ENRI-005
February 2018

Wild pigs negatively impact water quality: Implications for land and watershed management

Introduction

Growing populations of wild pigs (*Sus scrofa*) pose a challenge to both landowners and wildlife managers by threatening crop and livestock production, as well as native wildlife and their habitat. While these concerns are commonly known, the impacts of wild pigs on water quality are less apparent.

Introduced to North America in the 1500s as a reliable food source by early European settlers, free-ranging domestic pigs established initial feral populations. Later, the Eurasian wild boar was released primarily onto hunting preserves in the early 1900s, but they escaped to hybridize with free-ranging pig populations. Intentional (illegal) and accidental releases since have further contributed to wide-ranging and growing wild pig populations. In Texas, these animals are classified as free-ranging exotic livestock and regulatory authority falls primarily under the jurisdiction of the Texas Animal Health Commission, who established rules regarding their transportation and release.

Today, wild pigs occur in 3 varieties: feral hogs (those originating of domestic stock), Eurasian boar, and domestic-Eurasian hybrids. As of 2016, the National Feral Swine Mapping System (NFSMS) in collaboration with state natural resource agencies and the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS) reported that wild pigs occurred in at least 36 of 50 states including Hawaii[5] (Figure 1). In 2007, the estimated economic toll of these animals in the U.S. exceeded $1.5 billion[30]; an economic impact likely to be much larger today. Factors including the adaptability, intelligence, high fecundity and popularity of wild pigs as an exotic game species have complicated control efforts[25] with rapid population growth and range expansion. While wild pigs negatively impact land quality in numerous ways, the behavior, biology and preferred habitat of these animals also contribute to the degradation of water quality in riparian systems.

Population modeling indicated that as many as 3-5 million wild pigs are scattered across nearly all counties in Texas[37]. With so many on the landscape, wild pigs are causing noticeable and not-so-obvious problems. Wild pigs impact water quality directly through bacterial impairment and indirectly through the degradation

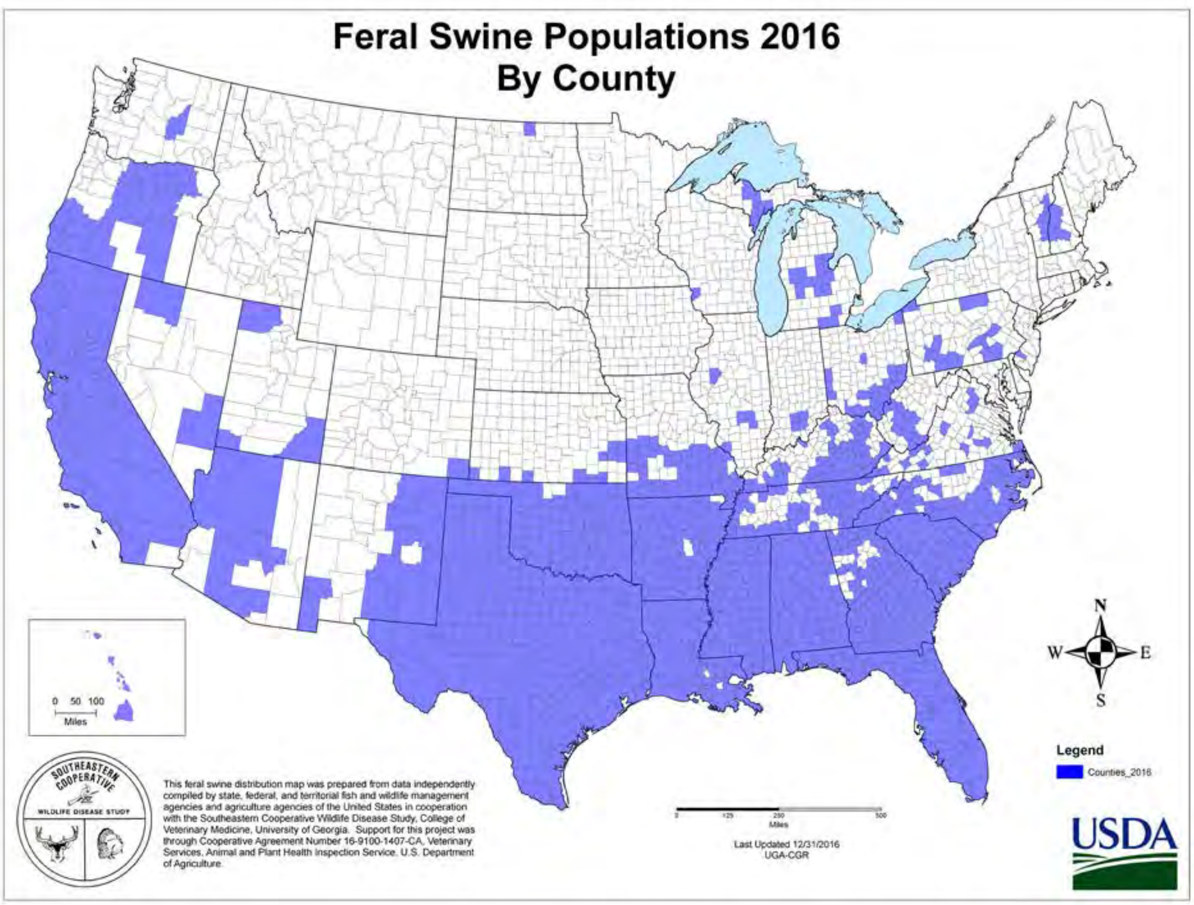


Figure 1. NFSMS data showing 2016 feral swine populations by county. (Image Credit – USDA-APHIS in Corn and Jordan 2017)

of riparian habitat. This can contaminate water used for agricultural production, recreation, and consumption by humans and wildlife as well as reduce recreational opportunities. While other sources of bacterial impairment include humans, livestock and native wildlife, wild pigs have been shown to increase *E. coli* bacteria levels in creeks, streams, rivers, and other surface water bodies[16].

Bacterial source tracking (BST) and other water quality monitoring data implicated various wildlife species, as contributors of *E. coli* to water sources depending on species density[18,28]. In this study the authors included wild pigs with native wildlife; however, many natural resource professionals are quick to point out that wild pigs (exotic livestock) should have been evaluated separately from native wildlife. No matter how they are categorized, wild pigs have especially high average defecation rates (1,121 grams per day), one of the highest among both livestock and wildlife species[22,27].

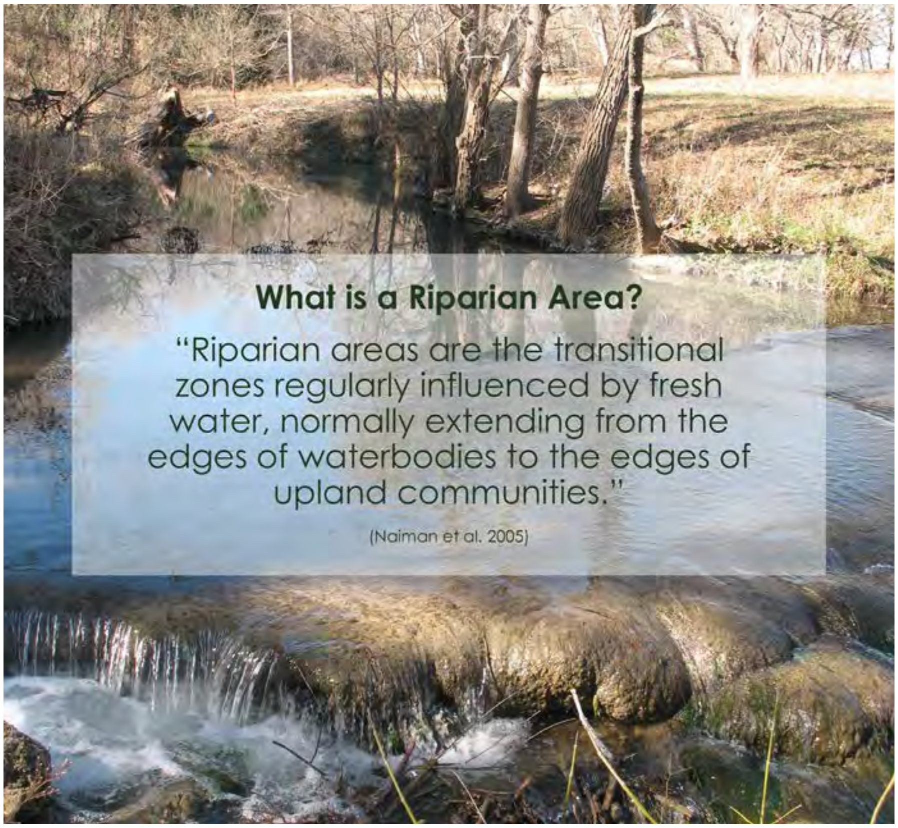
In addition to direct *E. coli* deposition in stream systems, wallowing and rooting behavior damages ecological communities surrounding water bodies by destroying key vegetation and causing soil disturbance. This leads to increased sedimentation, turbidity, pH imbalances, high bacteria levels, and other water quality impairments[8]. Given the prevalence and wide distribution of wild pigs in Texas, bacterial loading and other water quality impacts associated with this species are a growing concern to land managers and regulatory authorities statewide.

Reproduction, ecology and habitat requirements of wild pigs

Interbreeding among feral domestic pigs and Eurasian wild boar resulted in the wild pigs now found in many states. With an average lifespan of 4-5 years, adult sows (females) are capable of producing 1-3 litters per year. Females are typically sexually mature at 1 year, but pregnancy has been documented as early as 6 months. As sows mature they can produce larger litters[33], but those of 4-6 offspring are most common (Figure 2).

Even when wild pigs represent a relatively high percentage of available prey, few predators risk their own well-being by attempting to take on formidable adult wild pigs. While coyotes (*Canis latrans*), bobcats (*Lynx rufus*), feral dogs (*Canis lupus familiaris*) and other smaller predators are known to kill and consume juvenile wild pigs, mountain lions (*Puma concolor*) and humans remain the primary predators of adult wild pigs in North America. The relatively low mountain lion population paired with home ranges that exceed 100 square miles or more[21] prevent them from significantly

Figure 2. Mature sows are capable of having large litters, but most often they have 4-6 piglets per litter.



impacting wild pig populations. Even where wild pigs may be the most abundant prey available, deer (*Odocoileus sp.*) are found more frequently in the diets of mountain lions in Texas[7,15,24]. The annual harvest rate of wild pigs by humans is estimated to be 29%, and population modeling indicated that a 66% removal rate would need to be sustained for 5 years or more in order to stabilize population growth[37]. Put simply, this model suggests that if 2 out of every 3 wild pigs were removed annually, Texas would maintain the current estimated population of 3-5 million animals. The lack of significant predation, combined with the high reproductive output makes intentional management and sustained abatement programs essential to reducing wild pig populations.

Wild pigs are not always the prey, instead they are opportunistic omnivores known to consume a wide variety of food items in competition with other livestock and native wildlife. While the vast majority (>80%) of their diet consists of vegetation[2], opportunistic predation by wild pigs in wetland and riparian areas is another area of concern. For example, one study found that an estimated 3.16 million reptiles and amphibians were consumed by approximately 3,000 wild pigs in one year[17]. Such impacts on wetland species are not by chance, as wild pigs have distinct biological requirements that cause them to select wetland and riparian habitats.

Wild pigs frequent wetland areas because they do not have sweat glands. To cool themselves, they modify their behavior by occupying shaded places, restricting daytime activity, and wallowing in wet areas. They often use riparian zones and other habitats near water bodies more so than drier upland areas. These zones serve as travel corridors, concentrating wild pigs, which magnifies their pressure on water quality and surrounding habitat. As transitional zones between aquatic systems and upland areas, riparian communities are a vital component of overall water quality[26]. Wild pigs can negatively influence these communities in a variety of ways. For instance, they have been shown to decrease the abundance of native oaks (*Quercus sp.*) and hickories (*Carya sp.*)[3] which stabilize the soil, sequester carbon, and provide a valuable food source to native wildlife. Rooting activity and the removal of native mast (fruits and nuts) can then lead to the proliferation of invasive plant species. Water quality and riparian system degradation associated with wild pigs is often a direct result of their rooting, wallowing, and consumption of native plants and animals. These effects intensify as the wild pig population grows at an elevated pace.

Water quality and riparian ecosystem impacts

Water quality and riparian ecosystems are impacted by wild pigs in numerous ways (Figure 3). Research conducted on the water quality and riparian communities have shown that in areas where wild pigs are present they have:

- contributed fecal coliforms (*E. coli*) directly into water sources[16];
- increased sedimentation and turbidity, altered pH levels, and caused prolonged anoxia (complete oxygen depletion)[8];
- increased bacteria and nutrient loads including nitrogen, which can cause algae growth and reduce dissolved oxygen levels[1];
- caused major changes to plant communities and altered proportions of open water and bare ground[8];
- reduced vegetative ground cover necessary for plant seedling establishment and invertebrate habitat[4];
- reduced large-seeded tree abundance such as oak and hickory species through mast consumption[3];
- disturbed soil and led to an increase in exotic and invasive plant species such as the Chinese tallow tree (*Triadica sebifera*)[19,31];
- reduced the abundance of freshwater mussels and aquatic insects in streams[18]; and
- consumed the eggs of ground nesting birds such as northern bobwhite (*Colinus virginianus*) and wild turkeys (*Meleagris gallopavo*)[14,35].

Figure 3. Wild pig rooting and wallowing behavior can lead to a variety of habitat and water quality issues including increased erosion, water turbidity, and the deposition of fecal coliforms (*E. coli*) directly into surface water systems.

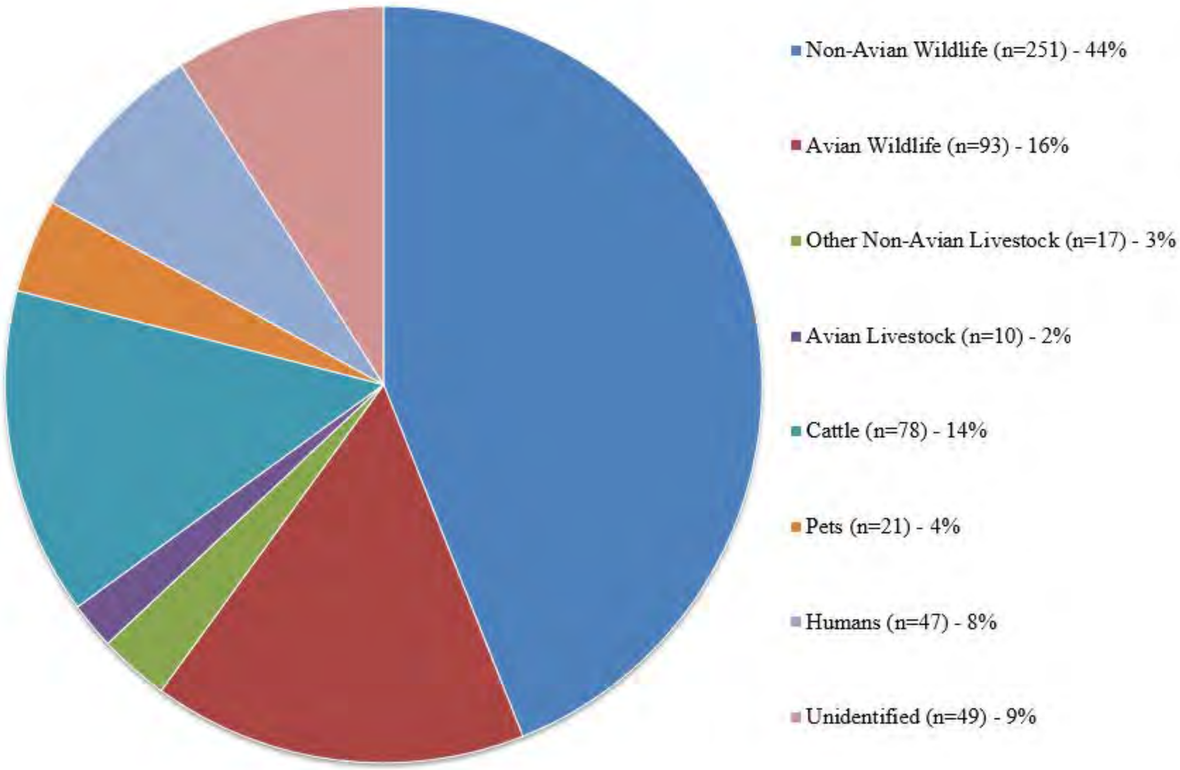


Figure 4. Bacterial source tracking efforts in the Leon River watershed of Texas found non-avian wildlife including wild pigs to be the greatest contributor of fecal pollution[12].

Tracking wild pig water quality impacts

Monitoring protocols including BST can help to identify and distinguish between human, livestock, or wildlife sources of fecal coliforms. This process, also known as fecal typing or Microbial Source Tracking (MST), is a relatively new means of sampling fecal bacteria in order to determine origin. One BST study conducted in the Buck Creek watershed in Texas found that as much as 50% of the *E. coli* bacteria samples it collected were from wildlife sources, which included wild pigs, while only 20% originated from domestic animals or livestock[13]. Another recent BST effort conducted in the Leon River watershed (Figure 4) observed similar results albeit during a drought year[12].

Many BST studies group wild pig bacterial contributions in with total wildlife sources, while others have concentrated on developing a means of isolating swine and other bacterial sources individually by species[18]. While more research is needed in order to reliably isolate the specific *E. coli* contributions of native wildlife species and exotic livestock - wild pigs[28], current methods can help provide valuable insight on the relative degree to which wild pigs bacterially impair surface water systems in areas where they are present.

Implications for impaired aquatic systems

Impaired water bodies and degraded riparian systems threaten agricultural production, livestock productivity, wildlife, and limit human use (Figure 5). Fecal contamination of water bodies can transmit pathogens and in extreme cases, potentially result in livestock, wildlife or even human mortality. One study found that livestock with continuous and adequate access to high quality water produced as much as 20% more animal gain compared to livestock with access to low quality or

Figure 5. Impaired water bodies negatively affect riparian zones, native plants and animals, crop production, livestock productivity, and human recreational uses.

impaired water[38]. Increased *E.coli* levels are commonly used as indicators of unsanitary or bacterially impaired water in restricting human water contact and recreational activities including swimming, wading, fishing, and others. The low dissolved oxygen and/or high nutrient levels associated with impaired water sources can reduce aquatic species abundance and diversity, and are known to lead to algal blooms that reduce available oxygen, resulting in fish kills.

While wild pigs are not the only contributor to watershed impairments, abatement efforts to reduce wild pig populations remain an important practice to safeguard water quality. As of 2012, the majority of waterbodies in Texas were listed as bacterially impaired[34]. Texas has wild pigs in nearly every county and the population is growing. There are many reasons to integrate wild pig removal techniques and stream health should be primary among them with the goal of delisting impaired water systems.

The benefits of wild pig abatement to water quality

Without consistent and widespread abatement efforts, wild pigs will likely increase their numbers; thus compounding their impacts on water quality in the future[28]. Reducing wild pig populations has been shown to improve water quality and riparian system processes, thus benefiting local ecosystems by:

- reducing relative bacterial impairment and thus decreasing the potential for disease transmission to humans and livestock[11];
- reducing the spread of invasive species[6,19];
- increasing plant cover by as much as 80 percent and decreasing bare ground by nearly 90 percent[32];
- increasing forest leaf litter, thereby facilitating nutrient cycling[32];
- decreasing erosion and nutrient loss[32]; and

- decreasing surface water turbidity and sedimentation; leading to an increase in the health and function of watersheds[6].

Wild pig control and management

Legal methods for reducing wild pig populations in Texas currently include trapping, aerial gunning, shooting, snaring and the use of trained dogs. Effective abatement often involves a combined approach[23], and landowners should consider working cooperatively with adjacent landowners to gain increased success and more widespread benefit. This can be accomplished by sharing traps, head gates, snaring sites (i.e., fence crossings), aerial gunning costs, property access for the use of trained dogs and other collaborative efforts.

It is important to understand that not all abatement strategies are independently capable of reducing wild pig populations. While techniques such as corral trapping (remote, suspended and animal-activated) as well as aerial gunning can effectively reduce populations, other techniques such as shooting, snaring, and the use of trained dogs can alter the movements of wild pigs and force them to abandon areas where they are causing damage. For example, one study found that agricultural damage in areas that allowed the shooting of wild pigs was less than half than in areas where this practice did not occur[9]. Studies have also shown that successful abatement efforts often follow a defined sequence, where large-scale population reduction practices are followed up by other techniques such as snaring and shooting, with the use of trained dogs being employed as a final measure to remove wild pigs missed by previous strategies[23,29].

Conclusion

Wild pigs contribute to water quality and bacterial impairment through direct fecal deposition, altering native plant and wildlife communities, degrading riparian and wetland habitat, increasing sedimentation and erosion, and in numerous other ways. Impacts associated with wild pig rooting and wallowing behavior within and near surface water negatively affect agricultural production, livestock productivity, and other human related uses. Emerging water quality testing and monitoring protocols including BST can help to better quantify wild pig *E. coli* contributions into water systems. More research is needed in order to reliably determine the relative abundance of wild pig bacterial depositions within aquatic systems statewide. Even so, reducing populations has been shown to benefit riparian ecosystems and overall water quality. Consistent and widespread abatement efforts remain necessary to reduce the impact of wild pig populations, foster functioning aquatic ecosystems and ensure water quality.

See other wild pig resources at http://agrilifebookstore.org.

- L-5523 Recognizing Feral Hog Sign
- L-5524 Corral Traps for Capturing Feral Hogs
- L-5525 Box Traps for Capturing Feral Hogs
- L-5526 Placing and Baiting Feral Hog Traps
- L-5527 Door Modifications for Feral Hog Traps
- L-5528 Snaring Feral Hogs
- L-5529 Making a Feral Hog Snare
- ESP-419 Feral Hogs Impact Ground-nesting Birds
- ESP-420 Feral Hog Laws and Regulations
- ESP-421 Feral Hogs and Disease Concerns
- ESP-422 Feral Hogs and Water Quality in Plum Creek
- ESP-423 Feral Hog Transportation Regulations
- L-5533 Using Fences to Exclude Feral Hogs from Wildlife Feeding Stations
- SP-467 Feral Hogs Negatively Affect Native Plant Communities
- WF-030 Reducing Non-target Species Interference While Trapping Wild Pigs
- EWF-033 Wild Pigs and Ticks: Implications for Livestock Production, Human and Animal Health

Literature Cited

[1] **Baird, J.V.** 1990. Soil facts: Nitrogen management and water quality. North Carolina Cooperative Extension AG-439-2.

[2] **Ballari, S.A. and M.N. Barrios-García.** 2014. A review of wild boar (*Sus scrofa*) diet and factors affecting food selection in native and introduced ranges. Mammal Review 44:124–134.

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

[4] **Chavarria, P.M., R.R. Lopez, G. Browser, and N.J. Silvy.** 2007. A landscape-level survey of feral hog impacts to natural resources of the Big Thicket National Preserve. Human Wildlife Conflicts 1:199-204.

[5] **Corn, J.L. and T.R. Jordan.** 2017. Development of the national feral swine map, 1982 – 2016. Wildlife Society Bulletin. doi: 10.1003/wsb.808.

[6] **Cushman, J.H., T.A. Tierney, and J.M. Hinds.** 2004. Variable effects of feral pig disturbances on native and exotic plants in a California grassland. Ecological Applications 14:1746–1756.

[7] **Dennison, C.C., P.M. Harveson, and L.A. Harveson.** 2016. Assessing habitat relationships or mountain lions and their prey in the Davis Mountains, Texas. The Southwestern Naturalist 61(1): 18-27.

[8] **Doupe´ R.G., J. Mitchell, M.J. Knott, A.M. Davis, and A.J. Lymbery.** 2009. Efficacy of exclusion fencing to protect ephemeral floodplain lagoon habitats from feral pigs (*Sus scrofa*). Wetlands Ecology and Management. DOI 10.1007/s11273-009-9149-3

[9] **Engeman, R.M., J. Wollard, H.T. Smith, J. Bourassa, B.U. Constantin, and D. Griffin.** 2007. An extraordinary patch of feral hog damage in Florida before and after initiating hog removal. Human–Wildlife Conflicts 1:271–275.

[10] **Fogerty, E.P.** 2007. National distribution and stakeholder attitudes toward feral pigs. Dissertation, Mississippi State University, Starkville, U.S.A. 1–99.

[11] **Gingerich, J.L.** 1994. Florida's Fabulous Mammals. World Publications. Tampa Bay.

[12] **Gregory L., E. Casarez, J. Truesdale, G. Di Giovanni, R. Owen, and J. Wolfe.** 2013. Bacterial Source Tracking to Support the Development and Implementation of Watershed Protection Plans for the Lampasas and Leon Rivers – Leon River Watershed Final Report. Texas Water Resources Institute (TWRI) TR-441.

[13] **Giovanni, G. D., L. Gregory, P. Dyer, and K. Wagner.** 2007. Bacterial Monitoring for the Buck Creek Watershed – Final Report. Texas AgriLife Research, Texas Water Resources Institute, and Texas AgriLife Extension Service. TSSWCB Project 03-07.

[14] **Hernandez F., D. Rollins, and R. Cantu.** 1997. Evaluating Evidence to Identify Ground-Nest Predators in West Texas. Wildlife Society Bulletin 25:826-831.

[15] **Iriarte, J. A., W. L. Franklin, W. E. Johnson, and K. H. Redford.**1990. Biogeographic variation of food habits and body size of the American puma. Oecologia 85:185–190.

[16] **Jay, M.T., Cooley, M., Carychao, D., Wiscomb, G.W., Sweitzer, R.A., Crawford-Miksza, L., Farrar, J.A., Lau, D.K., O'Connell, J., Millington, A., Asmundson, R.V., Atwill, E.R., and Mandrell, R.E.** 2007. Escherichia coli O157:H7 in feral swine near spinach fields and cattle, central California coast. Emerging Infectious Diseases 13:1908–1911.

[17] **Jolley, D. B., S.S. Ditchkoff, B.D. Sparklin, L.B. Hanson, M.S. Mitchell, and J.B. Grand.** 2010. Estimate of herpetofauna depredation by a population of wild pigs. Journal of Mammalogy 91:519-524.

[18] **Kaller, M.D., J.D. Hudson, 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.

[19] **Kotanen, P.M.** 1995. Responses of vegetation to a changing regime of disturbance: Effects of feral pigs in a California coastal prairie. Ecography 18:190-199.

[21] **Logan, K.A. and L.L Sweanor.** 2001. Desert puma evolutionary ecology and conservation of an enduring carnivore. Island Press, Washington, D.C. 463 p.

[22] **Mapston, M. E.** 2007. Feral hogs in Texas. AgriLife Extension B-6149 03-07, Texas A&M University, College Station, USA.

[23] **McCann, B. E. and D. K. Garcelon.** 2008. Eradication of Feral Pigs from Pinnacles National Monument. The Journal of Wildlife Management 72:1287-1295.

[24] **McKinney, B. P.** 1996. A field guide to Texas mountain lions. Texas Parks and Wildlife Department, Wildlife Division, Austin, Texas.

[25] **Mungall, E.C. and W.J. Sheffield.** 1994. Exotics on the range: the Texas example - part II. The New Animals. Texas A&M University Press, College Station, USA. pp. 67–73.

[26] **Naiman, R.J., H. Decamps, and M.E. McClain.** 2005. Riparian: ecology, conservation and management of streamside communities. Elsevier, San Diego, USA.

[27] **Ohio State University Extension.** 2006. Ohio livestock manure management guide. Bulletin 604. The Ohio State University, Columbus, USA.

[28] **Parker, I.D.** 2010. The role of free-ranging mammals in the deposition of Escherichia coli into a Texas floodplain. Dissertation, Texas A&M University, College Station, USA.

[29] **Parkes, J.P., D.S.L. Ramsey, N. MacDonald, K. Walker, S. McKight, B.S. Cohen, and S.A. Morrison.** 2010. Rapid eradication of feral pigs (Sus scrofa) from Santa Cruz Island, California. Biological Conservation 143(3):634–641.

[30] **Pimental, D.** 2007. Environmental and economic costs of vertebrate species invasions into the United States. Managing Vertebrate Invasive Species. College of Agriculture and Life Sciences, Cornell University, Ithaca, New York, USA.

[31] **Siemann, E., J.A. Carrillo, C.A. Gabler, R. Zipp, and W.E. Rogers.** 2009. Experimental test of the impacts of feral hogs on forest dynamics and processes in the southeastern US. Forest Ecology and Management 258:546-553.

[32] **Singer, F.J., W.T Swank, and E.E.C. Clebsch.** 1984. Effects of wild pig rooting in a deciduous forest. Journal of Wildlife Management 48:464-473.

[33] **Taylor, R.B., E.C. Hellgren, T.M. Gabor, and L. Ilse.** 1998. Reproduction of feral pigs in southern Texas. Journal of Mammalogy 79:1325–1331.

[34] **Texas Commission on Environmental Quality (TCEQ).** 2013. 2012 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d).

[35] **Timmons, J.B., J.C. Cathey, D. Rollins, N. Dictson, and M. McFarland.** 2011. Feral Hogs Impact Ground-nesting Birds. Texas AgriLife Extension Service. SP- 419.

[36] **Timmons, J.B., J. C. Cathey, N. Dictson, and M. McFarland.** 2011. Feral Hogs and Water Quality in Plum Creek. Texas AgriLife Extension Service. SP- 422.

[37] **Timmons, J.B., J. Mellish, B. Higginbotham, J. Griffin, R. Lopez, A. Sumrall, K. Skow, and J.C. Cathey.** 2012. Feral hog population growth, density and harvest in Texas. Texas A&M AgriLife Extension Service SP-472.

[38] **Williams, W.D., O. Kenzie, D. Quinton, and P. Wallis.** 1996. The water source as a factor affecting livestock production. In: Animal Science research Development: Meeting Future challenges. Proceedings, Can. Soc. Anim. Sci., Lethbridge, AB. E

Authors

Josh Helcel | Extension Associate
Texas A&M Natural Resources Institute

Forrest Cobb | Research Assistant
Texas A&M Natural Resources Institute

Dr. Jim Cathey | Associate Director
Texas A&M Natural Resources Institute

Acknowledgements and Disclaimer

We would like to thank John Kinsey, Wildlife Research Biologist, Texas Parks & Wildlife Department and Dr. Lucas Gregory, Research Scientist & QA Officer, Texas Water Resources Institute for their insightful review of this publication.

This publication was developed in part by the Plum Creek Watershed Feral Hog Project, with funding support from the U.S. Environmental Protection Agency through a Clean Water Act §319(h) Nonpoint Source grant administered by the Texas State Soil and Water Conservation Board and from the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture (USDA), National Integrated Water Quality Program. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the USDA.

Texas A&M AgriLife Extension

Texas A&M NRI
Natural Resources Institute