comment and hence the numbers add up to more than 88 comments.

1. Numerous commenters recognized the damages that feral swine cause and described a variety of ways they are harmful to the environment and expressed their support for the Proposed Action to continue the field evaluation of Hoggone®.

Response: Wildlife Services (WS) agrees that feral swine are detrimental to many resources. These comments are consistent with peer reviewed research referenced in the EA and relate to the purpose and need of the EA. The Need for Action is addressed in 1.2 of the EA and 2.2 of the EA describe that it is the mission of WS and its research arm, NWRC, to evaluate damage situations and develop methods and tools to reduce or eliminate damage and resolve land use conflicts. WS' thanks the commenters for the letters of support for the field evaluation of Hoggone®.

2. Several commenters expressed their support for the development and potential future registration and use of the product.

Response: WS appreciates those comments in support of this important research.

3. Several commenters expressed concern for the effects of sodium nitrite on threatened and endangered species, non-target wildlife and scavengers.

Response: WS believes this concern is adequately addressed in section 3.2.3 of the EA. This section describes the effects determinations that were made for each threatened and endangered species at each study site and where applicable, in compliance with section 7 of the Endangered Species Act, a concurrence letter was requested and received from the USFWS. This section also addressed the possible direct, indirect and cumulative effects on non-target wildlife and scavengers in detail. In Summary, there would be either no effect on T&E species, or the proposed study would not be likely to adversely affect T&E species.

4. Commenters expressed concern over whether or not baits could be delivered to feral swine in a species specific way without exposing the bait to non-target wildlife, domestic animals and livestock.

Response: The specifics to the bait station are shown in Appendix B of the EA. This issue is also discussed in Section 2.2.2. Previous research has shown the bait stations to be very effective at excluding non-target animals. One of the main objectives of the study is to continue evaluating the efficiency of the bait stations. Bait stations will be monitored with remote cameras at all times to evaluate this issue.

5. Commenters stated they are concerned pigs that have consumed a lethal dose of sodium nitrite may travel onto adjacent properties and die before succumbing to the toxicant, also suggesting that landowners could sue the adjacent landowner for damages associated with pig carcasses.

Response: As discussed in 2.2.1, the ingestion of a lethal dose of HOGGONE® quickly leads to shortness of breath, loss of consciousness and then death from the rapid depletion of oxygen to the brain and vital organs. This has been shown to occur in 2-4 hours (Snow 2017a). Also discussed in section 3.2.1. of the EA, data from Australia on free-ranging feral swine show that swine traveled a maximum of 230 meters from the nearest bait station after consuming a lethal dose of HOGGONE®. For the purpose of this study, WS would conduct the study on large private properties and will not place bait stations any closer than 300 meters from any adjoining property line unless WS also has an agreement with the adjoining property owner. This will ensure that no feral swine are likely to leave the study area before succumbing to the lethal effects of sodium nitrite.

6. Commenters stated that they were concerned about risks associated with sodium nitrite to human health.

Response: The EA analyzes the impacts and risks to human safety in detail in section 3.2.1. Any potential human exposure route is identified and is determined to be highly unlikely. WS recognizes that some people may disagree with our predicted level of human risk associated with this Proposed Action, however, WS believes the risks to be acceptable and reasonable to the majority of the public.

7. Commenters are concerned that WS does not use humane methods.

Response: Section 3.2.4 of the EA discusses the humaneness and ethics of conducting the study. The Institute of Medical and Veterinary Science in 2010 reported on the efficacy and humaneness of sodium nitrite as a potential toxicant for feral swine. Current research suggests that death from sodium nitrite intoxication is an acceptable humane method for damage management of feral swine. Humaneness was a factor in the early development of the product.

8. Commenters recommended the creation of a bounty system instead of applying a toxicant.

Response: Creating a bounty system is outside of WS legal authority and the scope of this EA. However, bounty systems were considered in USDA's 2015 Final Environmental Impact Statement, Feral Swine Damage Management: A National Approach and was dismissed because of several inherent drawbacks and inadequacies that have been proven over the years with bounty systems.

9. Commenters stated that a toxicant for feral swine must be cost effective.

Response: Cost effectiveness is addressed briefly in the EA in section 2.1.2. Due to the small scale of the study, cost effectiveness is not considered in detail.

10. Commenters suggested developing a bait that would sterilize pigs as opposed to a toxic bait.

Response: Sterilization is not within the scope of this EA. However research is currently being conducted for an effective oral or single injection contraceptive for use on feral swine, which may be useful for very specific situations. Current studies show promise; however, there is no registered contraceptive for use in controlling feral swine populations at this time.

11. Commenter requested that WS not conduct any lethal control of wildlife.

Response: WS acknowledges that some people will be opposed to lethal control; however, feral swine are a nonnative introduced species that can cause significant harm to various resources, as outlined in section 1.2, Need for Action. Section 1.7 in the EA also outlines the roles and authorities of WS to protect agriculture and other resources from damage caused by wildlife. In addition, section 1.12 describes Executive Order 13112 which establishes guidance to federal agencies to prevent, provide control of, and minimize economic, ecological and human health impacts of invasive species such as feral swine.

12. Commenter has suggested creating a group of hunters and trappers that requires a small membership fee that would provide access to private lands to assist landowners when damage is occurring instead of applying a toxicant.

Response: Creating a private hunting and trapping group is outside of the scope of this EA. Furthermore, current research indicates that this type of approach has failed to produce viable results in most situations.

13. Commenter expressed concern about the fate of swine carcasses, both the smell of dead carcasses and effects of many carcasses dying in one area.

Response: This issue is addressed in the EA in section 2.1.2. Odor from feral swine carcasses is not considered a health risk. Section 3.2.2 further explains the environmental effects of sodium nitrite in terrestrial and aquatic environments.

14. Commenter remarked that because it takes 2-4 hours for a pig to die from consuming the toxicant, a hunter or other predator could take or kill that animal and then unknowingly consume a lethal dose of the toxicant.

Response: This scenario is addressed in detail in section 3.2.1 under the Effects of Human Health and Pet Safety where it specifically outlines any potential risks to hunters. In addition, section 3.2.3 thoroughly discusses the effects on non-target and scavenging species. In summary, there are some minimal risks to hunters and scavenging species but WS believes that due to the biological properties of sodium nitrite and the most currently available data, these risks are minor and short term.

15. Commenter states that WS is not transparent and does not allow the public to know what activities are conducted and does not allow public comment.

Response: WS has prepared this EA to inform the public of the agency's proposed actions, provide analysis on the potential effects on the human environment, and allow for public comment on the alternatives and issues. Additionally, the proposed study would only occur after agreements with land owners/managers were developed between the parties.

16. Commenter suggested that if the product was registered and made available for public use that it "may not be controlled in the proper way".

Response: Under the proposed action, the product Hoggone® has been authorized by EPA under an Experimental Use Permit (EUP; Experimental Use Permit No. 56228-EUP-42; EPA Decision No.: 519205). Depending on the outcome of this EA and field trial, if selected and implemented, data from these trials may be provided to EPA for further evaluation and potential registration of the product. However, addressing a comment about the misuse of a potentially registered product is beyond the scope of this EA. Nonetheless, the commenter should understand that EPA has a rigorous evaluation process for approving all registered pesticides and puts in place very specific use requirements and restrictions. Any deviation or misuse of those use requirements is a violation of federal law and subject to strict penalties.

17. Commenter has suggested that the abundance of feral swine in Texas has created a market that benefits all citizens in the state.

Response: The commenter is referring to the hunting and the wild boar meat market in Texas. This issue is addressed in Section 2.1.2 and 3.2.1 and is not anticipated to have any impact on either resource.

18. Commenter suggested that feral swine will develop a resistance to sodium nitrite over time rendering it ineffective.

Response: Although it is true that vertebrate, invertebrate and plants have developed resistance to various pesticides and herbicides over time, this comment is beyond the scope of the EA because the proposed study is short term and does not address feral swine resistance to sodium nitrite. However, due to the biological properties of sodium nitrite, WS believes it has the potential for long term effectiveness.