FINAL PROJECT MEMORANDUM
SECASC Project 032

1. ADMINISTRATIVE

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Project Title:

Accelerating Conservation of At-Risk Species in the Longleaf System

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2. PUBLIC SUMMARY

The longleaf pine ecosystem in the southeastern U.S. supports several “at-risk” species that are currently undergoing status reviews by the U.S. Fish and Wildlife Service (USFWS) to determine if they are threatened or endangered due to habitat loss and other threats. These include five reptile and amphibian species that are the focus of this work: the gopher tortoise, gopher frog, striped newt, southern hognose snake, and Florida pine snake. Their ranges occur within the Coastal Plain region of Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, and North Carolina. Conservation partners are grappling with decisions about how best to improve the statuses of these species before declines are irreversible, and there is limited scientific information on which to base those decisions. To address this need, we used a collaborative approach with Federal, State, and other partners to assess current habitat conditions and population trend of each species and predict risk of species extinction under future threats and management options. We compiled a database of over 72,000 species location records collected from field surveys by partners and from citizen science programs. From these data, we developed range-wide models and predictive maps of habitat suitability for each species. We assisted USFWS in conducting the official Species Status Assessment for the southern hognose snake where we

used available datasets and expert judgment to estimate extinction risk under current conditions and future scenarios varying in degrees of urbanization, sea level rise, and management effort. Finally, we co-developed a decision-making framework for gopher frog conservation with partners to identify combinations of habitat and population actions that are predicted to best meet partners' goals relating to long-term persistence of the species at the site-, state-, and range-wide scales. Collectively, our results can aid partners in implementing effective conservation strategies and inform status designation decisions of the USFWS.

3. TECHNICAL SUMMARY

This work aimed to provide science-based assessments of five herpetofauna species historically associated with the longleaf pine (*Pinus palustris*) ecosystem in the southeastern U.S.: gopher tortoise (*Gopherus polyphemus*), gopher frog (*Rana* [*Lithobates*] *capito*), striped newt (*Notophthalmus perstriatus*), southern hognose snake (*Heterodon simus*), and Florida pine snake (*Pituophis melanoleucus mugitus*). The work was undertaken to inform (1) status designation decisions under the U.S. Endangered Species Act and (2) conservation management decisions – including identifying the places various actions could be implemented – that could be made by Federal, State, and other partners to improve species' viability in the future. The research project used a partner-driven approach to integrate best available data with expert judgment to develop several models that predicted species' current statuses and future statuses in response to expected threats and potential management actions. We developed a range-wide habitat suitability model for each of the five focal species to identify habitat features that best predict species presence and generate maps of habitat conditions useful for partners to identify priority areas for population surveys, habitat improvement, land acquisitions, and other actions. Habitat suitability models related over 72,000 occurrence records of focal species to a suite of landscape, environmental, and climatic variables extracted from spatial datasets. Data products have been reviewed by all partners and are publicly available on ScienceBase for potential applications to partners' decisions. We have also published a manuscript about this study in the Journal of Fish and Wildlife Management. Next, we were invited by the U.S. Fish and Wildlife Service (USFWS) to participate on the core team of the southern hognose snake Species Status Assessment (SSA: published in the Federal Register on 7 October 2019: 84 FR 53336). We worked with USFWS partners and species experts to develop a model estimating population persistence under current conditions and future scenarios varying in degrees of urbanization, sea level rise, and management effort. This persistence model was built using our comprehensive database of species records and the predictions from habitat suitability models, and a manuscript about the persistence model has been published in Biological Conservation. Lastly, work conducted under the project has been successfully leveraged toward other related endeavors. We have begun co-development of a decision-making framework, currently for the gopher frog but adaptable to each focal species, for evaluating the degree potential management strategies meet partners' objectives for species outcomes at site-, state-, and range-wide scales. We have conducted elicitation exercises to capture expert judgment about site conditions and the expected effects of management for 182 gopher frog sites and hosted workshops in February 2019 and 2020 with experts to further inform model construction. We are integrating these expert responses with presence-absence data collected from state agencies at selected sites to estimate persistence currently and under different management scenarios.

All work described above was made possible through SE CASC funding. We anticipate the publication of four peer-reviewed manuscripts out of this work, with two already published. Our work will have

impact in the region as it directly informs status designation and conservation planning decisions for at-risk herpetofauna species, but it will also contribute to scientific knowledge more broadly regarding species' ecology and trends as well as analytical approaches that can be adapted for predicting trends of other species with limited data. Our publications will describe innovations in habitat modeling, population modeling, and development of decision support frameworks for spatial strategic planning for at-risk species.

4. PURPOSES AND OBJECTIVES

With Federal, State, and other partners, we have developed this project to assess the statuses of five at-risk herpetofauna species associated with the longleaf pine system and to develop science-based frameworks to inform status decisions under the U.S. Endangered Species Act and identify where and how to invest in conservation resources. The impetus for status and conservation decisions stems from the following: previous research that identified local to regional declines in species distribution, occupancy, and/or abundance; forthcoming decisions (at the outset of the project in 2016) on Federal listing of each species under the U.S. Endangered Species Act that require formal Species Status Assessments to be completed by USFWS; and increased interest in coordinating and improving conservation efforts of Federal, State, and other partners across species' ranges, regardless of listing decisions. This work addressed three objectives: (1) synthesize species data and expert knowledge from previous research, monitoring, and management efforts, (2) develop comprehensive, range-wide models of current species distribution and persistence, and (3) predict future distribution and persistence under threat and management scenarios to inform stakeholder-based decision-making.

5. ORGANIZATION AND APPROACH

We addressed these objectives through three synergistic research efforts: (1) development of range-wide habitat suitability models for each species under current conditions of threats and management actions, (2) development of models that use additional, available datasets (e.g., presence-absence data, citizen science observations) to estimate population dynamics for cryptic species, and (3) development of a decision-making framework for spatial strategic conservation decisions that maximize species resiliency, redundancy, and representation in the future. However, the assembly of a network of research and management partners was a key initial task for this project, as progress was critically dependent on the acquisition of information, generation of ideas, elicitation of expert knowledge, and receipt of feedback from this network.

Dr. Brian Crawford, a postdoctoral researcher with the Georgia Cooperative Fish and Wildlife Research Unit at the Warnell School of Forestry and Natural Resources, led all project stages, including partner recruitment and communication, expert workshops and webinars, model development, delivery of technical presentations, and preparation of project publications. The project was instrumental in furthering the professional development of this early-career researcher.

Research effort 1 – Modeling habitat suitability: We developed habitat suitability (also called species distribution) models for each species. In short, habitat suitability models use measures of environmental and landscape attributes (e.g., soil characteristics, canopy cover, fragmentation, rainfall) in places where a species was known to occur over some time scale to project where similar conditions occur throughout the species' range. This approach required spatial datasets of these environmental and landscape attributes, as well as known species locations (presence data) that are contained in databases

of natural heritage programs, Federal and State agencies, and citizen science programs (e.g., HerpMapper). We incorporated expert judgment from Federal, State, and other partners to capture variation in ecological settings across species' ranges, prioritize predictor variables to test in models, mitigate data limitations by informing the selection of pseudo-absence points, qualitatively evaluate model estimates, and improve the likelihood that experts will trust and use model predictions for conservation. We have also collaborated with SE CASC staff to gather data and to model habitat and species outcomes under future land-use and climate change scenarios.

Research effort 2 – Modeling population persistence for data-limited species: Through participating on the USFWS core team for the SSA for the southern hognose snake, we developed a novel modeling framework to estimate population persistence using only occurrence records of the target species and citizen science occurrence data of non-target species to account for search effort and imperfect detection. We applied this framework to estimate current (as of 2018) and future persistence under plausible scenarios of varying levels of urbanization (using predicted scenarios generated by the SLEUTH model), sea level rise, and management for populations of southern hognose snakes.

Research effort 3 – Developing a decision-making framework for at-risk species: Our efforts under this project have transitioned toward development of a decision-making framework, currently for the gopher frog but adaptable to each focal species, for evaluating the degree potential management strategies meet partners' objectives for species outcomes. We are using the principles of structured decision making to develop this framework to guide partners through a series of steps that break down this complex conservation problem (e.g., identify objectives, create alternatives, estimate consequences). We have aligned partner objectives represented in this framework with those of the forthcoming SSA (resiliency, redundancy, and representation) to ensure that the results of our analysis will inform both partners' decisions and the SSA information needs. To estimate consequences of management alternatives, we have developed a model that links potential strategies to changes in habitat conditions (using our habitat suitability model) to changes in metapopulation persistence (using a hierarchical Bayesian model based on presence-absence data and expert judgment).

6. PROJECT RESULTS

Research effort 1 – Modeling habitat suitability: We assembled a comprehensive species database that includes (1) ~72,000 occurrence records for all five focal species; (2) presence-absence detection histories for gopher frogs at 192 repeatedly-sampled ponds (in 67 metapopulations) in NC, SC, GA, FL, and AL; and (3) line transect distance sampling survey data for gopher tortoise, conducted by State agencies, non-governmental organizations, and private landowners on 157 sites in SC, GA, FL, MS, and LA. We assembled a suite of landscape layers in a spatial database to use as predictors in species models, which included data on habitat, elevation, soil, climate, landscape connectivity, and land-use and protection status. We chose spatial predictors, as well as the scales at which certain predictors were averaged within a neighborhood ("smoothed"), based on existing literature and expert judgment from partners describing species' ecological needs. With these data inputs, we completed an iterative process of model building and adjustments in response to partner feedback that generated models and maps of habitat suitability across each species' range, given current conditions (as of 2018) of urbanization, climate, and other existing stressors and management actions. We also predicted future changes in

habitat suitability based on varying levels of predicted urbanization, sea-level rise, and habitat management actions (e.g., increased or decreased use of prescribed fire).

Research effort 2 – Modeling population persistence for data-limited species: We developed a novel model of population persistence that served as the core analysis for the USFWS SSA for the southern hognose snake. The model estimated current (as of 2018) population persistence for 222 populations of southern hognose snakes using only occurrence records of the target species and citizen science occurrence data of non-target species to account for search effort and imperfect detection. We used this model framework to predict future persistence under plausible scenarios of varying levels of urbanization, sea level rise, and management. We implemented the population model in a Bayesian framework using 2,196 southern hognose snake occurrence records and 5,473 occurrence records of non-target snake species from citizen science databases (HerpMapper.org).

Research effort 3 – Developing a decision-making framework for at-risk species: Our efforts under this project have transitioned toward development of a decision-making framework, currently for the gopher frog but adaptable to each focal species, for evaluating the degree potential management strategies meet partners' objectives for species outcomes. We have hosted workshops in February 2019 and 2020 and conducted elicitation exercises with species experts and managers to define the problem context, identify fundamental objectives, define a set of management strategies, and apply expert judgment to estimate current site conditions and expected effects of management for 182 gopher frog sites. Our partners are interested in maximizing the resiliency, redundancy, and representation of the gopher frog through 2050 by determining optimal combinations of terrestrial and wetland habitat management options, land acquisitions, and head-starting (either by augmenting existing metapopulations or translocating individuals to establish new metapopulations) that can be taken in the next 10 years. We have developed a model that links potential management strategies to changes in habitat conditions (using our habitat suitability model) to changes in metapopulation persistence (using a hierarchical Bayesian model based on presence-absence data collected from State agencies at 192 gopher frog ponds [grouped into 67 metapopulations] and expert judgment).

7. ANALYSIS AND FINDINGS

Research effort 1 – Modeling habitat suitability: Habitat suitability for all five species was strongly and positively influenced by well-drained, sandy soil, compatible (forest, scrub/shrub, grassland) land cover, and fire interval (Crawford et al. 2020b). Suitable habitat was distributed on known species strongholds, as well as private lands without known species records. The percentage of area in each species' range that was classified as suitable habitat was 14.6% (gopher tortoise), 8.6% (gopher frog), 8.9% (striped newt), 9.1% (southern hognose snake), and 11.4% (Florida pine snake). The percentage of suitable habitat in each species' range that was located in patches larger than 1 km^2 (100 ha) on publicly-owned lands was 47.9% (gopher tortoise), 60.1% (gopher frog), 45.4% (striped newt), 36.2% (southern hognose snake), and 40.7% (Florida pine snake). By overlaying predictions for each species, we identified areas of suitable habitat for multiple species on protected and unprotected lands. See Crawford et al. (2020b) for more details.

Research effort 2 – Modeling population persistence for data-limited species: We modeled persistence of 222 southern hognose snake populations between the period of 1950 to 2018 and then projected persistence into 2080 under different scenarios of urbanization, sea-level rise, and management efforts. Current population persistence was positively influenced by habitat suitability and percentage of land

within a population boundary that was publicly owned (Crawford et al. 2020a). Range-wide, a majority (133 [60%]) of 222 total populations had a current persistence probability less than 50%, meaning they were more likely than not to be extirpated; 49 (22%) had a current persistence probability greater than 95%. The geographic extent occupied by the species has likely decreased as all populations in the northeastern and western edges of the range are likely extirpated at present, including all populations in AL and MS. Persistence probability decreased for most populations in the future under all scenarios without additional management, as did the number and geographic distribution of populations with greater than 50% persistence probability. However, scenarios with additional management strategies to acquire and improve habitat for populations on currently privately-owned lands were predicted to slow the rate of population declines. See Crawford et al. (2020a) for more details.

Research effort 3 – Developing a decision-making framework for at-risk species: We have assembled all elements of the decision framework using significant partner input (including problem definition, objectives, and a list of management strategies). We modeled breeding frequency and population persistence for 67 gopher frog metapopulations for the period of 2010 to 2019 using presence-absence datasets. Our model included an effect of habitat suitability and environmental conditions (represented by a standardized precipitation index and assessment of predation vulnerability via fish presence) on the proportion of years predicted to have had breeding and viable recruitment of metamorphs into the metapopulation. We subsequently used a stage-based population model based on demographic parameters from published studies and expert judgment to estimate the relationship between breeding frequency and metapopulation persistence over 30 years. We are finalizing the decision model to link effects of management strategies at each site with changes in habitat suitability, breeding frequency, and metapopulation persistence in 2050. We will use the model to predict outcomes of metapopulation persistence and management costs under 17 strategies at each gopher frog site; then we will perform optimization procedures to identify combinations of strategies that could be taken across sites in a state or range-wide that maximize the number and geographic distribution of persisting metapopulations while minimizing cost.

8. CONCLUSIONS AND RECOMMENDATIONS

Our first research effort developing range-wide habitat suitability models identified important species-habitat relationships and the range-wide distribution and protection status of suitable habitat for five at-risk species in the longleaf pine ecosystem. We used a modeling approach that was informed by expert judgment over multiple stages of input and validation. Because numerous at-risk species are designated for formal status assessments or are the subjects of conservation planning initiatives, our work adds to previous habitat suitability modeling studies to demonstrate an expert-informed approach that produces decision-relevant information about habitat conditions even when available data, such as true absences, are limited.

In our second research effort, we developed a novel approach to estimate persistence using only occurrence records of the target species and citizen science occurrence data of non-target species to account for search effort and imperfect detection. This approach is applicable across rare and at-risk species for evaluating extinction risk with limited data and prioritizing management actions. We expect that numerous at-risk species meet similar conditions (i.e., in need of science-based conservation decisions but have limited existing data), and estimating risk of extinction using this approach is suitable before more rigorous demographic data can be collected for additional population viability models.

Our third research effort again took a partner-informed approach to design a decision framework for the gopher frog that will inform allocation of management resources at the site-, state-, and range-wide scale. The decision framework integrates preceding elements of this project by linking future threats and management actions to changes in habitat suitability and population persistence. Although the framework is fairly complex, partners have influenced every step of its construction (e.g., specifying predictors to include in the habitat suitability model, defining objectives and quantitative criteria the decision model measures). We used varied methods to frequently communicate among groups of scientists, decision-makers, and other experts (i.e., e-mail, online exercises, phone calls, in-person workshops). Despite the sustained effort required, this degree of expert and decision-maker involvement was beneficial for generating quality, trustworthy, and decision-relevant information that can aid at-risk species conservation. Practitioners developing models for assessing statuses of at-risk species in the future may agree the benefits outweigh any time- or effort-related costs of collaboration.

Despite these significant achievements, our project experienced some delays and fell short in fully achieving one objective. We experienced modest delays, especially early in the project, associated with logistical challenges in efficiently coordinating and communicating with many (>20) collaborating partners, scheduling workshops and webinars, and receiving expert feedback essential to multiple analyses. We worked through these challenges to make progress on all objectives while still involving partners to the intended extent in all stages. Regarding our third objective (predict future species persistence under stressors and management alternatives to inform decision-making), we have successfully built the decision framework for gopher frogs in full collaboration with partners, but we have not yet finalized analysis predicting future outcomes for this species nor adapted the framework to other species included in our project. We anticipate having the gopher frog analysis completed by next year (2021). We will continue working with partners to adapt elements of the population models and decision framework developed in this project to inform status designation and conservation management for all five focal species.

9. MANAGEMENT APPLICATIONS AND PRODUCTS

Collectively, our project results can – and have already begun to – aid regional partners in implementing effective conservation strategies and inform status designation decisions of the USFWS. Results from range-wide habitat suitability models have direct applications to management and conservation planning: partners can tailor site-level management based on attributes associated with high habitat suitability for species of concern; allocate survey effort in areas with suitable habitat but no known species records; and identify priority areas for management, land acquisitions, or other strategies based on the distribution of species records, suitable habitat, and land protection status. Certain State partners have already used habitat suitability maps to prioritize visits to private properties enrolled in conservation easements for surveying for new populations of at-risk species. Final maps of habitat suitability have been reviewed and approved by all partners and are publicly available on ScienceBase for further applications. The novel model of population persistence created in this project for the southern hognose snake served as the central analysis for the USFWS SSA (Docket FWS-R4-ES-2015-0063 at regulations.gov), and we expect this same model to be used for the forthcoming Florida pine snake SSA. Model results showed that future management scenarios that included strategies to acquire and improve habitat on currently unprotected lands with existing populations lessened the estimated rate of population declines. These results directly informed status designation decisions and can further

inform conservation planning for the southern hognose snake by Federal, State, and other partners. One of our partners had this to say about this joint effort:

> "The model that was produced as a result of this project raised the bar in terms of science used in a species status assessment. Decision makers were able to then make a more well-informed decision for a species that is highly secretive and where direct population data was lacking. We look forward to applying this model to similar species currently under review listing under the ESA." – *Melanie Olds, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service*

Finally, the decision framework we developed for the gopher frog will inform partners in allocating management resources at a focal site and across sites in their jurisdiction (e.g., sites within a state) based on metapopulation extinction risk and cost. The subcomponent of the decision model that estimates breeding frequency and persistence can inform partners in allocating monitoring resources across seasons when breeding is most likely based on a site's habitat suitability and seasonal trends in precipitation. We expect our decision framework and forthcoming results for the gopher frog to inform the USFWS SSA.

We received support from Mike Harris and D. Todd Jones-Farrand (USFWS) in the development of this work. Data and expert judgment that facilitated this work were generously contributed by many individuals from the North Carolina Wildlife Resources Commission, North Carolina Natural Heritage Program, North Carolina Museum of Natural Science, Davidson College, South Carolina Department of Natural Resources, University of Georgia Savannah River Ecology Laboratory, Francis Marion University, Georgia Department of Natural Resources, Joseph W. Jones Ecological Research Center, Florida Fish and Wildlife Conservation Commission, Archbold Biological Station, Coastal Plains Institute, Alabama Department of Conservation and Natural Resources, Auburn University, Mississippi Wildlife, Fisheries, and Parks, Louisiana Department of Wildlife and Fisheries, South Atlantic Landscape Conservation Cooperative, Department of Defense, US Army (Ft. Stewart), US Air Force (Eglin Air Force Base), Longleaf Alliance, The Nature Conservancy, Partners in Amphibian and Reptile Conservation, HerpMapper, and unaffiliated private landowners working in cooperation with these organizations.

10. OUTREACH

Our outreach consisted of a combination of workshops and webinars with project partners to guide the development and refinement of research products, consultations and service on advisory and expert panels, scientific conference presentations, refereed journal publications, and articles written for the public on partner-run blogs and other online media outlets. A complete list is provided below.

Peer-reviewed articles

Crawford B.A., M. Olds, J.C. Maerz, C.T. Moore. 2020a. Estimating population persistence for at-risk species using citizen science data. Biological Conservation 243: 108489. https://doi.org/10.1016/j.biocon.2020.108489.

Crawford B.A., J.C. Maerz, C.T. Moore. 2020b. Expert-informed habitat suitability analysis for at-risk species assessment and conservation planning. Journal of Fish & Wildlife Management 11 (1): 130-150. https://www.fwspubs.org/doi/pdf/10.3996/092019-JFWM-075.

Stakeholder workshops, webinars, and informational meetings

Crawford, B.A. 4 October 2016. Webinar. Introduction to the Longleaf ARC Project: At-risk species conservation in the longleaf system. University of Georgia, Athens, GA.

Crawford, B.A., J.C. Maerz, and C.T. Moore. 16 February 2017. Workshop. Longleaf ARC Project: At-risk Amphibian and Reptile Conservation in the longleaf pine system. Southeast Partners in Amphibian & Reptile Conservation annual meeting, Little Rock, AR.

Crawford, B.A. 15 June 2017. Webinar. The Longleaf ARC Project: At-risk amphibian and reptile conservation in the longleaf system. South Atlantic Landscape Conservation Cooperative.

Crawford, B.A. 26 October 2017. Webinar. Preliminary range-wide status modeling to accelerate conservation of at-risk herpetofauna in the longleaf system. South Atlantic Landscape Conservation Cooperative.

Crawford, B.A., J.C. Maerz, and C.T. Moore. 22 February 2018. Workshop. Longleaf ARC Project: Upland ecology & management. Southeast Partners in Amphibian & Reptile Conservation annual meeting, Helen, GA.

Crawford, B.A. 29 March 2018. Webinar. The Longleaf ARC Project: Upland workshop follow-up webinar. University of Georgia, Athens, GA.

Crawford, B.A. 21 June 2018. Webinar. The Longleaf ARC Project: Accelerating conservation of at-risk species in the longleaf system. South Atlantic Landscape Conservation Cooperative.

Katz, R., D.T. Jones-Farrand, and B.A. Crawford. 22-27 July 2018. Structured decision-making for gopher frog conservation planning. US Fish & Wildlife Service National Conservation Training Center: Southeast Regional Workshop. Gainesville, FL.

Crawford, B.A., J.C. Maerz, and C.T. Moore. 14 February 2019. Workshop. Structured decision-making for gopher frog conservation planning – Stage 2. Southeast Partners in Amphibian & Reptile Conservation annual meeting, Black Mountain, NC.

Crawford, B.A., J.C. Maerz, and C.T. Moore. 27 February 2020. Workshop. Structured decision-making for gopher frog conservation planning – Stage 3. Southeast Partners in Amphibian & Reptile Conservation annual meeting, Nauvoo, AL.

Crawford, B.A., J.C. Maerz, and C.T. Moore. 4 and 11 May 2020. Webinar series. Structured decision-making for gopher frog conservation planning – Stage 4. University of Georgia, Athens, GA.

Consultation and service on advisory and expert panels

Science communication on current and future status of the striped newt. Striped Newt Working Group, in-person and remote workshops, June 2017 – Feb 2019.

Expert elicitation and activity facilitation on definition of range-wide conservation targets for gopher tortoise (Workshop 3). Gopher Tortoise Council, 14-16 November 2017, Newton, GA.

Core team member and data analyst for the southern hognose snake Species Status Assessment. U.S. Fish and Wildlife Service, Aug 2018 – May 2019.

Expert elicitation on factors influencing resiliency, redundancy, and representation for the gopher tortoise Species Status Assessment. U.S. Fish and Wildlife Service, remote workshops, Nov 2019 – Feb 2020.

Conference presentations and posters
(Oral presentation, unless marked '[Poster]')

Crawford, B.C., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, and M. Harris. 2017. At-risk amphibian and reptile conservation in the longleaf pine system. Southeast Partners in Amphibian and Reptile Conservation annual meeting, 16-19 February 2017, Little Rock, AR. Poster presentation.

Crawford, B.C., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, and M. Harris. 2017. At-risk amphibian and reptile conservation in the longleaf pine system. Longleaf Partnership Council annual meeting, 4-5 April 2017, Montgomery, AL.

Crawford, B.A. 2017. The Longleaf ARC Project: At-risk amphibian and reptile conservation in the longleaf system. Striped Newt Working Group Meeting. Florida Fish & Wildlife Conservation Commission, 21-23 June 2017, Jacksonville, FL.

Crawford, B.C., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, and M. Harris. 2017. Accelerating conservation of at-risk amphibians and reptiles the longleaf pine system. Joint Meeting of Ichthyologists & Herpetologists, 12-16 July 2017, Austin, TX.

Crawford, B.C., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, and M. Harris. 2017. Longleaf ARC Project: At-risk Amphibian & Reptile Conservation in the longleaf system. Longleaf Implementation Team annual meeting. 1 August 2017, Rome, GA.

Crawford, B.C., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, and M. Harris. 2017. Accelerating conservation of at-risk amphibians and reptiles the longleaf pine system. Joint Georgia DNR-WRD/Warnell Wildlife Research Meeting, 8 August 2017, Mansfield, GA.

Crawford, B.C., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, and M. Harris. 2017. Preliminary range-wide status modeling to accelerate conservation of the gopher tortoise. The Gopher Tortoise Council, 13 October 2017, Edgefield, SC. Poster Presentation.

Crawford, B.C., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, and M. Harris. 2018. The Longleaf ARC Project: Accelerating conservation of at-risk species in the longleaf system. 2018 Annual meeting of Southeast Partners in Amphibian and Reptile Conservation, 22-25 February 2018, Helen, GA.

Crawford, B.A., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, & M. Harris. Range-wide status modeling to accelerate conservation of at-risk species in the longleaf system. Southeastern Association of Fish & Wildlife Agencies, 23 October 2018, Mobile, AL.

Crawford, B.C., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, and M. Harris. 2018. The Longleaf ARC Project: Accelerating conservation of at-risk species in the longleaf system. Alabama Gopher Frog Working Group annual meeting, 28 November 2018, Kinston, AL.

Crawford, B.A., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, and M. Harris. 2019. Range-wide status modeling to accelerate conservation of at-risk species in the longleaf system. Striped Newt Working Group Meeting. Florida Fish & Wildlife Conservation Commission, 6 Feb 2019, Orlando, FL.

Crawford, B.C., C.T. Moore, J.C. Maerz, M. Marshall, and M. Olds. 2019. Estimating extinction risk for the southern hognose snake to inform listing decisions under the U.S. Endangered Species Act. Southeast Partners in Amphibian and Reptile Conservation annual meeting, 14-16 February 2019, Black Mountain, NC.

Crawford, B.A., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, and M. Harris. 2019. Using experts and models to accelerate conservation of at-risk species in the longleaf pine system. Southeast Climate Adaptation Science Center, Regional Science Symposium. New Orleans, LA. 12-14 November 2019.

Crawford, B.A., C.T. Moore, J.C. Maerz, D.T. Jones-Farrand, & M. Harris. 2020. Using experts and models to accelerate conservation of at-risk species in the longleaf pine system. Southeast Regional Partnership for Planning and Sustainability Steering Committee Meeting. Atlanta, GA. 4 March 2020.

Non-technical publications

Crawford, Brian. 2020. “Habitat suitability maps for at-risk herpetofauna species in the longleaf pine ecosystem.” South Atlantic Conservation Blueprint Blog and Newsletter. February 2020. https://www.southatlanticlcc.org/2020/02/04/habitat-suitability-maps-for-at-risk-herpetofauna-species-in-the-longleaf-pine-ecosystem/

Crawford, Brian. 2020. “Providing science for the conservation of at-risk reptiles & amphibians in the southeastern longleaf pine ecosystem.” The Longleaf Leader. July 2020. https://issuu.com/thelongleafleader/docs/longleaf-leader-summer-2020-final