

17th Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles

Joint Annual Meeting of the Turtle Survival Alliance and
IUCN Tortoise & Freshwater Turtle Specialist Group

Program and Abstracts

August 4 - 8, 2019
Tucson, AZ



Additional Conference Support Provided by:

Arthur L. & Elaine V. Johnson Foundation, Brett & Nancy Stearns, In Memory of Charlie Green, John Iverson, Kristin Berry, Matt and Leigh Ann Frankel, Tim Gregory, and Walter Sedgwick

Support for the 2019 Behler Turtle Conservation Award Provided By:



With additional support from: Deb Behler, George Meyer and Maria Semple,
and Brett and Nancy Stearns



2019 Conference Highlights

Keynote Address: Shi Haitao



Since 1989 Shi Haitao has acted as Professor and Vice President of Hainan Normal University, as well as Vice Chairman of the Association for Science and Technology of Hainan Province. Shi's primary focus has been studying the ecology and conservation biology of roughly one-third of the tortoise and freshwater turtle species that occur in China. In 2003, he created an action plan for the conservation of turtles of China and formed the country's first turtle research team, now comprised of more than 50

members. The action plan has guided the research, conservation, and capacity building for turtles in China. In total, Shi has published 140 academic articles, 11 books, and has completed more than 40 research projects.

We hope everyone enjoys the festivities that this year's venue has to offer. Special thanks to the Loews Ventana Canyon Resort for helping us kick-off the festivities and also wrap up the celebration!



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Featured Presentations



Roy Averill-Murray

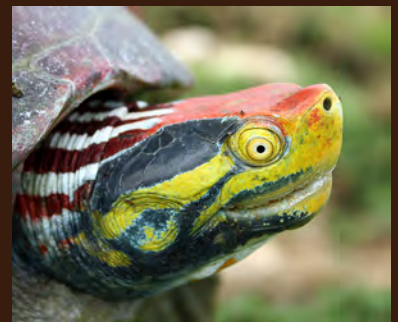
Challenges in Conservation and Recovery of Desert Tortoises: The Importance of Long-term Studies



Sue Carstairs

Ranavirus, Research, and Rehabilitation: The Interconnectedness of Conservation Strategies

Featured Session



Batagur Conservation

From the Program Co-Chairs: WELCOME TO TUCSON!

There is no better way to celebrate the month of August than attending the 17th Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles. After a very successful 2018 symposium in Fort Worth, Texas – to visit the city where the idea to create Turtle Survival Alliance was conceived – we are delighted to welcome you back to Tucson, Arizona! This year's meeting, sponsored by Zoo Med Laboratories, is being co-hosted by the Turtle Survival Alliance and the IUCN Tortoise and Freshwater Turtle Specialist Group at the Loews Ventana Resort in Tucson, Arizona. Here, you will be greeted with a magnificent view of the Catalina Mountains, fall in love with big skies and long views, and desert life forms from the saguaro cactus to the Gila monster, which inspired books by Edward Abbey, Charles Bowden, Barbara Kingsolver, and more. Come early to enjoy some extra time in laid back Tucson – stay late to explore the wonders of the Sonoran Desert and savor the regional cuisine!

We return to Tucson by popular demand, and have been assured by many locals and past Symposium attendees that the Old Pueblo was born ready to host the largest gathering of turtle biologists, zookeepers, husbandrists, and enthusiasts, anywhere in the world – for the fourth time! This year's symposium starts with a keynote presentation on *Chinese Turtles* by Shi Haitao, and aptly closes with a more locally flavored featured presentation on *Challenges in Conservation and Recovery of Desert Tortoises: The Importance of Long-term Studies* by Roy Averill-Murray. We have special sessions on *Batagur* Conservation, Turtles of the Southwest, Captive Husbandry, and Field Studies and Techniques. This year we have also added a fourth day to the Symposium to feature longer plenary presentations.

As this symposium enters its 17th year, its resounding impact on the conservation and biology of chelonians is quite evident. As always, we are looking forward to seeing many of our old friends, making new connections, and finding innovative ways to collaborate in the turtle conservation world. We hope to facilitate and encourage this level of continuity, which we do in part through Travel Grants and Student Presentation Awards. The Student Presentation Awards are made possible through generous donations from Anders Rhodin and the Chelonian Research Foundation. The generosity of our vendors, sponsors, and donors make Travel Grants and our social events a possibility, so please take the time to visit the sponsor booths, buy their products, or just say "thanks". We also thank the Arizona-Sonora Desert Museum for once again collaborating with the TSA and organizing the field trip.

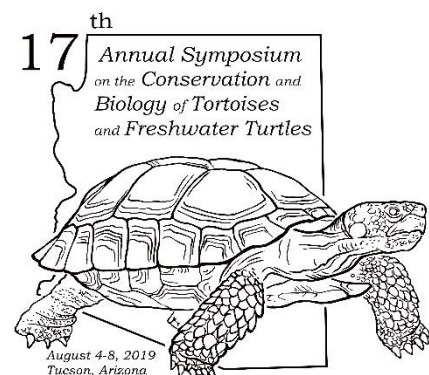
As the "front" people who interact with the presenters, an impression that we "organize" the conference is created. Nothing could be further from the truth. We can't thank Brooke Sauer of Visit Tucson and the wonderful staff of Loews Ventana Canyon Resort for getting us set up with this incredible conference space. We think everyone is going to enjoy this venue. Robert Villa and David Hedrick will be running the AV system and making sure your presentations run smoothly. Jordan Gray and David Hedrick will be pushing social media, and keeping you aware of what is going on. Nancy Reinert and Rose Tremblay will be here again to help run the hospitality suite, sell merchandise, run the auction, and do the million other necessary jobs to keep the conference running smoothly behind the scenes. And, of course, Lonnie McCaskill will be around to help with all sorts of details, logistics, and to answer any of your questions. Jan Holloway, TSA's Administrative Coordinator, and Emily Kiefner, TSA's new Administrative Assistant, with help from Clint Doak, Carol Alvarez, and Brianna Teats, will be getting you registered. If you are interested in volunteering at next year's conference, please come and talk with us. We are always looking for session chairs, student paper and poster judges, Program editors, and additional hands to help behind the scenes. We also welcome your comments and suggestions on ways to make this conference more meaningful and enjoyable.

We look forward to visiting with all of you. On behalf of the Symposium Committee and Volunteers, once again, welcome! We hope you enjoy the Symposium!

Andrew Walde and Cristina Jones, Program Co-Chairs

T-shirt Design Contest Winner!

Please join us in congratulating **Matt Patterson**. Matt submitted the winning entry in the T-shirt design contest for the 17th Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles. Be sure to purchase your own Conference T-shirt in the Exhibit Hall as a souvenir – supplies are limited!



From the Hosts: WELCOME!

On behalf of the Board of Directors of the Turtle Survival Alliance (TSA), and the leadership of the IUCN SSC Tortoise and Freshwater Turtle Specialist Group (TFTSG), we welcome you to the 17th Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles.

For the fourth time in conference history we are delighted to welcome you back to Tucson, in the heart of the beautiful Sonoran Desert, which has become a popular venue for us. Due to the extreme Summer heat – who else but a bunch of herp people want to be in Arizona in August ?? – we were able to negotiate a deal with the spectacular Loews Ventana Canyon Resort. Set in the stunning Catalina Mountain range this is a premiere destination for Arizona luxury resorts. It is fortunate we selected a resort on this scale because this conference will likely be our largest yet, judging by the number of hotel rooms booked, registrations and abstracts submitted. We had so many submissions in fact, that we decided to add another half day to the program on Thursday August 8, which will also provide time for some break out meetings that we need but never seem to find time for during our busy schedule. This has been an ongoing issue for the TSA over the years: we bring our staff and partners together, from all corners of the globe, but then don't have adequate time for planning and strategizing. We hope this will address that shortcoming.

Day 1, August 5, kicks off with a keynote address by Shi Haitao, widely recognized as China's most pre-eminent turtle ecologist and conservationist. On Wednesday night, August 7, Shi will receive the prestigious Behler Turtle Conservation Award at our annual Awards Banquet where he will be celebrated and honored. We will also present the student awards as well as number of Turtle Conservation Appreciation Awards, so it is shaping up to be an exciting evening.

We offer special thanks to the organizational skills of our conference team - Andrew Walde, Cristina Jones, Jordan Gray, Jan Holloway and Emily Kiefner - who managed to balance a multitude of details in the months leading up to the conference. We also pay tribute to our many sponsors, without whose support it would not be possible to provide a meeting of this caliber. Our longtime partner, Zoo Med Laboratories, is again the symposium's title sponsor. There are many other costs associated with this conference - travel grants, coffee breaks, catering, transportation and the all-important hospitality suite. For helping to offset these costs, and for their generosity, we thank Desert Tortoise Council, Turtle and Tortoise Preservation Group, ECO Wear and Publishing, Arizona Game and Fish Department, Tracks Software, Arthur L. & Elaine V. Johnson Foundation, Brett and Nancy Stearns, John Iverson, Kristin Berry, Reid Taylor, Matt and Leigh Ann Frankel, Tim Gregory, and Walter Sedgwick. Awards for the Best Student Presentations will again be presented and supported this year by Anders Rhodin and the Chelonian Research Foundation. And as a reminder please stop by and visit our vendors who have become such an integral part of this conference.

We look forward to another great symposium, and we thank you for being a part of it. This conference embodies the true spirit in which both the TSA and TFTSG were founded: that saving turtles would require a lot of like-minded people, from many backgrounds and professions, all working in synergy. We have said it before, but it is no less true this year: with the many people from diverse institutions and countries attending, this conference is a true microcosm of the global turtle conservation community, coming together once again to replenish and leverage our enthusiasm, find inspiration, and remind ourselves why we do what we do for turtles and tortoises.

Rick Hudson, TSA President
Craig Stanford, Chair, TFTSG

Behler Turtle Conservation Award

This year the 14th annual Behler Turtle Conservation Award celebrates and honors Shi Haitao, China's most pre-eminent turtle ecologist and conservationist. He is currently Professor and Vice-President of Hainan Normal University and Vice-Chairman of the Association for Science and Technology of Hainan Province. His early studies, on the ecology of the Central Asian Tortoise (*Agrionemys horsfieldii*), helped pave the way for future scientists to study turtle ecology and conservation in China. He has studied the ecology and conservation biology of about one-third of the tortoise and freshwater turtle species that occur in China. He created the Action Plan for the conservation of turtles in China in 2003, which has been guiding the research, conservation and capacity building of turtles in China. He was responsible for drafting proposals that resulted in all Chinese turtle species being listed under CITES regulations. He participated in the revision of China's new wildlife protection law implemented in 2017, in which he successfully opposed the uncontrolled policies and laws on wildlife domestication. He published his *Identification Manual for Turtle Conservation in China* in Chinese in 2008 with a second edition in 2011, and an English version in 2013. The book includes the 31 native and the 95 non-native traded turtle species which could be found in China at that time. He established the Biodiversity Museum of Hainan, which includes a special section specifically devoted to turtles, and he founded the Eco-Environmental Education Center in Hainan Province, which filled a void in environmental education in Hainan, with more than 700,000 visitors to the Center to date. He created the first turtle research team in China, which currently has over 50 members, including 8 staff, 12 Ph.D. students, and numerous Masters and undergraduate students. To date 5 students have graduated with a Ph.D. and 23 students with a Masters. They will be the main force in turtle research and conservation in China in the future.

The TFTSG and TSA are honored to be joined again this year by the Turtle Conservancy and the Turtle Conservation Fund as co-presenters of this prestigious Award, bringing together the four turtle organizations most closely tied to John Behler's legacy. This award would not be possible without the following group of dedicated and generous co-sponsors: Global Wildlife Conservation, Turtle Conservancy, IUCN/SSC Tortoise and Freshwater Turtle Specialist Group, Chelonian Research Foundation, Wildlife Conservation Society, Turtle Conservation Fund, Surprise Spring Foundation, Andrew Sabin Family Foundation, Turtle Survival Alliance, George Meyer and Maria Semple, Brett and Nancy Stearns, and Deb Behler.

Congratulations Shi, and thank you for your efforts on behalf of China's endangered turtles – your recognition as a Behler Awardee is most highly deserved!

*Anders G.J. Rhodin and Rick Hudson,
Co-Chairs, Behler Turtle Conservation Award Committee*

**Turtle Survival Alliance (TSA) and
IUCN Tortoise and Freshwater Turtle Specialist Group (TFTSG)
Policy on Annual Symposium Code of Conduct**

The TSA / TFTSG Annual Symposium is a forum to present, consider, and debate scientifically relevant research and viewpoints professionally and respectfully. All participants will at all times be held to the highest standard of professional ethics and conduct. TSA and TFTSG are committed to providing a professional meeting environment that (1) fosters open dialogue and the exchange of scientific information and ideas, (2) promotes equal opportunities for and treatment of all participants, and (3) is free of discrimination or any forms of harassment or objectification based on gender, sexual orientation, age, disability, nationality, race, ethnicity, religion or religious belief, or military/veteran status. This policy applies to all attendees, including speakers, exhibitors, staff, contractors, volunteers and guests at the symposium itself and at associated activities in hospitality suites and venue facilities. **All presenters are requested to review and assess their own presentations for appropriateness of content so as not to transgress against this Code of Conduct.** If anyone has any concerns about perceived Code of Conduct-related issues at the Symposium, please direct them to either TFTSG Chair Craig Stanford or TSA Chief Operating Officer Andrew Walde, who will discuss them with their teams.

Photo Policy

Photographers will be taking pictures at the conference, which may be used for promotional and educational purposes. Registration or participation in the meeting and other activities constitutes an agreement to allow TSA to use and distribute attendees' image or voice in photographs and recordings of the meeting — now and in the future.



If you are presenting...

Presenters, please plan on turning in your talk no later than the day **BEFORE** you present. No exceptions or last minute edits, please. To upload your talk online, please visit <http://bit.ly/2019tsaPresentations> Files should be named as Time_Day_LastName (ex: 1300_Fri_Smith). If that is not possible, talks will be accepted at the **Registration Desk** during the following times:

- August 4 – 3:00 PM – 6:00 PM
- August 5 – 8:00 AM – 4:00 PM
- August 6 – 8:00 AM – 4:00 PM
- August 7 – 8:00 AM – 1:00 PM

Contents of this Conference Program should be cited as:

Author. 2019. **Title.** In A.D. Walde and C.A. Jones (Eds.). Program and Abstracts of the Seventeenth Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles. Turtle Survival Alliance, Tucson, Arizona. pp. *xx-xx*.

Please visit the vendors, sponsors, and non-profits in the Exhibit Hall (Catalina Ballroom):

- Asian Turtle Program
- Desert Tortoise Council
- Holohil
- Mazuri
- Sonotronics
- Stoneridge Art Studios
- Turtle Conservancy
- the Turtle Room
- Turtle Survival Alliance
- Wildlife Materials, Inc.
- Zoo Med Laboratories

Conference Notes and Social Activities**Saturday, August 3**

- Registration 3:00 PM – 6:00 PM (Registration Desk)

Sunday, August 4

- Arizona Sonoran Desert Museum Field Trip – Bus Departs at 07:30 am
- Registration 3:00 PM – 6:00 PM (Registration Desk – Tortolita Room)
- Vendor Set up 2:00 PM – 5:30 PM (Catalina Ballroom)
- Auction Item Drop Off 3:00 PM – 5:30 PM (Catalina Ballroom)
- Poster Hanging 3:30 PM – 5:30 PM (Catalina Ballroom)
- Icebreaker 7:00 PM – 9:00 PM (Bill's Grill & Cascade Terrace)

Monday, August 5

- Registration 8:00 AM – 4:00 PM (Registration Desk – Tortolita Room)
- Auction Item Drop Off 8:00 AM – 1:00 PM (Catalina Ballroom)
- Exhibit Hall Open 8:30 AM – 6:00 PM (Catalina Ballroom)
- Poster Viewing 8:30 AM – 6:00 PM (Catalina Ballroom)
- Silent Auction Opens 4:00 PM (Catalina Ballroom)

Tuesday, August 6

- Registration 8:00 AM – 4:00 PM (Registration Desk – Tortolita Room)
- Exhibit Hall 8:00 AM – 4:00 PM (Catalina Ballroom)
- Poster Viewing 8:00 AM – 4:00 PM (Catalina Ballroom)
- Silent Auction #1 Closes 1:00 PM (Catalina Ballroom)
- Poster Session 3:30 PM – 5:30 PM (Catalina Ballroom)

- Silent Auction #2 Closes 5:00 PM (Catalina Ballroom)
- Drink Beer. Save Turtles. 6:00 PM – 9:00 PM (Hotel Congress Downtown!)

Wednesday, August 7

- Registration 8:00 AM – 1:00 PM (Registration Desk – Tortolita Room)
- Auction Payment / Pick-up 8:00 AM – 1:00 PM (Catalina Ballroom)
- Exhibit Hall Open 8:00 AM – 4:00 PM (Catalina Ballroom) *Please note – This is your last chance to purchase a TSA T-shirt or other conference souvenir!*
- Poster Viewing 8:00 AM – 12:00 PM (Catalina Ballroom)
- Silent Auction #3 Closes 1:00 PM (Catalina Ballroom)
- Poster Breakdown 12:00-1:00 PM (Authors, please take down your posters at this time. Any posters left behind will be discarded.)
- Cocktail Reception 5:30 PM – 6:30 PM (Grand Ballroom Foyer)
- Awards Banquet 6:30 PM – 9:30 PM (Grand Ballroom B & C).

Thursday, August 8

- Auction Payment / Pick-up 8:00 AM – 1:00 PM (Catalina Ballroom)

Support the TSA!

Be sure to visit the TSA merchandise tables in the Exhibit Hall (Catalina Ballroom) while you are here! Purchases of T-shirts, prints, and other items that benefit the TSA and its conservation programs. A cashier is available for TSA merchandise purchases anytime that the Registration Desk is open. Credit cards, debit cards, checks, or cash are accepted.

Auction Notes

The silent auction is always a fun part of the TSA Conference, plus it generates funds to help support the TSA's conservation programs. The silent auction will take place on Monday - Wednesday in the Exhibit Hall (Catalina Ballroom), in three segments.

Thanks to all of you who have items that you are donating to this cause. If you were not able to complete the auction form online prior to your arrival, you can do so at the auction drop-off table in the Exhibit Hall (Catalina Ballroom). Please note: no auction items can be accepted without completing this process! Auction items will be accepted from 3:00-5:30 on Sunday and from 8:00 AM-1:00 PM on Monday. **It is very important that you get your items turned in during this time!** This will allow our volunteers enough time to catalog each donation and make sure that everything runs smoothly.

To our lucky winners: auction items may be paid for and picked up in the Exhibit Hall from 8:00 AM – 1:00 PM on Wednesday.

Social Media

Stay up to date on the latest in turtle conservation news by following us on social media.

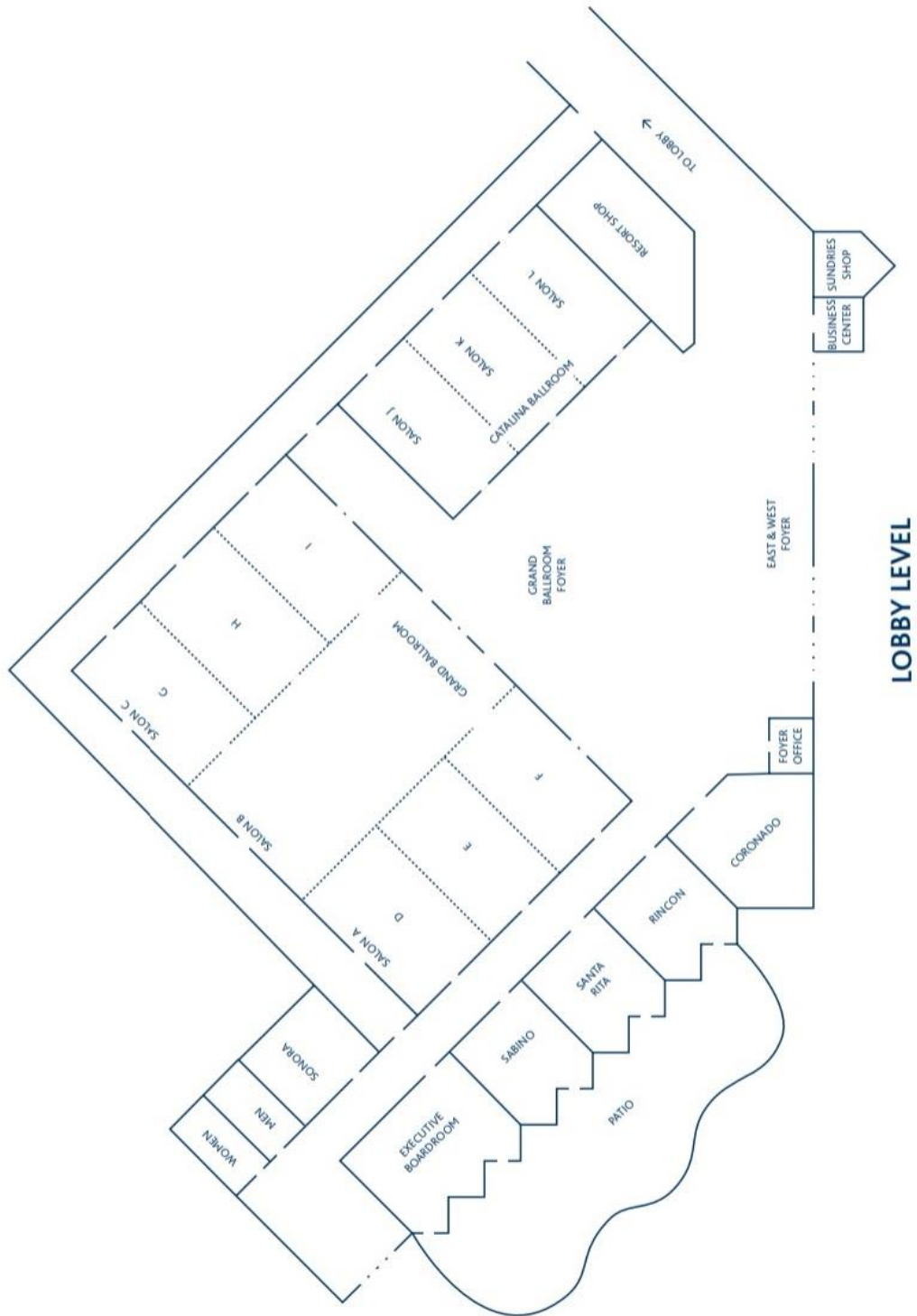
On Facebook: <http://www.facebook.com/TurtleSurvival>

Twitter: @TurtleSurvival

Instagram: @turtlesurvival

Join the conversation! Use #TSA2019 when you post or tweet about the meeting or to follow along!

Loews Ventana Canyon Resort



Conference Schedule Overview

Sunday August 4		Sunday August 4	Monday August 5	
7:30	<u>TCF Board</u> (Closed)	<u>Arizona Sonoran Desert Museum Field Trip</u> <u>Departs at 7:30 am</u>	Opening Address and Welcome TFTSG USFWS Funding	
8:00				
8:30				
9:00				
9:15				
9:30	<u>TSA Board</u> (Closed)			Global Conservation Status of Turtles and Tortoises
9:45				What Keeps me up at night?
10:00				Break/Posters
10:15				Keynote Address Shi Haitao
10:30				
10:45				
11:00				
11:15				
11:30				Lunch
11:45				
12:00				
12:30	Lunch	<u>Field Trip Returns to Hotel</u>		TSA in the Field
13:00	<u>TSA Board</u> (Closed)			
13:30				
13:45				
14:00				
14:15				
14:30				
14:45				
15:00			Break/Posters	
15:15			<u>Registration In Lobby</u> (open until 18:00)	
15:30				
15:45				
16:00				
16:15				
17:00				
17:30	Icebreaker Social (Bill's Grill and Cascade Terrace)			
19:00				
21:00				

Conference Schedule Overview

	Tuesday August 6-A	Tuesday August 6-B	Wednesday August 7-A	Wednesday August 7-B	Thursday August 8
8:30	Morning Announcements				
8:45	Turtles of the Southwest	Genetics	Population Manipulations	Captive Husbandry	Morning Announcements
9:00					Closing Plenary Session
9:15					
9:30					
9:45					
10:00					
10:15	Break/Posters	Break/Posters	Break/Posters	Break/Posters	Break
10:30	Turtle of the Southwest	Ecology	Field Studies	Conservation Planning	Closing Plenary Session
10:45					
11:00					
11:15					
11:30					
11:45					
12:00	Lunch	Lunch	Lunch	Lunch	End of Program
13:00	A Look Under the Shell	Reproduction Studies	Population Assessments	Habitat Protection	
13:15					
13:30					
13:45					
14:00					
14:15					
14:30	Organic Conservation	Techniques	Population Assessments	Documented Declines	
14:45					
15:00					
15:15					
15:30	Poster Session				
16:00					
17:00					
17:30					
18:30	Drink Beer. Save Turtles. Club Congress (6:00 – 9:00)		Banquet and Awards At Loews Ventana Canyon		
21:30					

Daily Schedule			
	Sunday August 4	Sunday August 4	Monday August 5
	Executive Board Room		Salon B/C
8:30	TCF Board (8:00 – 9:00) (Closed)	Arizona Sonoran Desert Museum Field Trip Meet in Ballroom Foyer at 07:15 Bus departs at 07:30. Bus returns to Hotel by 13:30	Turtle Survival Alliance - Opening Address
9:00			TFTSG - Update
9:15			New Funding Opportunities for Freshwater Turtles and Tortoises with U.S. Fish and Wildlife Service EARL POSSARDT
9:30	Global Conservation Status of Turtles and Tortoises ANDERS RHODIN		
10:00	What Keeps Me Up At Night? Thoughts on Improving the Long-Term Outlook for Turtles and Other Herpetofauna K BUHLMANN		
10:15	Break & Posters		
10:30	KEYNOTE ADDRESS SHI HAITAO		
11:15	Beyond Legends and Lament: Human Societies and the Yangtze Giant Softshell Turtle (<i>Rafetus swinhoei</i>) from the Neolithic through the Present Day JADA KO*		
11:30	Lunch		
12:00			TSA In the Field Chair: R. Hudson
13:00	TSA Board (9:30 - 17:00) (Closed)		Implementation of a River Turtle Monitoring Program in India R DUBLA (D RIEDLE)
13:15			Viability Analysis of a Sustainable Egg Harvest Program of <i>Podocnemis expansa</i> by the Community of La Virgen (Colombia) I VALENCIA
13:30			Raising captive born Central American River in Belize J SERANO*
13:45			Chelonian Conservation in Bangladesh – Program Updates S TRAGESER
14:00			Madagascar Update R HUDSON/C GRIFFOEN
14:15			Saving Cambodia’s Royal Turtle (<i>Batagur affinis</i>) C DOAK
14:30			Break
14:45			Batagur Conservation Chair: S Singh & A Walde
15:00			Protecting the Red-crowned Roofed Turtle, <i>Batagur kachuga</i> on the Chambal River S SINGH
15:30			Lessons learned in restoring <i>Batagur trivittata</i> to the Chindwin River of Myanmar S PLATT
15:45	Data from Post-Release Monitoring Improves Conservation of <i>Batagur affinis</i> in the Sre Ambel River System, Cambodia S SOM		
16:00	Recovering Northern River Terrapin, <i>Batagur baska</i> in Indian Sunderbans S SINGH		
19:00	Community-based Southern River Terrapin Conservation in Malaysia P CHEN		
21:00	Painted Terrapin Conservation Program in Sumatra, Indonesia J GUNTORO		
		Icebreaker Social (Bill’s Grill and Cascade Terrace)	

*Indicates Student Presentation for Student Awards Competition

Daily Schedule		
	Tuesday August 6 – Salon B	Tuesday August 6- Salon C
8:30	Morning Announcements	Morning Announcements
	<i>Turtles of the Southwest</i> Chair: C.A. Jones	<i>Genetics</i> Chair: D. Gaillard
8:45	Exploring Demographic Strategies of Yellow Mud Turtles in Texas J A ZENOR*	A Preliminary Examination of Codon Bias in Turtles V NGUYEN
9:00	Ecology of the Sonoyta Mud Turtle in the Sonoyta River, Mexico M A GRAGEDA*	Taxonomic Hide and Seek: Brought to you by <i>Cuora amboinensis</i> D GAILLARD
9:15	Preliminary Range Wide Assessment of Sonoran Mud Turtle P STONE	Conservation Genetics of Two Imperiled Graptemys Species L PEARSON*
9:30	Sonora Mud Turtle (<i>Kinosternon sonoriense sonoriense</i>) - An Example to Promote Multidisciplinary Science and Collaboration A SMITH	Conservation Genetics of Home's Hinge-back Tortoise, Central Ghana J KITTLE*
9:45	Ecology of the Arizona Mud Turtle on the Arizona-Sonora Border M JONES	Population Genetics of Two <i>Sternotherus</i> in the Pascagoula River G Brown*
10:00	How Useful are Scute Annuli for Estimating Demographic Parameters in Southwestern Turtles? R KAZMAIER	
10:15	Break & Posters	Break & Posters
	<i>Turtles of the Southwest (Cont.)</i>	<i>Ecology</i> Chair: C Doak
10:30	A Direct Role for Former Captives in Wild Conservation: Are Desert Tortoises Candidates K FIELD	Exploring Multilevel Habitat Selection by Flattened Musk Turtles (<i>Sternotherus depressus</i>): Informing Future Conservation Efforts J JENKINS*
10:45	Landscape Perspectives on the Role Invasive Species Play on the Growth and Health of Mojave Desert Tortoises T ESQUE	Assessing Suitability of Alligator Snapping Turtle Reintroduction Sites in Eastern Oklahoma K VOVES*
11:00	Population Genomic Analysis of Speciation Among Threatened Desert Tortoises G DOLBY	Use of saline environments by freshwater turtles: implications of sea level rise M AGHA
11:15	Are Painted Turtles (<i>Chrysemys picta</i>) Native in Arizona: a Review of the Evidence K CUMMINGS	Effects of Non-native Pond Sliders (<i>Trachemys scripta</i>) on Native Sonora Mud Turtles (<i>Kinosternon sonoriense</i>) P ROSEN
11:30	Reducing Common Raven Predation Pressure on the Desert Tortoise K HOLCOMB	Gopher Tortoise Demographic Responses to a Novel Disturbance H HOWELL
11:45		
12:00	Lunch	Lunch
	<i>A Look Under the Shell</i> Chair: S. Carstairs	<i>Reproductive Studies</i> Chair: D. Thompson
13:00	A Comparison of Hematology and Plasma Biochemistry of Alligator Snapping Turtles in Wild, Reintroduced, and Captive Populations S HANNABASS*	Seasonal Activity Patterns and Reproductive Cycles in a Captive Population of Alligator Snapping Turtles D THOMPSON
13:15	Innate Immunity of Eastern and Ornate Box Turtles M MERCHANT	Raccoons Reveal Repertoires Nesting Turtles have for Climate Change JS DOODY
13:30	Site Specific Differences in Health and Immune Function in Eastern Box Turtles (<i>Terrapene carolina carolina</i>) S BAKER	Effects of Constant Incubation Temperature on Life History Traits of the Six-Tubercled Amazon River Turtle Pre- and Post-hatching C CAMILLO*
13:45	Biodiversity of Apicomplexan Blood Parasites of Tortoises (Testudinidae): A Neglected Group C COOK	Comparative Reproductive Allometry of Black-Knobbed Sawbacks and Alabama Map Turtles, With Comparison to Three Congeners P LINDEMAN
14:00	The Role of Gut Microbial Symbionts in Alligator Snapping Turtle Hatchling Growth and Digestive Efficiency K SARDINA	Investigating Reproductive Output of Crowned River Turtle (<i>Hardella thurjii</i>) in Saryu River in India A SINGH*
14:15	Break & Posters	Break & Posters
	<i>Organic Conservation</i> Chair: M. Dupuis Desormeaux	<i>Techniques</i> Chair: P. Cain
14:30	Citizen Science in Turtle Road Mortality and Nesting Monitoring M DUPUIS-DESORMEAUX	Relocating Traps within a Wetland Increases Trapping Success E Hollender*
14:45	The Power of Community: A Grassroots Effort to Restore Native Populations of Northern Diamondback Terrapin J LIU	Estimating Population Size of a Threatened Turtle Using Citizen Science M CROSS
15:00	Use and Traditional Knowledge of the Bolson Tortoise R PALOMO-RAMOS*	Using Stable Isotopes to Study Freshwater Turtle and Tortoise J Seminoff
15:15	If You Build It, They Will Come: Private Habitat Restoration J IVERSON	Utilizing do-it-yourself open-source technologies P CAIN
15:30-17:30	POSTER SESSION	

*Indicates Student Presentation for Student Awards Competition

Daily Schedule		
	Wednesday August 7 – Salon B	Wednesday August 7 – Salon C
8:30	Morning Announcements	Morning Announcements
	Population Manipulations Chair: L Paden	Captive Husbandry Chair: S. Enders
8:45	Ontogeny of Movement Behavior in Alligator Snapping Turtles: Insights from a Reintroduced Population E KESSLER*	A Reproductive History of Rote Island Snake-necked Turtles (<i>Chelodina mccordi</i>) at the Turtle Survival Center C HAGEN
9:00	Movement and Behavior of Translocated Adult Alligator Snapping Turtles in the Choctawhatchee River, Florida R COZAD	Digital Chelonian Log: Making Data-keeping Accessible and Sharable to Both the Hobbyist and the Professional K LABILLE
9:15	Assessing Survival and Health of Translocated Gopher Tortoises R MCKEE*	Do spiny softshell turtles engage in “false Crawls” during the nesting season? M FELDMAN
9:30	A Spatial Assessment of Resident and Translocated Gopher tortoises (<i>Gopherus polyphemus</i>) using GPS Loggers L PADEN	The <i>Cuora galbinifrons</i> , <i>Cuora bourreti</i> , and <i>Cuora picturata</i> Studbooks: Population Status, Genetics and Successful Reproduction L AUGUSTINE
9:45	Post-release Movement and Survival of Differentially Head-started Mojave Desert Tortoises: Preliminary Results P MCGOVERN*	Successful Methods of Captive Management and Reproduction of the Bowsprit Tortoise, <i>Chersina Angulata</i> D STERANTINO
10:00	Population Viability Analysis and the Role of Head-starting for a northern Illinois Blanding’s Turtle Population J ROSS	
10:15	Break & Posters	Break & Posters
	Field Studies Chair: B. Atkinson	Conservation Planning Chair: B. Horne
10:30	Autecological Study of Gulf Coast Box Turtles in the Florida Panhandle Reveals Unique Spatial and Behavioral Characteristics J MECK	Conservation of <i>Chelodina mccordi</i> : Current Population and Habitat Assessment of Critically Endangered Turtle in Rote Island M AS-SINGKILY
10:45	Long-distance and Fine-scale Movements of Wood Turtles T AKRE	A Species on the Periphery: Gopher Tortoise Conservation in Louisiana K LEJEUNE
11:00	The Effect of Roads on the Distribution and Behavior of Desert Tortoises in Joshua Tree National Park S PUFFER	Florida Turtle Conservation Trust: Conserving Florida’s Rich Turtle Diversity Since 1999 G HEINRICH
11:15	Ecological Roles of the Southeast Asian Box Turtle N KARRAKER	Collaborative Conservation Planning in the Northeastern United States JD KLEOPFER
11:30	Flagler College Helping Hicatees: A Partnership with the Belize Foundation for Research and Environmental Education B ATKINSON	Rescue and Conservation of Tortoises and Freshwater Turtles at the Turtle Conservation Center, Cuc Phung National Park, Vietnam N THUY
11:45		What are WCS Brazil Activities to Save Turtles? C FERRARA
12:00	Lunch	Lunch
	Population Assessments Chair: E. Munscher	Habitat Protection Chair: C. Stanford
13:00	Distribution and Abundance of the Alligator Snapping Turtle (<i>Macrochelys temminckii</i>) in Mississippi L PEARSON*	Strategies for Private Land Conservation in the Tropical Deciduous Forest of Alamos, Sonora, Mexico J MACKAY
13:15	Turtle Assemblages of Lowland Habitats in Northeastern Louisiana B GRIZZLE*	Land for Survival of the Last Tiny Self-Sustaining Wild <i>Pseudemys umbrina</i> Population G KUCHLING
13:30	Community Structure of Freshwater Turtles across Four River Drainages in Mississippi L HARALSON*	The Nexus Between Buying Critical Habitat and Long-Term Management: The Geometric Tortoise (<i>Psammobates geometricus</i>) Ecosystem Preserve in South Africa. J JUVIK
13:45	Ecology of the Yucatán Box Turtle in Yucatán M JONES (L WILLEY)	Protection and Recovery of Agassiz’s Desert Tortoise at the Desert Tortoise Research Natural Area and Adjacent Critical Habitat K BERRY
14:00	Population Ecology of the Mexican Spotted Wood Turtle (<i>Rhinoclemmys rubida perixantha</i>) in the Pacific Coast of Mexico R MACIP-RIOS	The Bolson Tortoise Ecosystem Preserve: a Simple Concept with Not-so-simple Implementation P van Dijk
14:15	Break & Posters	Break & Posters
	Population Assessments (cont.)	Documented Declines Chair: K Holcomb
14:30	Population Dynamics of Gopher Tortoises on Cumberland Island J ENZ	Where are the Turtles? Looking for Western Chicken Turtles in Mississippi D MCKNIGHT
14:45	Twenty Years of Turtle Surveys at Rock Springs and Wekiwa Springs in Florida JB HAUGE	Large-Scale Poaching of Northern Diamondback Terrapins in NJ R WOOD
15:00		Long-term Changes in Population Structure and Space use in three Spotted Turtle Populations: Revisiting Graham and Milam and Melvin L WILLEY
15:15		Reassessment of the Florida Box Turtles (<i>Terrapene bauri</i>) on Egmont Key M JONES (J MAYS)

* Student Considered for Student Awards Competition

Daily Schedule	
Thursday August 8 – Salon B/C	
8:55	Morning Announcements
	<i>Closing Plenary</i> Chair: L Paden
9:00	Ranavirus, Research, and Rehabilitation: The Interconnectedness of Conservation Strategies S CARSTAIRS
9:30	Snapping Out at Overexploitation: Conserving Wild Turtles with Citizen Petitions E BENNET
10:00	Uniting Genomics to Provide an Integrative Solution for <i>Pseudemys</i> Systematics P SCOTT
10:15	Break
10:30	Restoring Nesting Areas on the E. S. George Reserve to Reverse the Decline in Nesting Survivorship That Threatens Population Stability of Painted, Blanding's and Snapping Turtles J CONGDON
11:00	Rapid Demographic Assessments for Freshwater Turtles: Filling in Data Deficiencies M DRESLIK
11:30	Challenges in Conservation and Recovery of Desert Tortoises: The Importance of Long-term Studies R AVERILL MURRAY
12:10	End of Program

Poster Presentations (Catalina Ballroom)	
Poster Session Tuesday, August 6th at 1530 h	
A Comparison of the Gut Microbiome among hatchlings, juveniles, and adults of the Herbivorous <i>Dermatemys mawii</i> : Next Generation Sequencing of a Novel System N BISHOP*	Demographics and Recruitment Patterns in a Reintroduced Population of Alligator Snapping Turtles (<i>Macrochelys temminckii</i>) M BLASKY*
Comparing Novel and Traditional Sampling Methodologies to Assess the Population Status of the Rio Grande Cooter, <i>Pseudemys gorzugi</i> A BOGOLIN*	Investigating the Aggressive Interactions of Two <i>Sternotherus</i> Species in the Pascagoula River Drainage G BROWN*
Clutch Size in an Illinois Ornate Box Turtle (<i>Terrapene ornata</i>) Population D EDMONDS*	Tracking the Movement of Western Alligator Snapping Turtles (<i>Macrochelys temminckii</i>) in a Unique and Atypical Urban Habitat, Buffalo Bayou, Houston, Texas V GLADKAYA
Assessing Fertility Patterns in a Captive Population of Alligator Snapping Turtles (<i>Macrochelys temminckii</i>) A GRATE*	Movement Patterns of the Florida Peninsula Cooter (<i>Pseudemys floridana peninsularis</i>) and the Florida Red-belly Turtle (<i>Pseudemys nelsoni</i>) Found in a Central Florida Spring System. T HOOTMAN*
Common Snapping Turtle Activity Patterns E HOLLENDER*	Proof of Dispersion over the sea of the freshwater turtles, red-eared slider and Reeve's pond turtle in japan. S KABURAGI*
Feeding strategies of the alien species, the red-eared slider, (<i>Trachemys scripta elegans</i>), in Japan N KAMEZAKI	The Influence of Age and Season on Basking in Alligator Snapping Turtles (<i>Macrochelys temminckii</i>) E KESSLER*
Bite force scaling across size classes in the alligator snapping turtle (<i>Macrochelys temminckii</i>) and the common snapping turtle (<i>Chelydra serpentina</i>) S LAGRANGE	Variation in Turtle Shell Shape A LICHTIG
A Consistent Relationship Between the Forelimb Proportions and Carapace Width in Turtles A LICHTIG	Home Range and Movement Dynamics of Two Populations of Spotted Turtle (<i>Clemmys guttata</i>) at the Southern Extent of Their Range J MAYS
Preliminary Results of a Long-term Freshwater Turtle Population Study in New Jersey J PIGNATELLI	An Overview of the Pennsylvania Amphibian and Reptile Survey: with a Special Focus on Turtles B RUHE (A WEBER)
Clinal Variation in Shell Morphology in a Musk Turtle Species (<i>Sternotherus peltifer</i>) M WELC*	Comparison of Body Size of Turtles in Different Habitats F XIAO
*Student Considered for Student Awards Competition	

Use of Saline Environments by Freshwater Turtles: Implications of Sea Level RiseMICKEY AGHA¹, JOSHUA R. ENNEN², AND BRIAN D. TODD¹¹*Department of Wildlife, Fish, and Conservation Biology, University of California, Davis, One Shields Avenue, Davis, California 95616 USA*²*Tennessee Aquarium Conservation Institute, 175 Baylor School Road, Chattanooga, Tennessee 37405 USA [magha@ucdavis.edu]*

Sea level rise (SLR) places many coastal vertebrates at risk, most notably species that are rather intolerant to increases in salinity – freshwater turtles. Freshwater turtles are disproportionately more threatened than any other taxa, thus, understanding their interaction with SLR, salinity, and habitat modification should be a research priority. To address this conservation issue, we investigated freshwater turtles and their present and predicted vulnerability to end of century SLR along coastlines via an exhaustive literature review, predicted range impact analysis, experimental test of their osmoregulatory response to elevated salinities, and a field assessment of their interactions with tidal marsh hydrological regimes. Our literature review suggested that some species exhibit potential for adaptation and plasticity in physiological, behavioral, and life history traits that enable them to endure short periods and levels of saltwater exposure. Our SLR analysis suggested that approximately 90% of coastal freshwater turtle species will be impacted by a 1-m increase in global mean SLR by 2100. Our experimental study revealed that freshwater turtles from coastal estuarine populations along the western US coast can tolerate varying levels of salinity and regulate their plasma osmolality via reduced feeding and drinking. However, rapid mass loss after two weeks of chronic exposure to elevated salinities suggested that these responses are unlikely to be effective under salinities expected from projected SLR. Finally, our field study suggested that freshwater turtle activity decreases with daily and seasonal increases in salinity. In sum, these studies move us closer towards understanding the ecological and evolutionary processes that have prolonged the existence of freshwater turtles in coastal saline habitats and may prove useful in predicting their response to a changing world.

Ecology: Oral**Long-distance and Fine-scale Movements of Wood Turtles (*Glyptemys insculpta*) in Virginia and Minnesota**THOMAS AKRE¹, JONATHAN DRESCHER-LEHMAN^{1,2*}, CHRIS FLEMING¹, DONALD BROWN^{3,4}, RON MOEN⁵, AND MADALINE COCHRANE⁵¹*Conservation Ecology Center, Smithsonian Conservation Biology Institute, Front Royal, Virginia USA*²*Department of Biology, George Mason University, Fairfax, Virginia USA*³*School of Natural Resources, West Virginia University, Morgantown, West Virginia USA*⁴*Northern Research Station, U.S. Forest Service, Parsons, West Virginia USA*⁵*Natural Resources Research Institute, Department of Biology, University of Minnesota-Duluth, Duluth, Minnesota USA [LehmanJ@si.edu]*

Little is known about long-distance dispersal movements in freshwater turtles, despite the probable importance of such movements for gene flow between populations. Individuals are rarely tracked long enough or frequently enough to record such movements, especially at a fine temporal scale. There is a pressing need to better understand these movements, with an increasingly fragmented landscape posing deadly threats to turtles wandering over land. This study aimed to look at these and other long-distance movements by tracking the movements of wood turtles (*Glyptemys insculpta*) using miniaturized GPS units attached to their shells. In addition to looking at long-distance movements, the data were used to estimate home range sizes and movement speeds using powerful new statistical techniques, as well as to analyze the shift in these metrics throughout an active season. In total, 61 wood turtles (38 females, 23 males) were tracked for one to three years each, with hourly or sub-hourly locational fixes recorded for the duration of the active season. Two datasets, one from Minnesota (n=25) and one from Virginia (n=36), were combined for a total of over 140,000 GPS locations. Overall, our results show that traditional measures of home range significantly underestimated actual home range sizes. Both home range size and movement speed for females increased temporarily during the nesting season while range-resident males showed much less variation. We captured numerous long-distance nesting movements, two long-distance relocation movements following flood displacement events, and two long-range dispersal events by younger male turtles. Our data demonstrates the magnitude of dispersal movements (>13 km within a year) as well as the dangers inherent in them. It also indicates

the potential of modern GPS technology for studying turtle movement and points toward the need for further studies with more individuals over longer timeframes.

Field Studies: Oral

Conservation of *Chelodina mccordi*: Current Population and Habitat Assessment of Critically Endangered Turtle in Rote Island, East Nusa Tenggara, Indonesia

MASLIM AS-SINGKILY¹, KURNIA LATIFIANA², KAYAT³, TIMBUL BATUBARA⁴, AND BRIAN D. HORNE⁵

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We investigated the current population size and habitat quality of the Rote Island Snake-Necked Turtle, *Chelodina mccordi*. Since it was recognized in 1994, only limited data on population size and habitat utilization has been published. Ten remaining lakes (Peto, Ledulu, Lendoen, Oenduy, Ina, Anak, Tua, Naluk, Kolli, and Seda) on Rote Island were surveyed both wet and dry season in 2016-2018. We assessed the lakes vegetation, water quality, and land change to identify any remain suitable habitat and threats to the turtles. Visual encounter surveys and various hoop traps were applied in turtle population surveys. The tree diversity associated with the lakes was dominant by two species; white paperbark species (*Melaleuca leucadendra*) (IVI 208.26) and yellow cheesewood (*Nauclea orientalis*) (IVI 103.8). Three lakes; Peto, Ledulu, and Lendoen were categorized as unpolluted using standard water quality for freshwater ecosystems. The spatial distribution pattern of land change (LC) in Rote Island during the year 1996 to 2016 showed a decrease on the total of high canopy density of 55.57% (6,190.85 ha) and the middle canopy density of 37.33% (7,025.76 ha). The increasing occurred on total area of settlement and agriculture about 31.19% (6,305.04 ha). This increasing of settlement and agriculture negatively impact on freshwater availability. The total area of open freshwater decreased 79.17% with overall loss about 121.5 ha. We were unable to detect any turtles in the lakes while visual survey also failed to find any evidence of the existence of the turtles. Unfortunately, we found an introduction to non-native fish species; snakehead (*Channa striata*), catfish (*Clarias batrachus*), and tilapia (*Oreochromis mossambicus*); almost on every lake on the Island. Predation activity of snakehead on turtle was also reported by the local community in Peto Lake in the 2000s. A short-monitoring resulted that fishing activity by the local fishermen seems to be partially successful in limiting the abundance of snakehead and catfish in Ledulu. As the population on the island possibly extinct in the wild, reintroduction is crucial to recover the species from extinction. Restoration and protection of the remaining lakes should be considered for conserving the habitat.

Conservation Planning: Oral

Flagler College Helping Hicatees: A Partnership with the Belize Foundation for Research and Environmental Education

BENJAMIN K. ATKINSON

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Central American River Turtles (*Dermatemys mawii*) are critically endangered freshwater chelonians endemic to Mesoamerica. Known locally as “hicatees,” they are the sole surviving members of the family Dermatemydidae. Harvest for consumption has created unsustainable pressure on wild populations, despite expansive intact habitat within their native range. The Turtle Conservation Coalition lists *D. mawii* as one of “the 25+ most endangered tortoises and freshwater turtles worldwide.” In 2016, a team of invited wildlife biologists and veterinarians assisted in filming *Hope for Belize’s Hicatee: Central American River Turtle*. At that time we conducted health and reproductive assessments on a captive breeding/headstart population at the Hicatee Conservation Research Center (HCRC) of the Belize Foundation for Research and Environmental Education (BFREE). The BFREE staff and I envisioned a long-term partnership with Flagler College. We now facilitate conservation goals of the HCRC by providing study abroad opportunities for qualified undergraduates. Long-term benefits and immediate gains can be achieved by pairing passionate students with imperiled turtles. Belize offers unique aspects that make it ideal for such high impact experiences. It is the only Latin American country with English as its official language. This

allows students to engage in cultural immersion without experiencing a communication barrier. Additionally, the proximity of Belize to Florida makes airfare inexpensive as compared to many other international destinations. Further, BFREE facilities demonstrate sustainable off-the-grid living in a tropical rainforest among the Maya Mountains. Flagler's "Belize Wildlife Ecology" study abroad course is the world's first to focus primarily on hicatee conservation biology. Hands-on opportunities for undergraduates to work with endangered reptiles are rare. Techniques learned at BFREE are essential to development of potential herpetologists. Students return with a grasp on both the daunting challenges and exciting opportunities often faced in the world of wildlife conservation. I will highlight our early success, discuss lessons learned, and share student perspectives on these experiences to date.

Field Studies: Oral

The *Cuora galbinifrons*, *Cuora bourreti*, and *Cuora picturata* Studbooks: Population Status, Genetics and Successful Reproduction

LAUREN AUGUSTINE

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The genus *Cuora* includes some of the world's most endangered chelonians. The Indochinese box turtles of the *Cuora galbinifrons* complex (Testudines: Geoemydidae) are critically endangered and genetic analysis of five historically recognized subspecies of *C. galbinifrons* found that three major mitochondrial DNA clades correspond to the three subspecies, *C. galbinifrons*, *C. bourreti* and *C. picturata*. These findings in conjunction with previously described morphological distinctions led the authors to recommend the elevation of these three subspecies to full species. These taxonomic changes have several consequences when planning conservation efforts including *ex situ* captive breeding ramifications. If these three species, *C. galbinifrons*, *C. bourreti* and *C. picturata* represent independent evolutionary lineages, than captive breeding programs need to reflect this in the recommended globally integrated breeding colonies. In North America, the captive populations of *C. bourreti*, *C. galbinifrons* and *C. picturata* are managed by a Species Survival Plan (SSP) of the Association of Zoos and Aquariums (AZA), and individuals are documented in their respective AZA studbooks. Since separating these species for management in 2006, data collection, increased population sizes, and genetic evaluation have all proved to be valuable tools in managing these populations. This talk will provide a look into the current North American populations of these species, the results of the genetic analysis, and highlight some of the successful reproductive efforts in North America.

Captive Husbandry: Oral

**Challenges in Conservation and Recovery of Desert Tortoises:
The Importance of Long-term Studies**

ROY C. AVERILL-MURRAY

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The Mojave Desert Tortoise (*Gopherus agassizii*) and the Sonoran Desert Tortoise (*G. morafkai*) share similar life histories—high adult survival, low juvenile survival, delayed sexual maturity—and occur in the deserts of the U.S. Southwest. The Mojave Desert Tortoise was listed as Threatened under the U.S. Endangered Species Act in 1990. A recovery plan in 1994 prescribed several management and research recommendations necessary to achieve recovery. However, recommendations in a revised recovery plan in 2011 largely reiterated those from 1994, indicating that little progress had been made in the intervening 17 years. In addition, populations continue to decline across much of the Mojave Desert Tortoise's range. A substantial reason for this apparent lack of progress is the complexity of tortoise life history, threats, and management. Conservation of the Sonoran Desert Tortoise faces similar complexities, even though it is not listed under the ESA. Ultimately, low densities and low population growth rates make trend detection and the effects of management on desert tortoise populations difficult to evaluate over the short term. For species like desert tortoises, long-term approaches are necessary to understand fundamental questions of status and trend. Long-term studies are even more important to understand demographic processes that give rise to population trends and to determine the effectiveness of management actions in turning demography toward species recovery. My presentation will illustrate these points, highlighting case studies on long-term monitoring of tortoise populations and spatially explicit population viability analysis, extensive and intensive study of reproductive output,

and a long-term research program addressing linkages between habitat, management, and effects on desert tortoises. Focused, long-term research programs, as well as integrating smaller-scale projects over space and time, are necessary to make meaningful progress toward conservation and recovery of long-lived species like desert tortoises.
Closing Plenary: Oral

Site Specific Differences in Health and Immune Function in Eastern Box Turtles (*Terrapene carolina carolina*)

SARAH J. BAKER^{1,2,4}, LAURA ADAMOVICZ¹, MARK E. MERCHANT³, AND MATTHEW C. ALLENDER^{1,2}

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Eastern Box turtle (EBT; *Terrapene carolina carolina*) populations are declining throughout their range, likely as a result of interactions between habitat loss/fragmentation, road mortality, collection for the pet trade, and disease. The objectives of our study were to evaluate site specific differences in health and immune function of EBTs in Illinois. We hypothesized that turtles from smaller more fragmented populations would have higher disease prevalence and lower immune function than those from a large contiguous population. We conducted physical exams and disease testing on 507 turtles from 5 populations from 2016-2018. We screened turtles for four ranaviruses, three herpesviruses, *Mycoplasma* spp., and *Terrapene* adenovirus using qPCR. In 2018, immune assays were conducted on a subset of captured individuals. We quantified innate immune function by challenging turtle plasma with bacteria and sheep red blood cells (SRBC). We found turtles from the smaller more fragmented populations had higher prevalence of ranavirus, and their plasma had lower bacteria killing ability and lower hemolysis of SRBCs than we measured in the larger contiguous population. Low quality degraded habitats have been shown to promote disease persistence in wildlife populations. Therefore, our results suggest conservation plans for EBTs should focus heavily on improving habitat quality to reduce disease and increase overall wellness in these populations.

A Look Under the Shell: Oral

Snapping Out at Overexploitation: Conserving Wild Turtles with Citizen Petitions

ELISE PAUTLER BENNETT

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Wild collection is the primary driver of turtle declines around the world and an ongoing threat to freshwater turtles in the United States, particularly in the Southeast and Midwest. State wildlife laws are the frontline defense for wild turtles, yet many states still allow unlimited commercial trapping of at least one species. These loose rules permit overexploitation and enable illegal trafficking from surrounding states. A comprehensive network of commercial turtle trapping laws is needed to end unsustainable trapping and close loopholes exploited by poachers and traffickers. State administrative procedure laws and the common law public trust doctrine provide an avenue to seek stronger wildlife protections. The common-law public trust doctrine vests states with the power and duty to protect wildlife for the benefit of its citizens. In turn, citizens can ensure states uphold this duty through administrative procedure act petitions seeking more effective wildlife regulations. Since 2008, the Center for Biological Diversity and conservation partners have used these legal principles, supported by a body of scientific study demonstrating the risk of commercial harvest, to seek laws banning or regulating commercial turtle trapping. These petitions have yielded great successes and highlighted opportunities for future work. With increased understanding of harvest frequency and intensity in the remaining states, future citizen petitions can bring a state-level mantle of laws to protect freshwater turtle biodiversity within reach.

Closing Plenary: Oral

Protection and Recovery of Agassiz's Desert Tortoise at the Desert Tortoise Research Natural Area and Adjacent Critical Habitat**KRISTIN H. BERRY¹ AND RON BERGER²**¹*U.S. Geological Survey, 21803 Cactus Ave., Suite F, Riverside, California 92518 USA*²*Desert Tortoise Preserve Committee, Inc., 4067 Mission Inn Ave., 4067 Mission Inn Blvd., Riverside, California 92501 USA**[kristin_berry@usgs.gov]*

In 1980, the Desert Tortoise Research Natural Area, a 102 km² mix of private parcels and public land administered by U.S. Bureau of Land Management, was formally designated by the U.S. Congress. Public lands were withdrawn from mining and grazing, closed to recreation vehicle use, a wildlife-permeable boundary fence was constructed, and interpretive kiosk and nature trails were established for education and recreation. A major effort to acquire inholdings and expand the original size has continued for >45 years with many partners. This protected area for Agassiz's Desert Tortoise became the site for a 34-year research project comparing tortoise populations and habitat inside and outside the Natural Area fence in a 7.77 km² plot in a before-and-after, control-impact research project. Outside the fence, tortoise populations experienced grazing, recreation vehicle use, and road traffic. After 1979, tortoise populations both inside and outside the fence declined, with the low point reached in 2002. Subsequently, the population inside increased in density, while the population outside continued downward. At the study end, the total population and breeding females were 3X higher inside than outside the fence. Causes of declines were excessive mortality and loss from collecting, vehicle kills, vandalism, gunshot, avian and mammalian predation, and disease. Hyperpredation by the Common Raven and infectious diseases were major drivers of deaths. The fence was effective in allowing recovery of habitat inside the Natural Area while outside the habitat deteriorated. Tortoise densities outside the fence were similar to those observed in critical habitat and were nonviable. The Natural Area has value beyond protection of the tortoise: protected habitat for the rare and endemic Mohave ground squirrel and Barstow woolly sunflower, burrowing owl and other sensitive species. The Natural Area is a major research site for tortoises and other species and for education; first discoveries of hyper-predation by the Common Raven on juvenile tortoises, upper respiratory tract disease (mycoplasmosis), sheep trampling, baseline health and physiology of tortoises, and selective choices of plant foods were made here.

Habitat Protection: Oral**A Comparison of the Gut Microbiome among Hatchlings, Juveniles, and Adults of the Herbivorous *Dermatemys mawii*: Next Generation Sequencing of a Novel System****NICHOLE D. BISHOP¹ AND RAYMOND R. CARTH²**¹*School of Natural Resources and Environment, University of Florida, Gainesville, Florida USA*²*U.S. Geological Survey, Florida Coop Fish and Wildlife Unit, University of Florida, Gainesville, Florida USA [n00051891@ufl.edu]*

Plant-based diets are generally low-quality due to the high percentage of refractory material present in plant cell walls. Because vertebrates lack endogenous enzymes capable of breaking down plant structural carbohydrates (e.g. cellulose), they must rely on endosymbiotic gut microflora (GMF) to metabolize nutrients that would otherwise be unavailable. Due to limitations posed by plant-based diets, herbivorous turtles (both fresh-water and marine) undergo ontogenetic dietary shifts from carnivorous or omnivorous hatchlings to herbivory as adults. However, the critically endangered *Dermatemys mawii*, or "hicatee", is herbivorous throughout its entire life, a feature unique to this genus among fresh-water turtles. The purpose of our study was to characterize the gut microbiome of different age classes for *D. mawii* and to assess whether there are ontogenetic shifts in the microbiome composition as the turtle ages. To do so, we employed high-throughput sequencing of the 16S rRNA V3-V4 hypervariable regions. Fecal samples (used as proxy for GMF) from hatchlings, juveniles, and adults were collected from a captive population of hicatee turtles in Belize and stored in RNAlater (field) and at -80°C (laboratory). Bacterial DNA was extracted, amplified, and purified. We then indexed and purified the amplicons in preparation for Next Generation Sequencing on the MiSeq (Illumina) platform. This study is currently underway and we plan to present our full results at the 2019 TSA Symposium. Our preliminary results indicate that the GMF is dominated by two phyla: Bacteroidetes and Firmicutes. These two phyla have been found across taxa as important contributors to the gut microbiome. We anticipate that GMF composition will differ among hatchlings, juveniles, and adults because body size constrains digestive efficiency. Therefore, smaller individuals (i.e. hatchlings) may rely on a different subset of

GMF to maximize their digestion and assimilation of plant material. Our study will be the first to characterize the gut microbiome of *D. mawii*.

Presentation type: Poster (student)

Demographics and Recruitment Patterns in a Reintroduced Population of Alligator Snapping Turtles
(*Macrochelys temminckii*)

MELISA P. BLASKY¹, BRIAN M. FILLMORE², AND DAY B. LIGON¹

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²USFWS Oklahoma Fish and Wildlife Conservation Office, Tishomingo, Oklahoma USA
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In conservation, the goal of reintroduction efforts is typically to re-establish a viable, self-sustaining population that provides the ecological services typical of the species. Post-reintroduction assessments are critical for determining the extent to which these objectives are met. In 2007, 249 adult and 16 head-started juvenile Alligator Snapping Turtles (*Macrochelys temminckii*) were translocated to the Washita River drainage in southeastern Oklahoma, a site where the species had been extirpated. Individuals were released into several permanent, semi-impounded wetlands along the river corridor that have connectivity with the river channel during periods of flooding. Post-release monitoring of this newly established population was conducted for 16 months following the release, and studies related to nesting and nest predation patterns have been conducted. To build upon these past monitoring efforts, we conducted surveys to assess patterns of recruitment 11 years after the initial translocation. Additionally, we analyzed feces of both new recruits and individuals that were part of the original reintroduction to characterize the dietary niche the species is occupying in our study population, and to compare it to that of diets of *M. temminckii* in other populations. We used baited hoop nets to capture and recapture turtles, and we estimated the age of subadult *M. temminckii* by counting scute annuli. In 2018, our effort totaled 325 trap nights and we captured 24 individual *M. temminckii*—four males, four females, and 16 juveniles whose sex could not be determined from external morphological characters. Of the 16 juveniles, 11 were new captures that we infer hatched from naturally-occurring nests. Fecal samples suggest that the turtles are primarily functioning as benthic detritivores; of 29 samples collected, only 13 samples indicated consumption of fish, and nearly all samples contained vegetation, seeds, and organic ‘muck’ that typify the substrates of the ponds we surveyed. Reliance on seemingly indiscriminate foraging from the benthos appeared to be higher than that reported from other populations.

Presentation type: Poster (student)

Comparing Novel and Traditional Sampling Methodologies to Assess the Population Status of the Rio Grande
Cooter, *Pseudemys gorzugi*

AMY BOGOLIN, RICHARD KLINE, MD SAYDUR RAHMAN, DREW DAVIS, AND ABDULLAH FAIZ RAHMAN

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Traditional sampling methodologies used to survey for turtle species are often time consuming, labor intensive, and invasive, limiting the amount of data that can be collected. The emerging technologies of drone surveys and environmental DNA (eDNA) analysis offer potential solutions to the shortfalls of traditional sampling by providing a minimally invasive and more diverse approach for wildlife detection. Little research has been conducted on *Pseudemys gorzugi*, but data suggests that populations are declining due to habitat destruction, pollution, and collection for the pet trade, and its conservation status is currently undergoing investigation by the United States Fish and Wildlife Service. We used a DJI Matrice 600 pro drone with a digital camera attachment, the SONY ILCE α6000, to conduct aerial surveys along the Rio Grande and its tributaries in south and west Texas for visual detection of *P. gorzugi*. Imagery was analyzed to differentiate between sympatric turtle species and the number of turtles detected was quantified. Water samples were also collected at these sites and analyzed through a PCR amplification procedure to determine if *P. gorzugi* eDNA was present. Additionally, traditional survey methods including visual surveys and baited hoop-net trapping were conducted, and comparisons were made between number of detections to determining sampling efficacy. Initial research has confirmed that the eDNA analysis is able to detect *P. gorzugi* and detection and quantification through drone surveys has been successful, demonstrating the

potential of these novel sampling methodologies for conducting surveys. Research will continue throughout 2019 to allow for a more robust analysis and comparison between different sampling methodologies.

Presentation type: Poster (student)

Investigating the Aggressive Interactions of Two *Sternotherus* Species in the Pascagoula River Drainage

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Intra- and interspecific competitive interaction have long been of interest for ecologists, particularly between closely-related species. As part of a larger study of the interactions of two lotic musk turtle species (genus *Sternotherus*), we conducted a study to quantify levels of aggression in the razorback musk turtle (*Sternotherus carinatus*) and the stripe-necked musk turtle (*S. peltifer*). 178 adult razorback musk turtles and 150 stripe-necked musk turtles from the Pascagoula River watershed were evaluated for carapacial damage. Aggression was quantified by counting damage to the posterior marginal scutes, an area often targeted by congeners (*S. minor*) during aggressive interactions. We recorded damage data from photographs of specimens from the field and also from preserved museum specimens at the Mississippi Museum of Natural Science. We used non-parametric rank-sums tests to determine if there were significant differences in the amount of damage between species, sexes of each species, across habitat types and in syntopic and allotopic populations of stripe-necked musk turtles. Our analyses found significant differences in the number of injuries between the two species, but it did not show significant differences in damage between sexes of each species. We also found that there was a significant increase in shell damage as upstream drainage area (i.e. stream size) increased. Stripe-necked musk turtles in syntopy with razorbacks exhibited significantly more damage than in allotopy. We speculate that razorback musk turtles are a territorial musk turtle species capable of inflicting serious damage to other syntopic *Sternotherus*.

Presentation type: Poster (student)

Comparing and Contrasting the Population Genetics of Two Lotic *Sternotherus* in the Pascagoula River Drainage

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The Pascagoula River Drainage represents a unique area of sympatry for two lotic musk turtles: the razorback musk turtle (*Sternotherus carinatus*) and the stripe-necked musk turtle (*Sternotherus peltifer*). In allopatry, these two species can be found in all lotic habitats of a given drainage system, but in areas of sympatry stripe-necked musk turtles are found almost exclusively in small to medium-sized creeks while razorbacks occur in large streams and rivers. To understand how these habitat associations affect the genetic population structure of the two species in sympatry, we used microsatellite loci to evaluate intra-drainage population structure. We hypothesized that razorback musk turtles would exhibit lower levels of genetic population structure due to higher connectivity of riverine populations, whereas we predicted a greater degree of structure among populations of stripe-neck musk turtles occurring in the headwaters and adventitious streams, which naturally increases isolation of turtle populations along a river continuum. To date we have genotyped 189 razorback musk turtles and 199 stripe-necked musk turtles from the Pascagoula River Drainage across 10 microsatellite loci. Preliminary analyses reveal higher levels of genetic differentiation across stripe-necked musk turtle populations within the drainage. This study provides empirical evidence into how habitat segregation can differentially affect the riverscape genetics of two closely-related turtle species.

Genetics: Oral (student)

What Keeps Me Up At Night?**Thoughts on Improving the Long-term Outlook for Turtles and Other Herpetofauna****KURT A. BUHLMANN***Savannah River Ecology Laboratory, University of Georgia, Aiken, South Carolina 29802 USA
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Finding solutions to conservation problems has never been more challenging. As an environmental studies college student in the 1980s, I naively thought that after a career in wildlife conservation, we would-by now- have fixed many of the endangered species problems. Alas, there are more. Regulations, permitting, surveys, monitoring programs, workshops, and environmental education all have valuable roles to play. However, for many species, including many reptiles and amphibians, we are way past the time of “conservation”, where conservation seems to mean “conserving what we have left.” What we have left is not enough, and this talk seeks to engage conversation not about conservation, but about species “recovery.” There are numerous recovery methods and concepts, including assurance colonies, headstarting, and reintroductions that need to be coordinated with habitat protection and aggressive habitat restoration. These arguably more risky population manipulations must be investigated with good science, seriously discussed among policy makers and regulators, and appropriately integrated into programs to *increase* the numbers of viable populations on the landscape.

Opening Plenary: Oral**Utilizing Do-It-Yourself Open-Source Technologies to Make Easier the Life of the Turtle Biologist****PATRICK CAIN***Georgia Gwinnett College, Lawrenceville, Georgia 30042 USA
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Turtle biologists are commonly required to fix, slice, hack, and modify field equipment to meet the needs of their research question. Not only does much of a turtle biologist’s training lack formal introduction to such methods, the cost of commercially available technology may also preclude certain unique or informal approaches to answering biological questions. Here, I present a primer on ways one can learn to become more familiar with and skilled at modifying common electronic field equipment. More specifically, I will introduce how open-source hardware and software (e.g. Arduino, Raspberry Pi, and Python) and the thriving do-it-yourself (DIY) community can help facilitate such skills. With just a cursory understanding of electrical engineering, soldering, circuits, and coding, the turtle biologist can overcome many of the limitations of cost and even develop customized field equipment. I will briefly discuss few examples of open-source do-it-yourself equipment such as environmental loggers, GPS data loggers, and VHF systems (transmitters, receivers, and antennas).

Techniques: Oral**Ranavirus, Research, and Rehabilitation: the Interconnectedness of Conservation Strategies****SUE CARSTAIRS¹, CHRISTINA DAVY^{2,3}, JAMES PATERSON², AND SIBELLE VILACA⁴**¹*Ontario Turtle Conservation Centre, Selwyn, Ontario, Canada L9J 6X2*²*Trent University, Environmental and Life Sciences Program, Peterborough, Ontario Canada K9J 7B8*³*Ontario Ministry of Natural Resources and Forestry, Wildlife Research and Monitoring Section, 2140 East Bank Dr., Peterborough, Ontario Canada K9J 7B8*⁴*Biology Department, Trent University, Peterborough, Ontario Canada, K9J 7B8
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The multiple anthropogenic threats facing turtles globally, require a multi-pronged approach for their mitigation. The Ontario Turtle Conservation Centre (OTCC; operating name of the Kawartha Turtle Trauma Centre) broadens its impact through this varied approach. Treatment, rehabilitation, and subsequent release, of turtles experiencing accidental injuries from roadways, boats and fishing by-catch can be shown to have a population impact, in essence ‘buying time’ for the underlying problem to be solved. Data-mining expands this impact; for example, the compilation of the sex ratio of turtles admitted, allowed us to revisit the hypothesis of sex-biased road mortality, and showed an equal number of males as females being impacted on roads, in painted turtles, snapping turtles, and Blanding’s turtles. The impact of infectious disease on an already threatened population, could be devastating. The OTCC can act as a convenient biomonitor for the health of the province’s turtle populations through sampling of

turtles from across the province; allowing concurrent studies on the prevalence of ranavirus and other diseases to be carried out. No turtles with clinical signs of disease have so far been found positive for ranavirus, but we have shown that there exists a low prevalence of subclinical disease across the province, which could have far reaching impacts on turtles as well as other ectotherms sharing the water source. Headstarting, as a natural extension of the hospital, also not only allows for an additional means to augment populations, but also can add to knowledge of Best Practices of headstarting and offer an opportunity to quantify the results. Our post-release studies have shown that released headstarts exhibit comparable fitness to wild-hatched turtles, suggesting that this work can directly support recruitment into turtle populations. Education is an essential piece to this conservation puzzle, and also must be addressed from all angles. Empowering the general public to carry out stewardship activities has far reaching positive effects; also, education of veterinary and rehabilitation professionals broadens the impact of the OTCC's hospital.

Closing Plenary: Oral

Community-based Southern River Terrapin Conservation in Malaysia

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The Southern River Terrapin, *Batagur affinis*, is a critically endangered freshwater turtle found only in southern Thailand, Indonesia (Sumatra), Cambodia, and Peninsular Malaysia. This species has been extirpated from much of its former range, with Malaysia harboring the last remaining viable wild populations. The decline of the *B. affinis* in Malaysia is attributable to various forms of habitat destruction, overexploitation, and alteration. Although largely undocumented, the use of indiscriminate fishing gear is another major threat. Conservation efforts for *B. affinis* in Malaysia have centered on egg protection and head-starting to bolster juvenile recruitment in populations that would likely decline because of direct harvest of eggs. These conservation programs were spearheaded by the Malaysian Department of Wildlife and National Parks (DWNP) in 1967. To date, this effort is known as the longest-running conservation project for any freshwater turtle in the world. A community-based *B. affinis* conservation project was initiated in Kemaman, Terengganu, Malaysia in 2011. Five local villagers were recruited to patrol the 250 m nesting bank during the nesting season. All female *B. affinis* were hand-captured after oviposition, and were weighed, measured and microchipped. All *B. affinis* eggs were brought to an *ex-situ* hatchery in the village for incubation. All hatchlings were head-started for 16 months before they were released into the Kemaman River. To date, more than 5,800 *B. affinis* eggs had been saved from human consumption and more than 2,800 head-started hatchlings had been released into the Kemaman River. I was named the Commonwealth Point of Light for Malaysia by H.M. Queen Elizabeth II in 2018 for my terrapin conservation efforts in the country. To increase public awareness of the plight of this species and our conservation efforts, workshops and dialogue sessions should be organized to recruit more villagers into the project. Awareness programs in schools and other public venues should be conducted to educate both children and adults. Despite our periodic attempts, we have yet to recapture post-release juveniles to determine their survival in the wild. Recapture efforts need to be intensified to provide an indication of the success of the head-starting program. Despite these needs for improvement, participation of local villagers, support from the Village Committee and other project successes make this project a model for other community-based conservation efforts with imperiled species.

Batagur Conservation: Oral

Restoring Nesting Areas on the E. S. George Reserve to Reverse the Decline in Nesting Survivorship That Threatens Population Stability of Painted, Blanding's and Snapping Turtles

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When we initiated our study of turtles on the E.S. George Reserve in the mid-1970s problems created by tree growth and invasion of the shrub (Autumn Olive, *Elaeagnus umbellata*) were not of our remotest concern. By the 1990s almost all old field nesting areas were reduced in size and three nesting areas had been abandoned due to tree

growth. From 1976-1989 (pre-loss of major nesting areas) to 1990-2003 (major loss of nesting areas) nest densities in remaining areas increased and survivorships decreased from 24%-7% (N= 455-1249) for Painted Turtles, 19%-2% (N=148-83) for Blanding's Turtles, 14%-14% (N=309-318) for Snapping Turtles. Analysis of life-history trait values of Blanding's turtles indicated that no reasonable combination of increases in juvenile survivorship, clutch size or frequency or decreases in age at maturity compensated for reduced nest success (i.e., the population is decreasing). In 2016-2018, we found nesting areas were totally restricted human created areas such as lawns, roads, and remnants of fire lane (i.e., no old field nesting areas remained). We initiated restoration by removing trees, shrubs, other vegetation from five nesting areas (primarily used by Painted and Snapping Turtles) using a BobCat with a tree masticator or a toothed bucket attached, chain saws, disc harrow, and PTO driven tiller. In 2018, we re-tilled one half of the Cattail Fields restored area and left the other half undisturbed. Re-growth from seeds and root sprouts were substantial enough to deter nesting except in a few < 1m open areas in the undisturbed area, whereas the re-tilled area was used by females of all three species (i.e., annual re-tilling will be required until roots are killed and seed banks are depleted). We observed use of the restored areas by older females (marked prior to 2008) and younger unmarked females of all three species, and monitored nest survivorships in all nesting areas in 2017-2018. Good news for restoration of nesting areas; older and younger naïve turtles used all five areas in all three years, bad news; nest mortality rates remained high (i.e., more, isolated, and larger restored areas and probably predator control will be required).

Closing Plenary: Oral

Biodiversity of Apicomplexan Blood Parasites of Tortoises (Testudinidae): A Neglected Group

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Apicomplexan blood parasites are obligate intracellular parasites infecting a range of vertebrate and haematophagous invertebrate hosts; vertebrates acting as intermediate hosts and invertebrates as definitive hosts (vectors). Development of these parasites is cyclic, alternating between asexual reproduction in the vertebrate and sexual reproduction in the vector. Infections are transmitted to vertebrate hosts during a blood meal by an infected vector, in which infective stages of the parasite are inoculated into the vertebrate, or via the ingestion by the vertebrate host of the infected vector. Groups reported infecting tortoises (Testudinidae) include haemogregarines and haemosporidia (malaria-like organisms). Approximately 400 haemogregarine species and >540 haemosporidia species have been described to date infecting a range of vertebrates worldwide. However, less than 20 of these have been described from chelonians, with less than 10 from tortoises; most descriptions from the beginning of the last century, with few elucidated life cycles. As such, most of the vectors and the transmission routes remain unknown. Recent molecular work has identified further concerns regarding these parasites' systematics, which further complicates the capacity to identify potential vectors. For some of the haemogregarines infecting tortoises, molecular work has proven invaluable. One such case is that of *Hepatozoon fitzsimonsi* (Dias, 1953), a parasite of southern African tortoises, previously described as a member of the genus *Haemogregarina* (a genus strictly transmitted by leech vectors via inoculation). Its recent assignment, based on molecular data, to *Hepatozoon* (a genus transmitted by various vectors via ingestion) has assisted in identifying the most probable vector, a tick, subsequently supported by the light microscopic isolation of infective stages. With the illegal trade in wildlife, particularly of reptiles, some of these vectors (ticks) have established populations in naïve habitats. Even though it would appear that many of these parasites are host-specific, some like *H. fitzsimonsi* appear to be generalist. As such there is a good probability that a number of these parasites may be able to infect naïve hosts with unknown consequences. This study serves as a review of these parasites in tortoises with the aim to encourage further awareness and studies in this field.

A Look Under the Shell: Oral

Movement and Behavior of Translocated Adult Alligator Snapping Turtles (*Macrochelys temminckii*) in the Choctawhatchee River System in Northwest Florida

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Translocation has increasingly been used as a conservation tool for multiple species to reestablish or augment existing populations. Alligator snapping turtle (*Macrochelys apalachicola*) populations are declining throughout their range, though those in the Florida panhandle are not well studied. Although the actual population size of alligator snapping turtles (ASTs) is unknown in the Choctawhatchee River system, it is presumed low from state surveys, making it a good candidate site for repatriation efforts. Nokuse Plantation received 9 adult ASTs (4 male, 5 female; mean carapace length 423.78mm) from the Florida Fish and Wildlife Conservation Commission that were confiscated from an illegal captive breeding facility and destined for release in the Choctawhatchee River based on genetic sequencing. All of the ASTs were released at the same location on the East River (a channel of the Choctawhatchee River system) on 6 Sept 2017 and radio-tracked to monitor survival and movement. One transmitter failed immediately post-release. We attempted to locate the remaining eight turtles approximately daily for the first year and 1-2 times per week thereafter. Each individual had 96–299 documented locations from release until 2 May 2019, with unknown locations attributed to the AST being out of receiver range and inaccessible or transmitter failure. Two individuals (1 male and 1 female) dispersed >5 miles upriver to a section of the Choctawhatchee within the first month of release and remained in this area. These two AST were found together at the same location numerous times, indicating interaction and potential mating opportunities. The other six ASTs remained primarily in the East River and adjacent floodplains. ASTs in the East River frequently used the same microhabitat locations, as some locations were used by multiple turtles at different times. Increased movement activity typically occurred during flood events, when higher water levels dramatically increased available habitat and connectivity. Though translocation success cannot be accurately measured in the short term for such a long-lived and cryptic species, the establishment of home ranges and continued overlap of turtles suggest that this population is likely to have successful reproduction and recruitment, although further long-term research is warranted.

Population Mechanics: Oral

Estimating Population Size of a Threatened Turtle Using Citizen Science
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Blanding's turtles (*Emydoidea blandingii*) are considered threatened or endangered throughout most of their range. A critical step in determining appropriate conservation actions for this species is assessing the status of remaining populations. The long-term surveys required to adequately document population trends are lacking as they are generally labor-intensive and time-consuming. We used citizen science-collected data and free pattern-recognition software to conduct a mark-recapture study on female Blanding's turtles in a northwest Ohio wetland. Over a five year period, citizen scientists gathered 115 images of 51 individual female Blanding's turtles. Our results suggest the wetland has a population of 70 (95% CI = 56-86; SE = 7.65) adult female Blanding's turtles. Deriving preliminary population estimates from photographic recapture data is an example of how the efforts of citizen scientists can benefit ongoing research projects and conservation efforts.

Techniques: Oral

Are Painted Turtles (*Chrysemys picta*) Native in Arizona: a Review of the Evidence
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The painted turtle (*Chrysemys picta*) is the only native turtle species with a range that extends across North America from the Atlantic to the Pacific Ocean. Two species and three sub-species are currently recognized, each located in different regions of the United States, Canada, and Mexico. There are small, scattered populations of western painted turtles (*Chrysemys picta bellii*) in the southwestern USA and northern Mexico, including Arizona, where the native status of turtles in the latter location has been questioned. The disjunct nature of these populations is not unexpected given the topographic extremes and aridity of this region. Western painted turtle records in Arizona extend from over 700 years ago as Native American (Hopi) artifacts, to the present time. Historically, *C. picta* were

collected and traded among Native American tribes, including the Hopi and Zuni, for ceremonial uses and as food. Modern records in the Southwest USA include the upper San Juan River basin of southwestern Colorado and northwestern New Mexico, the middle reaches of the Little Colorado River in Arizona, and an isolated population in Chihuahua State, Mexico. Aside from some questionable records, other places in Arizona where native painted turtles formerly occurred were in the vicinity of Lake Powell, in tributaries to the Colorado River in Glen Canyon, and the lower Little Colorado River near Winslow. Non-native populations of painted turtles are also established in Arizona. For example, we recently documented a breeding population of midland painted turtles (*C. p. marginata*) in a small, remote, man-made reservoir (cattle tank) in the Kaibab National Forest of northern Arizona, on the Colorado Plateau, over 2,000 km away from their nearest native location. The nearest native *C. p. bellii* population is 160 km to the southwest at Lyman Lake, Arizona. Introduced populations of various subspecies are also known from urban areas like Phoenix, Tucson, and Cottonwood, Arizona. We review criteria for defining a native species and conclude that *C. p. bellii* is indigenous to Arizona.

Turtles of the Southwest: Oral

Saving Cambodia's Royal Turtle (*Batagur affinis*)

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The future of the critically endangered *Batagur affinis* (Southern River Terrapin/ Royal Turtle) is uncertain in the country of Cambodia. Due to heavy sand mining, damming, and agriculture, habitat and nesting beaches for the Royal Turtle are rapidly declining in Cambodia. With only a few adult individuals left in the wild an *in-situ* breeding center is the keystone for the survival of this species. The Koh Kong Reptile Conservation Center (KKRCC), run by the Wildlife Conservation Society (WCS), was officially opened in November 2017 to help stem the decline of this beautiful species. At that time, a plan was created to increase the capacity of the *Batagur* breeding ponds that were already in place at a much smaller site. With assistance from organizations like the TSA, private companies, and AZA accredited institutions, the KKRCC is taking off and expanding. With many years of expansion left, WCS and TSA need more help to save this beautiful species in its native Cambodia.

Batagur Conservation: Oral

Population Genomic Analysis of Speciation among Threatened Desert Tortoises

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Speciation is a fundamental evolutionary process. By detailing the geological and climatic factors driving speciation we can better understand how Earth's evolution shapes the diversity and distribution of life we see today. Mojave and Sonoran desert tortoises (*Gopherus agassizii* and *G. morafkai*, respectively) are thought to have speciated about 5.3 million years ago when the Colorado River first drained into the Gulf of California. Over this time, however, the precipitation patterns across the species ranges have changed dramatically due to the development of the North American monsoon system. The two species exhibit different ecological preferences and, where they hybridize in northwestern Arizona, the hybrids show intermediate ecological preferences suggesting differential ecological adaptation has played a role in their divergence. We present a new reference genome build (gopAga2.0) that offers draft chromosome-scale scaffolds (N50=28.36 million basepairs; L50=26 scaffolds), as well as results from comparative genomic analyses using low coverage whole genome sequences of 20 individuals of the two species. Principle component analysis and folded joint site frequency spectra confirm clear species divergence. We find much higher genetic diversity in Sonoran tortoises than the Mojave tortoises, the latter of which is listed as threatened under the US Endangered Species Act. We estimate effective population sizes (N_e) to be 27,000–45,000 individuals for Mojave tortoises and 45,000–76,000 individuals for Sonoran tortoises across a range of different generation time assumptions. Finally, sliding window F_{st} scans reveal candidate genes with high divergence that may underlie differential ecological adaptation.

Turtles of the Southwest: Oral

Raccoons Reveal Repertoires Nesting Turtles have for Facing Climate Change

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Longer-lived oviparous ectotherms such as turtles may be particularly challenged as the climate continues to rapidly warm. The egg stage of the life cycle is particularly vulnerable because turtles do not care for their eggs, putting the spotlight on the choice of nest site as a set of interconnected behaviors that could be critical to reproductive success and thus population persistence. We reviewed the literature on nest site choice in turtles, asking what behavioral choices nesting mothers make, how these vary within and among populations and climates, and thus how they can respond to a rapidly-warming future climate. We suggest a way forward to test these ideas, and offer preliminary data for the Florida softshell turtle.

Reproductive Studies: Oral

Rapid Demographic Assessments for Freshwater Turtles: Filling in Data Deficiencies
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Freshwater turtles are one of the most imperiled vertebrate groups, and their conservation and recovery are often complicated by life history traits such as extreme longevity, late maturity, and limited reproductive capacity. Such life history traits make freshwater turtle populations particularly susceptible to anthropogenic disturbances such as habitat loss, collection, and roads. Extreme longevity can allow declining populations to persist on the landscape for decades, perhaps giving the appearance of population stability even when recruitment is minimal or non-existent. Chronic or severe perturbations which increase adult mortality can cause rapid population declines. Even when threats are mitigated, freshwater turtle populations may take decades to rebound due to their life histories. Nearly a third of the 357 recognized turtle species are ranked as endangered or worse. Unfortunately, basic life history and demographic data for many freshwater turtle species are either lacking or are represented from disparate geographical sources. Without basic life history and population-specific demographic information, it is difficult to determine the magnitude of declines, identify specific threats, target conservation actions, or monitor recovery success. We propose a three-part program consisting of capture-mark-recapture, radiotelemetry, and x-radiography to assess vital rates and life history characteristics rapidly. We also provide an estimate of program cost and potential sources of funding, at least in the United States. Although there are inherent caveats with the breadth of the data collected, we identify objective analyses to inform initial actions in the current conservation climate where time and money are limited.

Closing Plenary: Oral

Effects of Non-native Pond Sliders (*Trachemys scripta*) on Native Sonora Mud Turtles (*Kinosternon sonoriense*): Results of a 30-Year Introduction and Removal Study

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Turtles are not commonly thought of as invasive species but introduced Pond Sliders (*Trachemys scripta*) have been widely introduced and are thought to have negative effects on native turtle species both in North America and throughout the world. After Pond Sliders were introduced at Montezuma Well, Arizona, in the 1970's, the native Sonora Mud Turtle (*Kinosternon sonoriense*) population declined to less than 25% of their previous numbers, from 372 ± 64 in 1983 to 79 ± 20 in 2011. Montezuma Well is an isolated, highly stable, spring-fed limestone sink pond, and provided a unique setting for studying the effect of non-native Sliders on native turtles. We removed all non-native turtles from Montezuma Well using non-lethal trapping between 2007 and 2013, and simultaneously collected population, behavioral, and ecological data on the native mud turtles. Since the removal of the last non-native turtles, the mud turtle population has increased in numbers to 139 ± 34 in 2015. The mud turtles also significantly increased basking activity, similar to results observed in microcosm studies of basking competition between Pond Sliders and other emydid turtles. These results from Montezuma Well provide corroborating evidence on the occurrence and mechanism of negative impacts by introduced Pond Sliders on native turtle species. The small Sonora Mud Turtles are very different in size, morphology and ecology from Pond Sliders and the native emydid and geoemydid turtles affected in other studies, suggesting that impacts of Pond Sliders may be more pervasive than previously suggested. The data from the Montezuma Well system also indicate possible effects of the Sliders on body condition and reproductive output of the native mud turtles, and we present a more detailed hypothesis for the mechanism of non-native Slider effects on native turtle species. This hypothesis, in turn, suggests new approaches to evaluate the effects of introduced Pond Sliders on native turtle populations.

Ecology: Oral

Implementation of a River Turtle Monitoring Program in the Terai Turtle Priority Area, India

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The Indian foothills of the Himalayas, also known as the Terai Arc, encompasses a turtle diversity hotspot with 13 species of aquatic and semi-aquatic turtles and 1 species of tortoise. The Turtle Survival Alliance-Indian Turtle Conservation Program (ITCP) recognizes the Terai as a Turtle Priority Area (TPA), and the ITCP's first objective is to conduct species-habitat inventories throughout the region. The flagship species for the Terai TPA include the Indian Narrow-headed softshell turtle, *Chitra indica*, and the Crowned River Turtle, *Hardella thurjii*. In 2015 a monitoring protocol was designed to obtain abundance and survivorship estimates and data for species-habitat relationships on the Sarju and Ghagra rivers. The Sarju was sampled once at one site in 2014, again at three sites in 2015, and with the addition of dedicated funding, seven times to date at one site in 2019. To date we have made 1,590 captures of 10 species of aquatic turtles. The three most frequently captured species were *H. thurjii* (1281), *Pangshura tecta* (132), and *Nilssonina hurum* (83). *Hardella thurjii* was the only species currently with enough recaptures to date to calculate basic demographic parameters. Preliminary analyses place population estimates for *H. thurjii* at $4,436 \pm 1,185$, and survivorship was 1.00 ± 0.19 . Pradel's $\lambda = 1.06$ suggesting a slightly increasing population. Current funding will carry sampling efforts to 2021, and with increasing sample sites and additional captures we should begin to better understand river turtle assemblage composition and demographic traits of many species in this imperiled landscape.

TSA Partners: Oral

Overcoming Volunteer Fatigue: Citizen Science in Turtle Road Mortality and Nesting Monitoring

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The Toronto and Region Conservation Authority (TRCA) with York University have developed a Citizen Science based road mortality monitoring program that has been in place for the last eight years. The program relied on fewer

than a dozen dedicated volunteers and has led to the implementation of numerous mitigation measures such as specialized fencing and a dedicated wildlife passage. Because of a combination of volunteer fatigue as well as the successful implementation of mitigation measures, there was less of a requirement for intensive road mortality monitoring. This summer we added a new twist by re-engaging these previous volunteers and other new volunteers in a turtle nest monitoring program. The program engages high school students and a local library in researching, designing, printing and painting turtle decoys to be placed on artificial nesting structures. Other volunteers check known nesting sites on a daily basis and monitor these specific artificial sites for nesting activity. Another set of volunteers actively searches for nesting sites elsewhere in the wetland complex. Fresh nesting sites will be protected by using a special nest cage designed and built in partnership with Kingston Turtles and a local hardware store. We report on results and challenges.

Organic Conservation: Oral

Clutch Size in an Illinois Ornate Box Turtle (*Terrapene ornata*) Population

DEVIN EDMONDS

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Reproductive output is a key demographic trait. In turtles, there is a great deal of variation in clutch size and even within the same species different numbers of eggs may be produced depending on geographic location and body size. The Ornate Box Turtle (*Terrapene ornata*) is a threatened species in Illinois with very few remaining populations in the state, and so understanding the reproductive output at the population-level is useful for site managers. To learn clutch size of Ornate Box Turtles, I radiographed female turtles over two breeding seasons at a site in northwest Illinois. I then examined the association between length, mass, and clutch size to determine if there is a relationship. Not all females produced eggs each year and clutch size varied between individuals. The results of this project provide the first estimates of reproductive output at one of the last remaining Ornate Box Turtle populations in Illinois.

Presentation Type: Poster (student)

The Population Dynamics of the Gopher Tortoises on Cumberland Island, Georgia

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Due to habitat loss, urban sprawl, and overexploitation, the Gopher tortoise is now listed as a threatened or endangered species in much of the southeastern United States and is considered a critical “keystone” species in their habitats as their burrows provide shelter for numerous other species. Therefore, any information regarding the current status, distribution, density, and impacts that may affect this species is critically important to the long-term viability of the species. This information is particularly critical for remnant populations such as the previously unstudied population of Gopher tortoises on Cumberland Island, Georgia with only anecdotal references to this population being found in history books written about the Island. In order to effectively manage this remnant Gopher tortoise population, accurate population data and movement patterns must be known. The purpose of this study was to characterize the size, distribution, and age classes of the tortoises on the Island. In addition, activity patterns, temperature regulation, and movement patterns were monitored using appropriate modern technology instruments on the 104 square kilometer Island and will be presented. Preliminary evidence supports that a viable population of 250-300 individuals exists on the Island with tortoises of all age classes found, along with evidence of reproduction and egg-laying. The unique nature of this National Park Island has also contributed to some rather unique behaviors of this population which will also be discussed.

Population Assessments: Oral

Landscape Perspectives on the Role Invasive Species Play On the Growth and Health of Mojave Desert Tortoises**TODD ESQUE¹, KRISTINA DRAKE¹, MELIA NAFUS^{2,3}, KENNETH NUSSEAR⁴, ROY AVERILL-MURRAY⁵, AND RONALD SWAISGOOD²**¹Western Ecological Research Center, U. S. Geological Survey, Henderson, Nevada 89074 USA²Institute for Conservation Research, San Diego Zoo Global, San Diego, California 92027 USA³Fort Collins Science Center, U. S. Geological Survey, Fort Collins, Colorado 80526 USA⁴Department of Geography, University of Nevada-Reno, Reno, Nevada 89557 USA⁵Desert Tortoise Recovery Office, U. S. Fish and Wildlife Service, Reno, Nevada 89502 USA

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Habitat disturbances from wildfire and other human activities can have dramatic and long-lasting effects on the composition and structure of desert ecosystems, especially the establishment and proliferation of invasive plants. These changes often impact wildlife, as most species rely on native plant communities for shelter, protection, or food. In an effort to understand how the threatened Mojave desert tortoise (*Gopherus agassizii*) responds to disturbed landscapes and altered diets in Nevada, we conducted multiple controlled and natural field studies over a 10-year period. We designed these studies in part to understand how changes in diet availability and composition influences the growth, health, immune function, movement, and survival for juvenile and adult tortoises. In addition, we evaluated site and climate features including annual and perennial vegetation, soil textures, rodent burrows, temperature, precipitation, etc. at each study area. Repeatedly, we found that juvenile tortoises were more vulnerable to habitat changes and invasive plants than adult individuals. In our controlled experiments, juveniles foraging on the non-native invasive grass red brome (*Bromus rubens*) demonstrated rapid declines in growth, immune function, condition, and survival compared to individuals foraging on native plant diets. In natural environments, we found that tortoises generally grew more, increased movement and home range, and had higher survival in habitats with less invasive non-native annual vegetation (e.g. *B. rubens*, *Schismus barbatus*). Our findings support previous research on the potential negative effects of non-native annual plants for young tortoises. When possible, reducing non-native vegetation or protecting habitats from potential plant invasions and other disturbances may improve recruitment and conservation for this species.

Turtles of the Southwest: Oral**Do Spiny Softshell Turtles Engage in “False Crawls” during the Peak of the Nesting Season?****MARK FELDMAN AND ELIZABETH FELDMAN**

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In previous years we have reported on a wide variety of agents to induce egg laying in aquatic American turtles. We achieved a 94% success rate (a turtle laying all its eggs after a single induction) with a variety of slider and map turtles using Lutalyse (prostaglandin F2 alpha) alone. During the American summers of 2010-2017 we tried some of the same methods with softshell turtles. Our highest success rate was only 80%. This was achieved by giving Sedivet (romifidine) intramuscularly and Lutalyse subcutaneously 20 minutes later. Our relative lack of success made us look at the differences in our selection methods. Easily palpated species, like sliders and map turtles, were selected on the basis of being on the nesting area and having more than 2 palpable eggs in the lower pelvis of appropriate turgor. Accurate palpation was not possible with softshell turtles so we just included any we found on the nesting area that were X-ray positive. This was probably a mistake because some of those animals may have been on a false crawl. To see if this was true we took a series of time lapse videos in July, 2018 of the softshell nesting area at the Concordia Turtle Farm. We wanted to determine if some softshell turtles do return to the water without attempting to lay. We found that many did engage in false crawls but the period of filming was at the very end of the nesting season. This may have prejudiced our results. This June we will repeat the process, but at the height of the nesting season, to see if false crawls are still a frequent event that may account for our reduced success rate. We will be taking about 200 hours of video and compressing that into a ten minute presentation. We have established a web-site (inducingturtles.com) featuring an instructional PDF and videos of our methods in English with Chinese subtitles. Later this year we will be adding all the data we have accumulated over the past two decades.

Captive Husbandry: Oral

A Direct Role for Former Captives in Wild Conservation: Are Desert Tortoises Candidates?**KIMBERLEIGH J. FIELD***Desert Tortoise Recovery Office, United States Fish and Wildlife Service, Reno, Nevada 89502 USA
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Rare or at-risk species may spend periods of time in captivity for a variety of reasons that include rehabilitation after injury, confiscation of illegally collected animals, and establishment of assurance colonies. Time in captivity can range from very brief to many years and may span the individual's entire life at that point in time. We may know little about origin of some individuals, including whether the individual was at one time wild or was captive-born. In some situations, these animals have the potential to be used in conservation-based translocations in attempt to re-establish populations or enhance viability of existing populations after threats have been addressed. Some have debated the advisability of using formerly captive animals in wild conservation, yet for some species it is the only option for restoring populations in the wild. While large numbers of Mojave desert tortoises (*Gopherus agassizii*) remain in the wild, most populations have been declining for decades. In contrast, a captive population is flourishing in the backyards of private citizens throughout the desert southwest. As common with other captive animals, there is an overabundance of unwanted Mojave desert tortoises due to uncontrolled breeding and lack of ability to provide appropriate care. While this tortoise is not yet on the brink of extinction in the wild, experts had the unique opportunity to develop protocols for the use of former captives in wild translocations and evaluate the outcomes of several such translocations. Under very controlled conditions, in which risks are carefully evaluated and mitigated, formerly captive tortoises do show potential for a role in wild conservation efforts. The protocols developed for the Mojave desert tortoise and results of the translocations may be valuable to inform augmentation strategies for this species and other at-risk chelonians.

Turtles of the Southwest: Oral**A Game of Taxonomic Hide and Seek: Brought to you Courtesy of *Cuora amboinensis*.****DANIEL GAILLARD¹, TORSTEN BLANCK², SHI HAITAO¹, LIN LIU¹, AND ZHANG TING¹**¹*College of Life Sciences, Hainan Normal University, Haikou 571158 China*²*Cuora Conservation Center, 8530 Deutschlandsberg, Austria
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Taxonomic relationships of organisms need to be determined for effective conservation management plans to be developed and executed. Inaccurate or insufficient data on relationships can lead to multiple species being classified as only one species or "pseudo" species being elevated to a full independent species. Either scenario can lead to ineffective management plans and time and resource usage. These two scenarios have been observed previously within Chelonians. The first scenario typically deals with a species that occupies a large geographic area that has multiple potential barriers to gene flow, and our focal species, *Cuora amboinensis*, falls into this category. Currently this species is divided into 4 recognized, but somewhat disputed, subspecies based on geographic locality, color and morphology. In this study, we used genetic markers to elucidate the taxonomic relationships within this potential species complex. We obtained 116 samples representing 14 broad geographic localities. Based on our genetic results, *C. amboinensis* contains four possible species and two subspecies with genetic distances ranging from ~1.2-5.2% divergence. According to our findings, *C. amboinensis* is no longer a single broadly distributed species, but contains four species with varying distribution sizes and conservation threats.

Genetics: Oral**Tracking the Movement of Western Alligator Snapping Turtles [*Macrochelys temminckii*] in a Unique and Atypical Urban Habitat, Buffalo Bayou, Houston, Texas****VALERIA GLADKAYA¹, CHIS DRAKE², JEFF STEIN³, ARRON TUGGLE⁴, ANDREW WALDE¹, JORDAN GRAY¹, AND ERIC MUNSCHER^{1,3}**¹*Turtle Survival Alliance, Charleston, South Carolina 29407 USA*²*Estancia Electric Company, Sugarland, Texas 77498 USA*³*SWCA Environmental Consultants, Houston, Texas 77040 USA**[valeriaglad@gmail.com]*

The Western Alligator Snapping Turtle (*Macrochelys temminckii*) is one of the largest species of freshwater turtles in the world. Despite extensive research efforts in some parts of the species' range, gaps remain in our knowledge of the species western range extent, demography, and behavior within certain ecosystems. In 2016, a highly unique population of *M. temminckii* was discovered in a vastly developed urban setting in southeast Texas. The discovery of this urban population in metropolitan Houston, Texas, prompted a long-term population monitoring program. As part of our population study of this State Threatened species, we initiated a telemetry project to ascertain how the animals are utilizing this unique system. This includes tracking and recording specimen movement (including direction and distance travelled), effect of natural barriers and hydrologic levels on movement, and correlation of microhabitat utilization and movement to temperature. Ten (n=10) specimens were selected at random (7 males and 3 females) via capture in baited hoop traps. The specimens were acquired at two separate sites, approximately 6.4 river km, from one another along Buffalo Bayou. These turtles were fitted with radio transmitters and tracked throughout a 14.4 km segment of the bayou from November 2018 through July 2019 (study is ongoing). Specimens are tracked weekly or biweekly (dependent upon weather and bayou levels), by kayaking the total distance of the bayou segment. Early evidence shows specimens are associated with microhabitat and structure (fallen logs and undercut banks). The mean linear home-range for all turtles was (~186.2 m). The largest movement was 0.81 km downstream by a large male (607 mm max CL). This study started in early winter and progressed through spring and early summer. Little to no movement was observed during the winter months with movement frequency and distance increasing in early spring. More time is needed to further study the movements of this species within this system. Due to the population's persistence in a highly urbanized setting, this data could help with future conservation efforts of this species in the Greater Houston metropolitan area and other urbanized habitats in Texas.
Presentation type: Poster (student)

Population Size and Movement Analysis of the Sonoyta Mud Turtle (*Kinosternon sonoriense longifemorale*) in the Sonoyta River, Sonora, Mexico

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The endangered Sonoyta mud turtle (*Kinosternon sonoriense longifemorale*) is a subspecies endemic to a small portion of the Sonoyta River in Sonora, Mexico and Quitobaquito Springs in Arizona. Human development in the region and economic activities, such as agriculture, livestock production and mining, have caused overdraft of the Sonoyta aquifer and reduced flow in the river. Lower flows in the river have led to a reduction in the wetted habitat available for the Sonoyta mud turtle. Localities with Sonoyta mud turtles have been reduced from seven sites in 2003 to three natural sites and two transplanted sites in 2019, one of which is a sewage treatment lagoon. The largest natural population occurs in the Agua Dulce reach of the Sonoyta River, a roughly 2 km long reach that contracts to only pools during the dry season. From 2017-2019, we estimated the mud turtle population size of the Agua Dulce reach using the capture-recapture sampling method. Additionally, we quantified mud turtle movements based on ten individuals (5 males and 5 females) that were radio-tagged in 2017 and 2018. Using these data, we estimated mud turtle home ranges by calculating the Minimum Convex Polygon (MCP) based on all locations where tagged mud turtles were documented. Using the Schumacher-Eschmeyer model, we estimated a population size of 351 turtles, and with a 95% confidence interval ranging from 186 to 400 turtles. Radio-tagged individuals had a mean home range size of 0.09 ha and travel paths with a mean length of 173 m. Females had larger mean home ranges than males (0.12 ha vs 0.04 ha) and longer mean travel paths (239 m vs 91 m). Despite their ability to survive in degraded wetlands and tolerate periodic loss of flow in the river, decreasing dry season habitat poses a serious conservation concern. As wetted area and the size of remnant pools further decrease due to climate change and water withdrawals, the Sonoyta River may not continue to support a healthy population of turtles.

Turtles of the Southwest: Oral (student)

Assessing Fertility Patterns in a Captive Population of Alligator Snapping Turtles (*Macrochelys temminckii*)

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Global turtle declines have accelerated in recent decades, and as a result many conservation initiatives use captive breeding as a means to restore populations and assure species survival. Despite its importance for many taxa, turtle mating systems remain understudied and little is known about factors that influence reproductive success. The purpose of our study was to evaluate egg fertility patterns in the context of reproductive success in a captive breeding population of alligator snapping turtles (*Macrochelys temminckii*) housed in southeastern Oklahoma. We used a technique known as Oocyte-membrane Bound Sperm Detection to quantify sperm densities in alligator snapping turtle eggs that showed no signs of embryonic development to ascertain whether or not individual eggs had been fertilized. We inferred that eggs that had high sperm densities but showed no evidence of development likely had been fertilized, but that early embryonic mortality resulted in egg failure. Conversely, eggs that failed to develop and had little or no evidence of sperm presence were inferred to be infertile. This research highlights an important conservation challenge facing this and other species of turtle that exhibit variable hatching success rates, and will be especially informative for captive propagation efforts.

Presentation type: Poster (student)**Turtle Assemblages of Lowland Habitats in Northeastern Louisiana**

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The southeastern United States is an area of high species richness for freshwater turtles, and several of these species are of conservation concern. Over the course of 2018 and up to May of 2019, we deployed traps for turtles at 18 different sites across the four national wildlife refuges that comprise the North Louisiana Refuges Complex, totaling 747 trap-nights. Trapping was conducted across a broad range of ecotypes in the Mississippi alluvial plain, from cypress-tupelo swamps to an anthropogenically restored bayou channel. In addition, basking surveys were performed at 4 sites across 2 of the refuges. Through this combination of surveys, we confirmed the presence of 11 turtle species, including 3 classified as state and/or federal species of concern: the alligator snapping turtle (*Macrochelys temminckii*), the razorback musk turtle (*Sternotherus carinatus*), and the Ouachita map turtle (*Graptemys ouachitensis*). Three hundred ninety-nine total turtles were caught in traps, giving a total catch-per-unit-effort (CPUE) of 0.5341 turtles/trap-night. Red-eared sliders (*Trachemys scripta elegans*) were the most common turtle caught, with a total of 298 individuals and a CPUE of 0.3989, followed by common musk turtles (*Sternotherus odoratus*) with a CPUE of 0.0375. The other species caught in traps were, in order of abundance, common snapping turtles (*Chelydra serpentina*), Mississippi mud turtles (*Kinosternon subrubrum hippocrepsis*), alligator snapping turtles (*Macrochelys temminckii*), eastern river cooters (*Pseudemys concinna concinna*), razorback musk turtles (*S. carinatus*), and spiny softshells (*Apalone spinifera*). The CPUE for *S. carinatus* was 0.0040, and the CPUE for *M. temminckii* was 0.0080. Three additional species were observed by basking surveys: southern painted turtles (*Chrysemys dorsalis*), Ouachita map turtles (*Graptemys ouachitensis*), and Mississippi map turtles (*G. pseudogeographica kohnii*). Three-toed box turtles (*Terrapene carolina triunguis*) were observed through incidental encounters.

Population Assessments: Oral (student)**Painted Terrapin Conservation Program in Sumatra, Indonesia**

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Painted Terrapin (*Batagur borneoensis*) is one of most endangered turtles in the world and protected species in Indonesia. Conservation of this aquatic species has been implemented in northern Sumatra, Indonesia, since 2010 and achieve positive impact. The program are consisted of main activities, they are annual nest patrol, rescue and release, community outreach including public campaign and public policy. The program which only started in

District of Aceh Tamiang has been expanded to cover more district today. As of today, about 2,500 hatchlings - result of nest patrol - in District of Aceh Tamiang have been released into wild (estuaries). Some of those number are successfully recaptured and identified. Annual survey is also conducted to monitor wild population. Thousands of people, locally and nationally, are reached by our public campaign platform: video/television, printing, social media, public meeting. To develop alternative income for villagers in Aceh Tamiang, mangrove tourism is being planned and it is expected that money will be used by people to manage and conserve mangrove and ecosystem properly. The conservation efforts are being planned and expanded in two another district (District of East Aceh and Langkat) where the wild populations are found. This year, for the first time, the program is successfully released 8 hatchlings of Painted Terrapin in District of Langkat. These hatchlings are result of our two months nest patrol in Langkat Timur Laut Wildlife Reserve, District of Langkat, Province of North Sumatera.

Batagur Conservation: Oral

A Reproductive History of Rote Island Snake-necked Turtles (*Chelodina mccordi*) at the Turtle Survival Center (TSC)

CRIS HAGEN, CAROL ALVAREZ, NATHAN HAISLIP, CLINTON DOAK, AND JOHN GREENE
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The critically endangered Rote Island Snake-necked Turtle (*Chelodina mccordi*) is found on the islands of Rote and Timor in the Indonesian archipelago. Populations on Rote Island were decimated during the 1970's to the early 2000's and the species is now considered functionally extinct on the island, with the last known wild individuals seen around 2010. The species was not described until 1994, but was already being maintained in zoos and private collections around the world and bred in captivity for many years prior. The Turtle Survival Center maintains one wild caught pair, as well as one captive bred pair and in early 2019 hatched their first offspring. This presentation details a wild caught pair of *Chelodina mccordi* that were kept in isolation for 20 years before coming together at the TSC and gradually becoming reproductive again.

Captive Husbandry: Oral

A Comparison of Hematology and Plasma Biochemistry of Alligator Snapping Turtles in Wild, Reintroduced, and Captive Populations

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Population monitoring is an important but often undervalued component of assessing the effectiveness of wildlife reintroduction efforts. Monitoring should be multifaceted, and health assessments can complement assessment of survival, growth, and shifting demographics. Additionally, comparisons between captive, wild, and reintroduced populations can identify incipient problems. The goal of our study was to compare hematologic and plasma biochemical values of four alligator snapping turtle (*Macrochelys temminckii*) populations: indoor and outdoor captive populations in a head-start program, reintroduced head-starts, and a wild population. We obtained blood samples from 25 indoor and 25 outdoor captive turtles, 30 reintroduced turtles, and 17 wild turtles. Uric acid, total protein, and globulins were significantly higher in the wild population than the reintroduced population, likely resulting from a diet higher in protein. Both captive populations had significantly higher eosinophil counts than the reintroduced and wild populations, which may indicate either high parasite load or result from inflammation. Differences in demographics and diet and environmental conditions may explain several of the differences we detected among the populations. No group presented as categorically "unhealthy" based on the variables we analyzed.

A Look Under the Shell: Oral (student)

Community Structure of Freshwater Turtles across Four River Drainages in Mississippi

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Mississippi boasts impressive turtle diversity, with over 30 species native to the state. This richness, which is mostly attributed to riverine species, represents approximately 10% of global turtle diversity. Despite being situated in one of the global hotspots for chelonian diversity, Mississippi has a relative paucity of turtle records and research. This multi-year study aims to delineate community structure across the major river drainages in the state, including the Pascagoula, Pearl, Tombigbee, and Yazoo river systems. Using baited hoop nets (90 cm and 120 cm diameter), turtles collected from river stretches and associated oxbow lakes are sexed, measured, and sampled for genetic information. Preliminary results from the 2019 field season from the Tombigbee River drainage will be compared with prior surveys of the Pascagoula, Big Black, and Pearl River drainages. Trapping in these three systems has yielded a total of 1,199 turtles, representing 16 turtle species from four families (Trionychidae, Chelydridae, Emydidae, and Kinosternidae). Catch per unit effort varied dramatically between drainages, with the Pascagoula (0.92 turtles/trap nights) and Big Black (0.80 turtles/trap night) being significantly more productive than the Pearl (0.35 turtles/trap night). This study will expand to include the Yazoo River drainage in 2020, which will conclude the sampling effort across the state. Future objectives of this research will explore anthropogenic land use and habitat degradation as it affects water quality and the subsequent impact on basic health functions and chronic stress of riverine turtles. It is our goal to provide significant demographic information as well as distribution amendments that will help inform conservation and management of turtle populations in Mississippi.

Population Assessments: Oral (student)

Twenty Years of Turtle Surveys at Rock Springs and Wekiwa Springs in Florida

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In 1999, two college professors and a dozen students conducted a one-day turtle survey of Rock Springs where 13 *Pseudemys nelsoni* were captured and marked. Since that time, one to three surveys have been conducted per year in the Wekiwa Springs/Rock Springs area and over 4,800 turtles of 10 species have been marked. In the process, the TSA – North American Freshwater Turtle Research Group (TSA – NAFTRG), a volunteer, citizen science organization was born. Results from the first 15 years for four species are discussed here. Using Cormack-Jolly-Seber models in Program MARK, we calculated apparent annual survival, recapture rates, population estimates, and Pradel's λ . For adult *P. nelsoni* and *P. floridana peninsularis*, apparent survivorship was ca. 0.83 and slightly higher for males than females. Recapture probability was moderate at ca. 0.36. Population estimates were 1,411 for *P. nelsoni* and 1,119 for *P. floridana peninsularis*. For *Sternotherus odoratus* and *S. minor*, apparent survivorship was ca. 0.75 and slightly higher for female *S. odoratus* and for male *S. minor*. Recapture probability was low at ca. 0.13. Population estimates were 1,977 for *S. odoratus* and 3,417 for *S. minor*. Pradel's λ suggests stable to slightly growing populations for all four species. TSA-NAFTRG is currently working in eight spring systems in Florida and planning expansion into three more in the next year.

Population Assessments: Oral

Florida Turtle Conservation Trust: Conserving Florida's Rich Turtle Diversity Since 1999**GEORGE L. HEINRICH^{1,2} AND TIMOTHY J. WALSH^{2,3}**¹Heinrich Ecological Services, 1213 Alhambra Way S., St. Petersburg, Florida 33705 USA²Florida Turtle Conservation Trust, 1213 Alhambra Way S., St. Petersburg, Florida 33705 USA³Bruce Museum, 1 Museum Drive, Greenwich, Connecticut 06830 USA

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Florida's wide variety of habitats support 28 of the 62 (45.2%) species known to occur in the United States, the most turtle-rich country. Considering that 20 (71.4%) species in Florida are in need of conservation attention, the significant habitat diversity and species richness not only make the state a chelonian hotspot, but critical to the conservation of many species as well. The Florida Turtle Conservation Trust (FTCT) was formed in 1999 by a group of biologists and conservationists concerned with the outlook for Florida turtles. This NGO focuses on research, education, and advocacy by engaging with diverse partners. This presentation will review numerous projects completed over the past twenty years. Despite the broad threats facing turtles, opportunities for conservation are abundant. The FTCT welcomes partners interested in working to conserve Florida's rich turtle diversity.

Conservation Planning: Oral**Reducing Common Raven Predation Pressure on the Mojave Desert Tortoise****KERRY L. HOLCOMB**

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Common Raven (*Corvus corax*) populations have grown exponentially across many of the arid and semi-arid ecosystems of North America, due to the ever increasing availability of anthropogenic subsidies—i.e., transmission tower nest-substrates, road kill carcasses, garbage, pet as well as livestock food and water, etc. Breeding Bird Surveys document a 700 percent increase of Common Raven populations in the Mojave Desert over the last forty years. Consequently, Common Raven predation has contributed substantially to the decline of avian and reptilian species. In many parts of the western Mojave Desert, Common Raven depredation of the Mojave desert tortoise (*Gopherus agassizii*) has caused the number of 3 to 9 year-old (i.e., 60 to 120-mm midline carapace length) tortoises to decline precipitously, thus shifting the demography of these populations in favor of larger adult animals—and all but stifling recruitment into sub-adult and adult size classes. In 2008, the Fish and Wildlife Service in partnership with the Raven Subgroup of the Desert Managers Group published an Environmental Assessment (EA) to enable implementation of a phased Raven Management Program, designed to reduce Common Raven predation pressure on the Mojave desert tortoise in California's Deserts by at least 75 percent. A phased approach ensured that all nonlethal Common Raven management options were exhausted before broad-scale Common Raven removal is considered. As part of phases I & II the Raven Subgroup has or is implementing an environmental education program, wildlife-proof trash-receptacles installation program, road kill removal program, landfill soil-capping program, green lasers hazing program, Common Raven egg oiling program, and Common Raven Removal program for all ravens associated with a tortoise depredation. We are also in the process of analyzing all raven management data collected between 2013 and 2018, which will provide us with a comprehensive database of identified Common Raven nests. My presentation will expand on each of the Common Raven Management programs and will summarize our recent success using three-dimensionally printed TechnoTort™ tortoise decoys to estimate the likelihood that 3 to 9 year old tortoises will be depredated by a Common Raven during a single Mojave desert tortoise spring active season.

Turtles of the Southwest: Oral**Common Snapping Turtle Activity Patterns****ETHAN C. HOLLENDER AND DAY B. LIGON**

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Understanding patterns of animal activity, particularly when those patterns vary among individuals and change in response changing environmental cues, is important in developing appropriate study methods and conservation measures. We investigated the activity patterns of Common Snapping Turtles (*Chelydra serpentina*) on both daily

and seasonal time scales. This species has a broad geographic distribution and inhabits a wide range of biomes; although studies related to movements and seasonal activity have been published previously, most have been conducted at either the northern extent of the species' range in Canada or in subtropical environments in the southeastern United States. Our study was conducted in temperate grasslands in southeastern Kansas near the latitudinal center of its range. We equipped ten turtles (4 males, 6 females) with radio transmitters and data loggers that recorded the temperature hourly. Carapace temperature profiles were generated depicting hourly temperature from August 2017 to August 2018. At the end of this period, data loggers were recovered from nine of the turtles. For comparison, environmental temperatures were collected from a series of data loggers at known positions near turtles' overwintering locations. Air temperature data were obtained from a weather station near our study site. All turtles became primarily inactive during the winter months, although five moved substantial distances in November and December: two turtles moved between ponds, and in both cases these movements occurred within hours before an abrupt temperature decline. Although it is tempting to conclude that these were responses to changing barometric pressure, more data are needed to test this hypothesis. In summer 2018, one of the wetlands most frequently used by our turtles dried up entirely. All of the Common Snapping Turtles known to inhabit that wetland moved to other wetlands, but responses were variable: six remained active in the water of their new ponds, whereas three buried themselves in mud at the edge of their new ponds and remained inactive for 3–8 weeks before emerging and returning to water. Our results suggest that the responses of Common Snapping Turtles to physiologically challenging environmental conditions are variable both within a population and across the species' range.

Presentation type: Poster (student)

Relocating Traps within a Wetland Increases Trapping Success

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To accurately assess the size and composition of a turtle community, it is necessary to maximize the proportion of individuals captured and marked. To determine whether regularly relocating traps in a wetland can improve capture rates, we simultaneously deployed two sets of eight traps in a small pond in the Mined Lands Wildlife Area in southeastern Kansas. In one group, traps remained in their original locations for 35 days. In the other, traps were moved to new locations after 14 days, then returned to their original positions after a further 14 days. During the first period, there was no significant difference in capture rates between groups. During the second period, traps that had been moved captured 2.18 times more turtles than stationary traps, a difference that was statistically significant ($p = 0.005$). In the final period of 7 days, with all traps back in their original positions, traps that had been moved captured 2.10 times more turtles than traps that had been stationary ($p = 0.035$). We captured six species of turtles, but two species—*Trachemys scripta elegans* and *Sternotherus odoratus*—composed 41% and 56% of individuals, respectively. Therefore, we restricted our interspecific comparisons of capture patterns to these two species. The effects of moving traps differed significantly between species with regard to the total number of individuals captured. The number of *S. odoratus* captured increased dramatically as a result of moving traps, whereas the number of *T. s. elegans* remained relatively unaffected. These interspecific differences in capture patterns resulted in stationary traps generating different, and incorrect, conclusions about the composition of the aquatic turtle community. Our results demonstrate that trap relocation is an important component of maximizing trapping success and, by extension, generating accurate population estimates.

Techniques: Oral (student)

Movement Patterns of the Florida Peninsula Cooter (*Pseudemys floridana peninsularis*) and the Florida Red-belly Turtle (*Pseudemys nelsoni*) found in a Central Florida Spring System

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Little has been published about the movements of the Florida Peninsula Cooter or the Florida Red-belly turtle. The *Pseudemys* genus species are among the least studied turtles in North America. In a 20-year population study conducted by the Turtle Survival Alliance – North American Freshwater Research Group, turtles were noted leaving the spring system and returning in nonconsecutive years, turtles marked at one site were captured at another site ten river miles apart, and there is evidence of movement up to 113 river km between springs. This phenomenon leads to the question of where these turtles are migrating to and from. In July 2018, forty-eight turtles were outfitted with radio transmitters. Tagged turtles were monitored and tracked using a three-element Yagi antenna for 6 months by boat every weekend, covering approximately 48 river km, for 6 months (and will be continuing for 1 full year). Locations were recorded using a handheld GPS unit and were loaded into ArcGIS for analysis. This movement data will be used to determine home ranges for these species. This project represents the first study of its kind to assess the movement patterns of these two species to better understand their overall ecology, behaviors, habitat preferences, and human impact concerns. The results will be utilized for the conservation and habitat protection of these species in addition to serving as a model for other freshwater turtle species conservation.

Presentation type: Poster (student)

Gopher Tortoise Demographic Responses to a Novel Disturbance Regime in Florida

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The long-term viability of gopher tortoise (*Gopherus polyphemus*) populations is jeopardized by increased urbanization and habitat degradation owing to fire suppression. Because the species' remaining natural habitats in the southeastern U.S. exist within a mosaic of anthropogenic land uses, there is a need to understand demographic responses to contrasting land uses and habitat management regimes. Here we examine differences in demographic parameters among fire-suppressed sandhill, restored sandhill, and former sandhill (i.e., ruderal) habitats at Archbold Biological Station in south-central Florida. Using program MARK, we estimated population size and sex-specific and habitat-specific survivorship based on 6 years of mark-recapture data. We also analyzed individual growth trajectories and clutch sizes to determine whether growth rates or reproductive output differed among habitats. Tortoises in the open, ruderal habitat exist at much higher density (8.24/ha) than in adjacent restored (1.73/ha) or fire-suppressed (0.30/ha) sandhill units. Despite this dramatically higher density, both adult survivorship and body size was significantly higher in the ruderal habitat, and we detected no offsetting negative demographic effects. In particular, there were no significant differences in body condition, asymptotic body size, or growth rate among the three habitat types. In fact, larger female body size in ruderal habitat likely contributed to both the increased annual survivorship and slightly larger average clutch sizes. Our results suggest that anthropogenic, grass-dominated habitats may be important components of the habitat mosaic currently available to this at-risk species.

Ecology: Oral (student)

If You Build It, They Will Come: Private Habitat Restoration and Conservation

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On-the-ground conservation biology is generally the purview of institutions, organizations, and government agencies. The Turtle Survival Alliance, for example, undertakes many in situ and ex situ turtle conservation projects around the world. However, the value of private, grassroots, local conservation efforts, particularly focusing on turtles and other herps, should not be overlooked. I purchased a 36-acre mid-growth forest after the big trees were logged in 1993, and expanded it with the purchase of a contiguous 40-acre cornfield in 1997. By exploiting readily

available government Classified Forest, Conservation Reserve, and US Department of Agriculture programs, and taking advantage of Federal Farm and Conservation Easement tax deductions, I have constructed 41 permanent to ephemeral wetlands (24 by hand), planted over 50,000 trees, reduced invasive herbaceous species by over 98%, and hence, created a 71-acre reforested, permanently protected wildlife reserve on previously abused land in Indiana, all at a net profit to date of \$5500 (including land costs). The habitat now supports thriving populations of 17 amphibian and 13 reptile species, including *Terrapene*, *Chrysemys*, *Sternotherus*, and *Chelydra*. Think globally, but act locally.

Organic Conservation: Oral

Exploring Multilevel Habitat Selection by Flattened Musk Turtles (*Sternotherus depressus*): Informing Future Conservation Efforts for One of North America's Most Imperiled Turtle Species

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The Flattened Musk Turtle (*Sternotherus depressus*) is a small kinosternid turtle endemic to the portion of the Black Warrior River Basin (BWR) above the Fall Line in Alabama. Listed as threatened under the Endangered Species Act and critically endangered by the International Union for the Conservation of Nature, *S. depressus* populations have experienced range-wide declines attributed to sedimentation and chemical pollution from mining, agriculture, and development. In this study, we utilize trapping, visual encounter, and radio telemetry surveys in conjunction with side-scan sonar and point-transect habitat surveys to explore 2nd (population level), 3rd (individual level), and 4th order (microhabitat level) habitat selection by *S. depressus* in the relatively unimpacted populations of Bankhead National Forest. Our results will be utilized to inform and focus upcoming conservation efforts for the species in the BWR.

Ecology: Oral (student)

Ecology of the Arizona Mud Turtle (*Kinosternon arizonense*) on the Arizona-Sonora Border

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The Arizona Mud Turtle (*Kinosternon arizonense*) is found in tanks, seasonal ponds, roadside ditches, and washes from Pima County, Arizona, USA to central Sonora, Mexico. The species is most frequently distributed at elevations from 200 to 800 m, and most occurrences in the United States have been reported from the Tohono O'odham Nation Reservation. *Kinosternon arizonense* is one of the least-studied freshwater turtles native to the United States. Despite its restricted range and association with relatively xeric landscapes in an area undergoing a drying trend, *K. arizonense* is considered to be secure and of "least concern" by the IUCN. *Kinosternon arizonense* is primarily active during the monsoon rains of July and August, during which time adults have been found crossing roads. Although *K. arizonense* is known to make large overland movements, its dispersal behaviors and seasonal ecology are poorly documented, and metapopulation dynamics have not been examined in depth. From July 2016 to December 2018, we conducted a long-term, telemetry-assisted ecological study of a population largely on federal land. We focused our sampling effort within two anthropogenic tanks located 430 m apart within 300 m of the Arizona-Sonora border, which is demarcated by a dirt road and bollard-style fencing. Thirteen adult turtles (6F, 7M)

were tracked for periods ranging from 1–2 years. Two of 13 turtles used both primary tanks, and 11 turtles were found only within and adjacent to a single tank. Turtles were found in the tank only during the summer and fall monsoon rains from July to October. During the remainder of the year, most turtles remained primarily within Kangaroo Rat (*Dipodomys* spp.) mound complexes, although some overwintered in shallow soil or unidentified mammalian burrows. Overwintering sites ranged from 24 to 335 m (mean=129 m) from the aquatic habitat. Most turtles within the USA used only one (46%) or two (46%) distinct upland activity areas, usually encompassing a mound complex; one turtle used three distinct upland sites. Three turtles (23%) crossed the border into Sonora during a portion of the active season. We will present detailed movement analyses, demographic data, conservation implications, and management needs.

Turtles of the Southwest: Oral

A Reassessment of the Florida Box Turtles (*Terrapene bauri*) on Egmont Key

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The Florida Box Turtle population on Egmont Key, Hillsborough County, Florida, was the subject of long-term ecological studies from 1991–2006 by C. K. Dodd, Jr. and colleagues. Among North American Box Turtle populations which tend to demonstrate population decline over time, the Egmont Key population was unusually dense and demographically robust with an increasing population trajectory estimated to be 780 turtles in 1991 and 1480 turtles in 2006. In 2017–2018, we conducted three extended surveys of the island to reassess the condition of the Box Turtle population and evaluate the effects of a 26-hectare (ha) wildfire that occurred in July 2016. We implemented standardized sampling protocols including point-centered ¼ ha plots, a cross-island transect, and GPS-referenced visual encounter surveys. We detected 348 box turtles, of which 33 were alive and 315 were dead. The 33 live Box Turtles were captured 37 times and included only four turtles marked previously by Dodd et al. (12.1%). Of the 315 dead Box Turtles, 83 (26.4%) had been marked by Dodd between 1991–2006, 119 (37.8%) had not been previously marked, and 113 (35.9%) were too badly damaged to ascertain. Randomized, time-constrained surveys within the wildfire area revealed an average of 38.5 dead turtles per ha, from which we extrapolate approximately 1005 (95% CI=786–1223) observable, dead box turtles across the entire extent of the 2016 wildfire. While not all of these died in the fire, the extrapolated number of dead turtles within the 2016 wildfire area represents nearly 68% of the last population estimate in 2006. A randomized, east-west transect produced comparable results. Although there are many sources of uncertainty, the 2016 wildfire resulted in a significant mortality event. Simple log linear estimators indicate a current population size of 238 animals, though low detection rates and elevated rates of recent mortality indicate that we may violate key assumptions of closed-population modeling. Our reassessment indicates that a once-robust and regionally-significant Box Turtle population has been substantially reduced in numbers, and that mortality rates from chronic and stochastic sources are higher than they were during the initial years of study.

Documented Declines: Oral

Ecology of the Yucatán Box Turtle (*Terrapene yucatana*) in Yucatán

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The Yucatán Box Turtle (*Terrapene yucatana*) is the southernmost representative of the North American Box Turtles and the subfamily Emydinae, and one of only three Emydine lineages to occur within the tropics. As such, *T. yucatana* is an enigmatic biogeographic outlier and a significant evolutionarily lineage. We studied the demography, movements, seasonal ecology, and behavior of the Yucatán Box Turtle in Yucatán, Mexico from July 2014 to December 2018. Our study area encompassed 23 ha of tropical forest and thornscrub in a remote, largely forested area used primarily for cattle grazing. We evaluated home range size, interannual home range fidelity, and habitat use by using radiotelemetry to study the movements of 10 females and 7 males for periods ranging from 3 to 5 years. Annual home range size using the 100% minimum convex polygon (MCP) method averaged 0.84 ha for females and 1.41 ha for males; males use significantly larger areas than females on an annual basis. The long axis of the MCPs averaged 165 m for females and 194 m for males. Turtles were found predominately in upland forested habitats with occasional observations in clearings dominated by columnar cacti, thornscrub, and graminoids. The active season varied annually but usually extended from late spring to late autumn. Gravid turtles were observed in July, but no nesting was observed. Twenty-one instances of courtship or mating were observed from June to November, with more than half occurring in September or October. Fighting between males was observed on three occasions between August and November. Turtles were primarily observed dormant in roots, shallow burrows, rocky cavities, and dense vegetation during the winter months. Using loglinear models, we estimated the population size within our study area to be 56.1 (49.0–60.3), equivalent 2.4 turtles/ha. We encountered three other turtle species within our study area: *Kinosternon scorpioides*, *Rhinoclemmys areolata*, and *Trachemys venusta*. The Yucatán Box Turtle is a significant evolutionarily lineage that would benefit from large-scale forest conservation programs on the Yucatán Peninsula, since the species is clearly threatened by urbanization, energy development, deforestation, prescribed fire, climate change, and increasingly rampant collection.

Population Assessments: Oral

The Nexus between Buying Critical Habitat and Long-Term Management: The Geometric Tortoise (*Psammobates geometricus*) Ecosystem Preserve in South Africa

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The acquisition and long-term management of private property by foreign entities for conservation in developing countries presents complex challenges. For historical reasons land issues are politically charged in South Africa. The remaining unique Fynbos habitat of the critically endangered Geometric Tortoises (*Psammobates geometricus*) has been dramatically reduced (90%+) over the past two centuries to a few comparatively small, privately owned isolates embedded within a largely human transformed agricultural and suburban landscape near Cape Town. For several years the Turtle Conservancy worked closely with the Provincial government's conservation agency CAPENATURE and other local tortoise scientists to identify and prioritize candidate tortoise populations/habitat areas with long term sustainability potential. Over previous decades since the 1970s several private/public tortoise reserves in the area had failed due to inadequate size, incompatible adjacent land uses, and changing private land owner priorities. These failures helped inform our strategy. Based on a range of assessment criteria including complex legal considerations we purchased undeveloped farm land with the largest surviving population of tortoises remaining within the range and created a local South African "public benefits" (tax exempt) Trust to hold ownership of the property and channel funding to management. Trustees of the Southern Africa Tortoise Conservation Trust include both local and international membership. Now operating for several years under local management and close cooperation with adjacent farm owners our Preserve is a well-accepted neighbor in the rural landscape, benefitting from close cooperation on issues of wildfire mitigation, farm security and shared resources (farm equipment, labor). We have also implemented a plan of direct hiring of unemployed local farm workers to staff the reserve's ongoing habitat management efforts (alien species clearing and native species restoration, fence and firebreak maintenance, tortoise monitoring, predator control, etc.).

Habitat Protection: Oral

Proof of Dispersion over the Sea of the Freshwater Turtles, Red-eared Slider and Reeve's Pond Turtle in Japan**SYUN KABURAGI AND NAOKI KAMEZAKI**

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In Japan, the red-eared slider (*Trachemys scripta elegans*) from North America were introduced in the 1960s, and the Reeve's pond turtle (*Mauremys reevesii*) were introduced from the Chinese continent around the 17th century, and are now distributed throughout the western part of western Japan. These two alien species have recently become the dominant species. On the other hand, there is an inland sea called Seto Inland Sea in Japan, and 727 islands are scattered there. Since these islands have different environments and distances from land, it is thought that clarifying the species composition of freshwater turtles will reveal the environmental conditions under which these turtles will settle and thrive. A survey of freshwater turtles on 9 islands in the Seto Inland Sea (area: 0.08 km² to 14.49 km²) during the period from April to September 2018 found that the red-eared slider and the Reeve's pond turtle inhabited 6 out of 9 islands. These six islands had small ponds, and the three islands where turtles did not live had no ponds. Of the six islands where turtles inhabit, four were islands where humans lived, and two were uninhabited islands. Based on the above, these two species, especially the recently introduced red-eared slider, were considered not to have been brought in and disseminated by humans, but to invade through the sea and to settle if there was a pond there.

Presentation type: Poster (student)

Feeding Strategies of the Alien Species, the Red-eared Slider, *Trachemys scripta elegans*, in Japan**NAOKI KAMEZAKI AND HAJIME SAITAKE**

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The red eared slider turtle, *Trachemys scripta elegans* is an alien species native to North America. It is omnivorous in diet but is more herbivorous. It is extremely adaptable to the Japanese environment, and is extremely increasing in rivers and ponds. However, it has not yet been clarified what kind of influence it has on the Japanese ecosystem. Therefore, in order to estimate the effect, the contents of the stomach of 119 individuals (females: 82 and male: 37) eliminated in two rivers were classified and their wet weights were measured and analyzed. The most common stomach content of turtles from rivers was 50.3% in the waterweed especially *Egeria densa* and then 36.1% in the filamentous alga *Spirogyra*. In Japan, this species is herbivorous as in the America, and 86.4% of the food is occupied by plants. On the other hand, animals accounted for 13.6% of the whole stomach contents, mainly crustaceans and insects, and a small amount of snail and fish. The contents of plant matter were mainly waterweed and filamentous algae, but the ratio was biased depending on the river. The plants in the stomach contents were different between two rivers. One river was dominated by waterweed and the other was flooded with algae. Also, turtles eating animals were more common in rivers where waterweed is the main source. These differences in stomach contents are thought to be caused by the river's biota. In addition, as the density of this turtle increases, producers in the ecosystem are consumed, making it an environment where various organisms could not survive.

Presentation type: Poster

Ecological Roles of the Heavily Traded Southeast Asian Box Turtle (*Cuora amboinensis*)**NANCY KARRAKER¹, MIRZA KUSRINI², JESSICA ATUTUBO¹, RYAN HEALEY¹, AND AINI YUSRATUL²**

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The Southeast Asian box turtle (*Cuora amboinensis*) is numerically the most important turtle exported from Indonesia. Listed as Vulnerable by the IUCN, this turtle is heavily harvested in Indonesia for food and traditional medicine trades largely in China and for the pet trade in the U.S., Japan, and Europe. Despite its significance in global markets, very little is known about the species' importance to ecosystems. We conducted our research in a

national park in Sulawesi, Indonesia, and our objectives were to document food habits, capacity for seed dispersal, and whether ingestion of seeds by *C. amboinensis* enhances germination. We obtained feces from 200 individual turtles and found that the species is omnivorous, feeding on crustaceans, mollusks, insects, vertebrates, and plants. In a seed passage experiment, turtles passed seeds for 3–9 days after ingestion. Radio-tracked turtles moved, on average, about 35 m per day, between terrestrial and aquatic habitats, indicating that seeds from ingested fruits could be dispersed moderate distances from the parent tree. In a seed germination experiment, we found that ingestion by turtles increased germination success of seeds of three of six plant species tested, as compared with control seeds. Two of the tree species that benefitted from ingestion are two of the most common trees in the national park and are also highly valued outside of the park for their lumber for house and furniture building. Protection of *C. amboinensis* populations may be essential for maintaining important ecological roles that benefit biodiversity and local economies.

Field Studies: Oral

How Useful are Scute Annuli for Estimating Demographic Parameters in Southwestern Turtles?

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Scute annuli have a long and controversial tradition of use amongst turtle researchers, with opinions on their utility ranging from them being highly useful to them being rarely useful. These opinions are largely based on studies that have focused on the robustness of the scute annuli technique to accurately estimate the age of an individual. However, scute annuli potentially have broad utility to address other research questions, such as the use of age-structured data for demographic analyses. Of all demographic analyses, the estimation of annual survival has been particularly problematic, but use of both radiotelemetry and open population capture-mark-recapture models have been demonstrated to provide very robust survival estimates across diverse taxa. Unfortunately, both of these traditional techniques can be very expensive or require labor-intensive long-term research projects that may stress resources. We used scute annuli to calculate annual survival estimates using age-structured regression for one population of Texas tortoises (*Gopherus berlandieri*), one population of ornate box turtles (*Terrapene ornata*), and five populations of yellow mud turtles (*Kinosternon flavescens*). In all populations examined, the percent of individuals that were too old to effectively age using scute annuli was generally <5%. We then compared those estimates to more traditional survival analyses derived from Kaplan-Meier annual survival estimates using radiotelemetry and/or open population capture-mark-recapture models for the same populations. Within both the Texas tortoise and ornate box turtle populations, the difference between the highest and lowest survival estimates was only 6%. For yellow-mud turtles, differences between annual survival estimates from scute annuli and those derived from capture-mark-recapture were generally less than 3%. Thus, age-structured regression from scute annuli data produced annual survival rates that had remarkable concordance with estimates from the other methods. Although using scute annuli is not without problems, under certain conditions they may provide a rapid, relatively inexpensive alternative to estimating survival for a variety of different turtle populations in the southwestern United States.

Turtles of the Southwest: Oral

Ontogeny of Movement Behavior in Alligator Snapping Turtles (*Macrochelys temminckii*): Insights from a Reintroduced Population

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Alligator Snapping Turtles (*Macrochelys temminckii*) grow significantly over their lifetime whereby the largest adults attain masses nearly four orders of magnitude greater than hatchlings. With such a drastic change in size, *M. temminckii* must exhibit strong ontogenetic shifts in behaviors. Most work describing *M. temminckii* movements have focused on adult or subadult turtles leaving little known about the ecology of juveniles. Our ongoing

reintroduction program consists of radio-equipped young head-started (two- to four-year-old individuals) and older subadult and adult (captive raised or confiscated) individuals ranging in sizes from 102 g to > 7 kg. We fit turtles with radio-transmitters and located them several times a week during the active season (May–October) from 2014–2016. We recorded > 6,500 movements across 187 individuals. For locations taken < 3 days apart, the median distance moved was 12.3 m, with rare movements of > 1 km. Mean daily movements of subadult turtles were greater than juveniles. Also, many individual movement patterns were characterized by periods of inactivity punctuated by movements to new locations. Our results provide data not only for our reintroduction efforts but for the understudied juvenile stage of these unique turtles.

Population Mechanics: Oral (student)

The Influence of Age and Season on Basking in Alligator Snapping Turtles (*Macrochelys temminckii*)

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Alligator Snapping Turtles (*Macrochelys temminckii*) are considered among the most highly aquatic turtle species in North America. Until recently, *M. temminckii* were thought only to leave the water for nesting. However, several recent published observations have shown aerial basking to be natural behavior in *M. temminckii*. As part of our reintroduction monitoring efforts in southern Illinois, we fitted temperature-logging iButtons to juvenile, subadult, and adult turtles. Each logger recorded shell temperatures hourly for a year. Elevated temperatures consistent with basking behavior (aerial or aquatic) were detected in all age classes but were more common in younger individuals. Also, basking events were more prevalent in early spring. Aerial basking was observed in *M. temminckii* of various sizes on multiple occasions during radio tracking; however, the method likely underestimates basking behavior as turtles often retreated to the water on approach. Our study attempts to quantify the ontogeny and seasonality of thermoregulatory behavior of *M. temminckii*, a topic of great interest to species experts.

Presentation type: Poster (student)

Application of Conservation Genetics to a Home's Hinge-back Tortoise (*Kinixys homeana*) Population in Central Ghana

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The Home's hinge-back tortoise (*Kinixys homeana*) has been draft listed as Critically Endangered under IUCN Red List standards since 2013. This species is declining due to harvesting for food, traditional medicine practices, and the international pet trade. In Kakum National Park and Pra Suhein Forest Reserve in Central Ghana, local communities harvest tortoises primarily for sustenance. Because of the cryptic nature of *K. homeana* in its natural rainforest habitat, monitoring the ecology and impacts of harvesting on this population is challenging. We proposed conducting a population genetics study to measure genetic diversity levels in this population to contribute to this research. Amplified Fragment Length Polymorphisms (AFLPs) were used for estimating diversity, inbreeding, and bottleneck in the population. We successfully amplified AFLPs from 83 individuals and found low levels of expected heterozygosity (Nei's genetic diversity, $H_T=0.1026$) and moderate levels of inbreeding ($F_{AFLP}=0.15$). No bottleneck was detected, and no population structuring was present between the two parks ($F_{ST}=0.058$, 95% CI=-0.0178–0.0609). Since there are not yet other *Kinixys* population studies to which we can compare our results, we conducted a literature analysis to document commonly-observed diversity and inbreeding values for turtle populations. Inbreeding values ranged from 0.019–0.294 (F_{IS} values; $n=13$), while expected heterozygosity had a mean of 0.72 ($SD=0.12$, $n=43$). Whether our genetic diversity values are lower because of our exclusive use of AFLPs is unknown. Future proposed studies will use other molecular markers to measure these genetic values (e.g. microsatellites and SNPs). Identification and genetic analyses of other *K. homeana* populations throughout Ghana, coupled with harvesting rates, would assist greatly in designing broader-scale conservation efforts.

Genetics: Oral (student)

**Collaborative Conservation Planning in the Northeastern United States:
Regional Conservation Needs Grant Program**

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The management and implementation of conservation actions can often be inhibited when the distribution of a species crosses multiple government jurisdictions. In the United States, the Northeast region of the Association of Fish and Wildlife Agencies (NEAFWA) and Region 5 of the U.S. Fish and Wildlife Service (USFWS) is comprised of 13 states and the District of Columbia. Distributed within this region are 21 species of fresh and brackish water turtles, twenty of which are listed in at least one State Wildlife Action Plan (SWAP). To address the need of range wide conservation actions and coordination, the NEAFWA, the USFWS, and the Wildlife Management Institute partnered in 2007 to create the largest multi-jurisdictional collaborative in the United States: the Northeast Regional Conservation Needs Grant Program (RCN). Recognizing shared elements of SWAPs, participating states agreed to pool 4% of their respective State Wildlife Grant apportionments to fund cooperative projects that impact regional-level conservation and restoration initiatives that extend beyond state borders. The central goal of the RCN program is to develop, coordinate and implement conservation actions that are regional or sub-regional in scope, to build upon the multiple regional initiatives that already exist and complement ongoing work in individual states. Specifically, RCN projects produce 1) unifying maps of the target region's habitats, 2) common language and condition analysis of those habitats, 3) identification of regional conservation focus areas (what they are and where they are), and 4) consistent metrics to measure success and gauge effectiveness. Each year, approximately \$350,000 of State Wildlife Grant funds are provided by NEAFWA states, leveraging another half million dollars or more from the Wildlife Management Institute and proposal applicants. Since its creation in 2007, four RCN grants totaling nearly one million dollars have been awarded to address five species of turtle: Blanding's Turtle (*Emydoidea blandingii*), Wood Turtle (*Glyptemys insculpta*), Spotted Turtle (*Clemmys gutatta*), Woodland (Eastern) Box Turtle (*Terrapene carolina carolina*) and Northern Diamond-backed Terrapin (*Malaclemys terrapin terrapin*).

Conservation Planning: Oral

**Beyond Legends and Lament: Human Societies and the Yangtze Giant Softshell Turtle (*Rafetus swinhoei*)
from the Neolithic through the Present Day**

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Current knowledge about the Yangtze Giant Softshell Turtle (*Rafetus swinhoei*) is based on local legends and narratives constructed by biologists and conservationists. This contributes to a relatively homogeneous image of the species as large, rare, and mysterious. Now the focus of human attention, these three surviving individuals, the last of their kind on the planet, stir simple feelings of awe, hope, and lament in the general public, in part because of that homogeneous image. As increasing public attention toward *Rafetus swinhoei* focuses on science and myths, there is little representation or discussion of the experiential, such as communities interacting with these giant reptiles. As such, it is difficult for the public to fathom the meaning of the loss of this critically endangered species for human communities. If we consider the relationships between humans and *Rafetus swinhoei* in a natural setting, we can then recognize the roles the species played in different human cultures, and how and why such roles developed under different social, cultural, historical, and environmental contexts. I present archaeological and ethnohistorical data collected from China and Vietnam, respectively, to discuss various human interactions, such as natural sightings, hunting, and consumption, with wild *Rafetus swinhoei* across time and space. By integrating lived experiences into the ongoing discussion of conservation for the endangered *Rafetus swinhoei*, I draw attention to how anthropogenic processes contributed to their rapid decline, and how their eventual extinction also means a tremendous loss in the diverse ways in which different cultures have interacted and survived with the species, and the myriad of emotions attached to these experiences.

Opening Plenary: Oral (student)

Land for Survival of the Last Tiny Self-Sustaining Wild *Pseudemydura umbrina* Population**GERALD KUCHLING***Western Australian Department of Biodiversity, Conservation and Attractions, 5 Dundee Road, Wanneroo, WA 6065, Australia**[Gerald.Kuchling@dbca.wa.gov.au]*

The only recorded wild populations of the Western Swamp Turtle *Pseudemydura umbrina* were two discovered on private properties at the northern outskirts of Perth in the 1950s and a population at Perth Airport land discovered in 1970. Private land was acquired specifically for the protection of *P. umbrina* in 1962 and two nature reserves were gazetted: Ellen Brook Nature Reserve (EBNR) and Twin Swamps Nature Reserve harboring together about 200 turtles. However, by the late 1980s/ early 1990s the Twin Swamps population and the airport population were functionally extinct and only about 25 individuals survived at EBNR, representing the last self-sustaining wild population. The *P. umbrina* habitat at EBNR (about 30ha) was smaller than the potential home range of an individual and turtles frequently used areas on the adjacent private properties. When I got involved with *P. umbrina* conservation in the late 1980s I submitted a proposal to the Department of Conservation and Land Management to acquire about 30ha of neighboring agricultural land for habitat restoration to increase the carrying capacity of the EBNR population. About five hectare were acquired in 1991, six in 2006 and five in 2016, still well short of my original proposal of 30 years ago, but experience was gained on successful methods to restore and create ephemeral swamp habitat with the help of community groups, to control predators and to provide drought refuges, allowing the EBNR population to increase slowly through natural recruitment. However, over the last decade the development pressure in this area increased dramatically. Adjacent land use is now not only threatening turtles directly when the venture on to neighboring land, but also polluting catchment areas and impacting swamp hydrology. Land prices are high due to encroaching housing developments and industries, but a new draft ten year Recovery Plan has as its highest priority to acquire enough land to triple the existing area of EBNR, partly using offsets from developments. Land management will remain government responsibility, but involvement of community groups becomes increasingly instrumental in fund raising, habitat restoration and lobbying authorities and politicians.

Habitat Protection: Oral**Digital Chelonian Log: Making Data-keeping Accessible and Sharable to Both the Hobbyist and the Professional****KÉVIN LABILLE AND STEVE ENDERS***theTurtleRoom, P.O. Box 521, Lititz, Pennsylvania 17543 USA**[kevin.labille@theturtleroom.com]*

Although keeping data and records about turtles and tortoises is time-consuming and effortful, it is yet a very important task to accomplish for both hobbyists and professionals. Today, whilst few softwares allow one to keep chelonian records, they tend to be unhandy and costly for both the private keeper and institutions. To overcome these problems, we introduce Digital Chelonian Log (DCL), a free web-based software that not only offers a wide range of data-keeping features, but also offers inter-users data sharing. Indeed, sharing private data and logs is of high importance for research and conservation purposes, as it could ease and enhance contributions to chelonian knowledge. To that extent, DCL was specifically designed for easily keeping and sharing uniformed chelonian records that respond to both conservationists and hobbyists needs. DCL allows one to track a specimen's general information, basic and advanced measurements, courtship behavior, clutch information, health records, pictures, and life events. In addition, DCL offers various graphical visualization tools such as graphs or matrices and allows a user to store numerous types of documents such as CITES papers, DNA paperwork, Veterinary paperwork, or various permits. Users can control both their personal privacy as well as their specimen's privacy with a fine granularity, allowing them to make certain data public, as well as to connect with other users. Finally, Digital Chelonian Log was designed with the latest web technologies and is therefore highly user-friendly, of a simple usability, and provides safe data storage with daily backups. By the mean of an Internet connection and a web browser, the software is accessible from any device, i.e., PC, laptops, tablets, and phones from any geographical locations, thus allowing one to access data at home or even on the field. A year after DCL was officially released, 60 users have joined our community with 525 specimens being safely recorded and 443 amongst which are publicly shared.

Captive Husbandry: Oral

Bite Force Scaling across Size Classes in the Alligator Snapping Turtle (*Macrochelys temminckii*) and the Common Snapping Turtle (*Chelydra serpentina*)SETH LAGRANGE¹, ETHAN KESSLER^{1,2}, AND MARK MERCHANT³¹Illinois Natural History Survey, Prairie Research Institute, University of Illinois, Champaign, Illinois, USA²Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign, Champaign, Illinois, USA³Department of Chemistry, McNeese State University, Lake Charles, Louisiana, USA
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Understanding feeding performance, specifically bite force, can help answer questions relating to feeding ecology and a species' niche. Feeding performance and morphology can either limit or increase access to different prey items and, thus, can greatly affect the trophic level of a species. The alligator snapping turtle (*Macrochelys temminckii*) (AST) and the common snapping turtle (*Chelydra serpentina*) (CST) are two closely-related, sympatric species with documented interspecific interactions. Due to their relative phylogenetic and functional relatedness, the mechanisms driving their feeding ecology and realized niche at different size classes are of great interest. One important aspect of feeding performance in these species is bite force. Bite force has been associated with overall performance, feeding ecology, and niche and is especially important for prey selection and availability. To better understand changes in feeding ecology between these two species we measured the bite performance of ASTs and CSTs across size classes. To do this we developed a bite force meter using piezoelectric force transducers that would accurately measure forces exerted during a defensive bite. We measured ASTs ranging from 0.23kg to 75kg and CSTs ranging from 0.38kg to 22.2kg. We elicited a bite by placing the bite force probe into the mouth and touching the beak. We measured bite forces in ASTs ranging from 8.22N to 1872N and in CSTs ranging from 3.5N to 895N. Our data shows that bite force increases with increasing mass and that at similar size classes ASTs and CSTs have similar bite forces but when the AST surpasses the CST in mass its bite performance is considerably greater. Therefore, at similar size classes ASTs and CSTs maybe be in direct competition for food resources but the greater size of ASTs could allow them to exploit a greater variety of resources than CSTs.

Presentation type: Poster**A Species on the Periphery: The Status of Gopher Tortoise (*Gopherus polyphemus*) Conservation Efforts in Louisiana**

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The Gopher Tortoise (*Gopherus polyphemus*) is a federally threatened species in Louisiana and faces several threats, including habitat loss and fragmentation, lack of prescribed fire, and incompatible land management practices. Louisiana's gopher tortoise population represents the western periphery of the overall geographical range of this species and is restricted to three eastern parishes in the state. The Louisiana Department of Wildlife and Fisheries has been working diligently over the past decade on state and regional efforts to ensure the continued persistence of this species in Louisiana and rangewide. Proactive conservation at the state and regional levels is critical to the long-term survival and viability of this keystone species. An overview of Louisiana's population assessment and habitat restoration efforts will be provided as well as updates on state and regional partnership efforts.

Conservation Planning: Oral**A Consistent Relationship between the Forelimb Proportions and Carapace Width in Turtles**

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The limbs of turtles must allow a turtle to move and reach necessary resources. This has to be accomplished within several fundamental restrictions, including that the limbs must fit inside the shell of the turtle. The development of neck retraction by turtles during the Jurassic must have forced modifications to the shell and limbs because the acquisition of head retraction increased the minimum possible size of the shell's anterior opening. Furthermore, the musculature and bones of the pectoral girdle, cervical vertebrae and the skull must be accommodated within the

anterior body cavity rather than just the pectoral girdle. The interdependency of the limbs and shell is demonstrated by the consistent ratio between humerus length and carapace width. The humeri measured (y) and associated carapace widths (x) fit the equation $y=0.349x-6.3977$ ($R^2 = 0.9479$). The ulnae (y) measured have a relationship to the carapace width (x) of $y=0.2357x-5.5824$ ($R^2 = 0.9468$). The manus (y) has a wider degree of variation and more loosely relates to the carapace width (x) by the equation $y=0.2541x-6.3411$ ($R^2 = 0.8002$). We attempted to assess the utility of a two element forelimb model based on the ulna and hand. These were plotted on a bivariate plot as the raw numbers without normalizing to a proportion of total limb length. The trend line of all of the measured forelimbs was calculated based on this. The turtles were divided into terrestrial and aquatic. The trend line of the equation y (hand length) = $1.0235x$ (ulna length) + 1.2845 separates the terrestrial and aquatic turtles with a high degree of accuracy. This was based on 55 specimens of 51 terminal taxa. Of these, four species were potentially misclassified: (1) two emydids that are in what would be called semi-aquatic *Glyptemys insculpta* were found to be aquatic, whereas we classified them as terrestrial; and (2) *G. muhlenbergii* was found to be terrestrial, whereas we had classified it as aquatic. *Cuora zhoui* and *C. amboinensis* were found to straddle the trend line, which appears to reflect their semi-aquatic habitus.

Presentation type: Poster

Variation in Turtle Shell Shape

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To assess the variability of turtle shell shape, the proportions of the carapace-width-to-plastron-width ratio and the length of each plastral scute relative to the plastron's length were measured for the emydid turtles *Terrapene ornata ornata* ($n=10$), *Trachemys scripta* ($n=25$) and *Pseudemys suwanensis* ($n=29$), and the testudinids *Gopherus agassizii* ($n=26$) and *Geochelone platynota* ($n=12$). *Kinosternon sonoriense* ($n=6$, 3m:3f), *Graptemys versa* ($n=5$, 4m:1f) and *T.s scripta* ($n=17$, 8m:9f) were examined for sexual dimorphism in shell structure. All specimens were all collected in small geographic areas, so geographic variation is minimized. The change within individuals was assessed using repeated measurements of *Graptemys psuedogeographica* ($n=4$) and hybrid *Mauremys sinensis/M. reevesi* ($n=2$). The measurements of the plastral scutes of the first group were quite variable. No clear pattern emerges; while *P. suwanensis* and *T. ornata* are similar in their variation, *T. scripta* differs in that its most variable scute (anal) is the least variable in the other two. The two testudinids both vary mostly in one of the two scutes that make up the medial portion of the plastron. The carapace-width-to-plastron-width ratio was also measured for all of these turtles. *Gopherus*, *Terrapene* and *Trachemys* varied little, <1% coefficient of variation. Conversely, *P. suwanensis* and *Geochelone* were more variable, with a coefficient of variation of 4-8%. Expected variation between the genders was found in *Graptemys*, *Kinosternon* and *Trachemys*. In the repeatedly measured individuals, the carapace-width-to-plastron-width ratio is nearly the same over ontogeny. Conversely, the proportions of the plastral scutes varied by as much as 40% between the two measurements. The *Graptemys* are not very variable in carapace-width-to-plastron-width, changing 0.8-3% between the two measurements. The high degree of variation in *Mauremys* and *Trachemys*, whether through phenotypic plasticity or genetic variation, may help explain why these animals are able to inhabit such wide areas of Europe, Asia and North America, respectively. The variation creates a better chance that at least some of them will be able to exploit any environment that they may encounter. This may also explain the relatively limited range of *Kinosternon*, as its small degree of variation likely limits the exploitable range of habitats.

Presentation type: Poster

Comparative Reproductive Allometry of Syntopic Black-Knobbed Sawbacks (*Graptemys nigrinoda*) and Alabama Map Turtles (*Graptemys pulchra*) in the Alabama River, With Comparison to Three Congeners

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In many freshwater turtle species, increasing adult female body size is accompanied by increases in both clutch size and egg size. Because clutch size and egg size represent competing sinks for the increasing abdominal space that can

be devoted to reproductive potential as a female grows larger, both are hypoallometrically related to body size, i.e., each increases at less than the rate at which body size is increasing. I studied the reproductive allometry of two species of the map turtle and sawback genus (Emydidae: *Graptemys*) in syntopy in the Alabama River. Relative to congeners, *Graptemys nigrinoda* is a small-bodied species and *Graptemys pulchra* is a large-bodied species. In the study populations, adult female *G. pulchra* were on average 23% larger in plastron length and 125% larger in body mass and there was no overlap in size. Both species had positive but hypoallometric relationships of both clutch size and egg size with body size, a pattern reported for three congeners previously, thus further demonstrating the competing sinks of increases in both variables and refuting the optimal-egg size hypothesis. There was no significant effect of species on clutch size after accounting for the effect of plastron length. The effect of species on egg width and width of the pelvic aperture was significant, with *G. pulchra* having wider eggs and pelvic apertures, perhaps related to their more domed carapace and their larger body sizes. Compared to three congeners, the two Alabama River species had relatively small clutches of relatively large eggs. Latitudinal effects on reproductive output appear to be important in *Graptemys*, with more northerly populations tending toward larger clutches of smaller eggs. There is a need to analyze more data from more populations with log-log analyses of reproductive allometry to confirm the trend. There is also a need to consider shape allometry in future analyses, in particular, the hypoallometry of both shell height and shell width relative to shell length.

Reproductive Studies: Oral

The Power of Community: A Grassroots Effort to Restore Native Populations of Northern Diamondback Terrapin (*Malaclemys terrapin terrapin*) in Northern New Jersey

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Northern diamondback terrapin (*Malaclemys terrapin terrapin*) populations have declined due to a number of factors since the early 1900's. The species has been identified by the New England Partners in Amphibian and Reptile Conservation (NEPARC) as a species of concern. Historic commercial fisheries, loss of habitat, drowning in commercial and recreational crab pots, increased nest failure due to predation from raccoons and other subsidized predators, and road mortality have been the primary causations for population decline (Brennessel n.d.). Illegal trade for the pet and food markets, both domestic and abroad is also be a major threat. The Turtle Conservancy has partnered with the Terrapin Nesting Project and the Turtle Room to promote a grassroots campaign to protect nesting sites for the terrapin, prevent road mortalities, and re-beach nesting sites previously developed for housing. Since 2011, the Terrapin Nesting Project has released 13,672 hatchlings in Barnegut Bay, New Jersey. This effort is entirely led by volunteers, showcasing the power of community engagement. As of 2018, the project has grown to over 900 volunteers. Surveillance and tagging turtles are vital tools in preventing and tracking illegal poaching of Diamondback Terrapins in recent years. These efforts have enabled the recovery of this keystone species, leading to the recovery of eelgrass, seahorses, and more.

Organic Conservation: Oral

Population Ecology of the Mexican Spotted Wood Turtle (*Rhinoclemmys rubida perixantha*) in the Pacific Coast of Mexico

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The natural history and population ecology of the Mexican spotted wood turtle (*Rhinoclemmys rubida perixantha*) is barely known. This turtle is endemic to Western Mexico, inhabiting the lowlands of the Pacific Coast. Being a fully terrestrial turtle and mainly occupying patches of tropical deciduous forest, the fieldwork and sampling on this taxon is difficult to achieve, making this turtle hard to study and to estimate its conservation status. From 2012 to 2017, as part a series of other projects conducted on this turtle in the Chamela-Cuixamala, Jalisco, Mexico, seven sampling events were conducted in the Chamela Biological Station at the Chamela-Cuixamala Biosphere Reserve. A capture-mark-recapture protocol was used to estimate the abundance, density, sex ratio, and the population structure of the

Mexican spotted wood turtle. To test for sexual size dimorphism, a morphological comparison between males and females was conducted. A total of 234 turtles were collected during the sampling events. The estimated population size was 1051 (\pm SE 217.4) turtles, with an estimated density of 43 individuals per hectare. Sex ratio was slightly skewed to males (1.2:1) and population was structured mostly by adults. Females were larger ($12.80 \pm$ SD 1.67 cm) and heavier (280.83 ± 92.17 gr) than the males (10.36 ± 0.84 cm; 139 ± 31.05 gr). The population seems healthy. Some hatchlings were captured during the study, which suggest the population is recruiting. Nevertheless, even with several years of intensive sampling in the study area the recapture rate was low. More fieldwork is needed, and special attention is required on the effects of high impact climatic events such hurricanes on the demography of the studied population.

Population Assessments: Oral

Strategies for Private Land Conservation in the Tropical Deciduous Forest of Alamos, Sonora, Mexico

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Private land conservation in Mexico has been proven to be the most effective way of ensuring protection of critically endangered ecosystems. The reason for this is that even within the federally protected areas, all land is privately owned. These lands sustain pressure of livestock over-grazing, agriculture, harvesting of natural resources and overall habitat degradation. Nature and Culture International is one of the few organizations in México that specializes in private and public land conservation. We started working in the Sierra Madre Occidental region of Alamos, Sonora 14 years ago with the vision of creating a 25,000-acre reserve to protect the watershed of the Cuchujaqui River and the biodiversity within it. NCI has purchased 14 contiguous pieces of land, Reserva Monte Mojino (ReMM). So far, we are working to protect 16,800 acres of Tropical Dry Forest (TDF) and Pine-oak ecosystems. Of the less than 15% of the TDF remaining only 5% is legally protected. In Alamos TDF there are over 1200 plant species, 48 different species of orchids, 330 different bird species (migratory and residents) 5 out of the 6 different species of big cats known in México and 6 species of chelonians. Amongst these chelonians is the Goode's thornscrub tortoise (*Gopherus evgoodei*). This recent significant discovery of a new tortoise species is evidence that there is still so much that is unknown about the TDF in this region. Long term conservation and protection of ReMM relies on how effective we are as an organization to engage and work alongside local, regional, and federal governments, especially with the agencies that could support our research and conservation work, but more importantly is working with the people and communities that surround the reserve. NCI's *bottom up* conservation model is to not only protect habitat but to engage the communities where we work to support conservation through different programs such as guardabosques (forest guardians) of ReMM, environmental education, compatible cattle grazing management with neighbors, and as assistants to researchers that visit ReMM.

Habitat Protection: Oral

Home Range and Movement Dynamics of Two Populations of Spotted Turtle (*Clemmys guttata*) at the Southern Extent of Their Range

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The spotted turtle (*Clemmys guttata*) is a Species of Greatest Conservation Need in Florida, where it reaches the southern periphery of its range. This species was recently petitioned for listing under the U.S. Endangered Species Act, citing habitat fragmentation and population declines. Spotted turtles have been documented from 15 counties in Florida, though most records are limited to single specimens found on roads between March and May. Little information exists on the habitat, abundance, distribution, and ecology of spotted turtles in the Southeast, with no previous studies targeting the species in Florida. Since 2014, we've used radio telemetry and mark-recapture techniques to investigate home range, movement, habitat, seasonal phenology, and population dynamics for two

populations of spotted turtles in Florida. We captured a total of 70 individual spotted turtles and tracked 27 using radio-telemetry. Adult home range size varies between sites and individuals, from very small (0.1 ha) to large (43 ha), with an overall mean of 6.6 ha. Both sexes remain active year-round, with males moving greater distances and utilizing larger areas. Shallow water and abundance of woody debris within complex, forested wetlands appear to be the most reliable habitat characteristics for predicting spotted turtle presence in Florida, with roads/high traffic volume negatively impacting populations and constricting movement and dispersal. Population size at occupied sites is small, with known sites scattered and isolated across the landscape. Results from this study indicate spotted turtles in Florida are both uncommon and cryptic, favoring a highly aquatic lifestyle, and rarely basking or spending time upland. Protection of large-scale wetland complexes and preserving connectivity is necessary for the long-term conservation of this rare and secretive species.

Presentation type: Poster

Post-release Movement and Survival of Differentially Head-started Mojave Desert Tortoises (*Gopherus agassizii*): Preliminary Results

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Head-starting—the captive rearing of offspring until they are of a size where presumably they are more likely to survive post-release—is increasingly being explored as a recovery tool for the Mojave desert tortoise. Most desert tortoise head-starting programs have focused on solely outdoor rearing and have been burdened by slow tortoise growth and expensive long-term husbandry. Efforts have shown it can take between 5-9 years using these traditional outdoor methods for tortoises to reach predator-resistant release sizes (~105 mm MCL). Here, we explore using a combination of indoor and outdoor captive rearing to maximize post-release success and rearing efficiency. We assigned 48 neonates (2016 cohort) to one of two treatments: 1) ‘Outdoor-only’ (n=24), where neonates were reared exclusively in outdoor predator-proof enclosures for two years; 2) ‘Combo-reared’ (n=24), where neonates were reared indoors for 1 year followed by outdoor rearing the 2nd year. A third treatment group of 6-7-yr-old animals reared exclusively outdoors (n = 30) was also compared. All animals (n=78) were released in the Mojave National Preserve, CA on 25 Sep 2018. We compare pre-release shell hardness and body condition as well as post-release movement and survival through the first activity season (7 mo post-release) among these treatment groups. Pre-release body condition was not significantly different among groups, however, 2-yr-old ‘Outdoor-only’ head-starts had significantly softer shells relative to the other two treatments. Excluding one missing animal, released head-starts experienced 92% survival from September – April, with all mortalities (n=6) resulting from predation. While all released head-starts settled within 3.2 km of the release area, Combo-reared head-starts moved significantly less than either of the solely outdoor-reared treatment groups.

Population Manipulations: Oral (student)

An Island of Misfit Tortoises: Assessing the Survival and Health of Translocated Waif Gopher Tortoises

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Due to many anthropogenic threats, the gopher tortoise (*Gopherus polyphemus*) is declining throughout its range. Although habitat management plays an important role in the species' conservation, alone it may be insufficient to recover severely depleted populations. As a result, population augmentation through translocation—the intentional movement of animals from one location to another—has become a valuable conservation tool. While there are risks associated with any translocation, waif tortoises—animals that have been collected illegally or have unknown origins—are generally excluded from translocations due to heightened concerns of introducing disease. Additionally, because waif tortoises are often housed in captivity for extended periods, the survival of translocated waifs may be lower than the survival rates reported for wild tortoise translocations. However, if these risks could be managed, waif tortoises could provide the needed numbers and genetic diversity to stabilize populations and prevent extirpations. In the early 1990s, a small population of gopher tortoises ($n \leq 10$) was discovered near Aiken, South Carolina. This discovery expanded the species' known range and resulted in the creation of the Aiken Gopher Tortoise Heritage Preserve (AGTHP). Due to the preserve's dire need for augmentation, the state's lack of suitable donor populations, and the site's isolation from other tortoise populations, the AGTHP provided the rare opportunity to study the effect of waif tortoise translocation without jeopardizing a viable population. Since 2006, over 260 waif tortoises have been introduced to the preserve. In order to evaluate the efficacy of the reintroduction efforts to date, we conducted recapture efforts from May–July in 2017 and 2018. We estimated the long-term apparent survival of tortoises and evaluated health through physical examination and by testing for common pathogens. The estimated annual apparent survival of tortoises was high (>0.91) for adult and subadult tortoises. We detected two pathogens common in wild tortoise populations, but overall, the individuals assessed appeared healthy. Survival rates and health profiles were comparable to wild gopher tortoise populations.

Population Manipulations: Oral (student)

Where are the Turtles? Looking for Western Chicken Turtles in Mississippi

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The chicken turtle (*Deirochelys reticularia*) is an atypical member of the Emydidae family that is found in shallow, lentic bodies of water throughout the southeastern corner of North America. There are currently three recognized subspecies, with the Mississippi River largely separating the eastern (*D. r. reticularia*) and western (*D. r. miaria*) subspecies. One exception to this delineation exists in the Mississippi Delta region of Mississippi where several *D. r. miaria* were documented on the eastern side of the river in 1966 and 1967. Subsequent documentation of *D. r. miaria* in Mississippi has been scarce, and it has been several decades since the last confirmed sighting. This is significant because *D. r. miaria* is currently declining throughout its range, and it is important to know whether populations like the Mississippi Delta population have persisted. Therefore, we attempted to capture *D. r. miaria* in the Mississippi Delta region from 18 to 24 May 2018, using trapping methods that we have successfully employed for *D. r. miaria* in Oklahoma and Arkansas. We deployed traps on private property near a previously reported location for *D. r. miaria*, as well as on two nearby national wildlife refuges (Morgan Brake and Panther Swamp NWRs) for a total of 269 trap nights. We documented eight species of turtle but did not capture any *D. r. miaria*. The wildlife refuges contained habitat that appeared suitable for *D. r. miaria*, but they also contained dense American alligator (**Alligator mississippiensis**) populations, and our catch rates were low for all turtle species (total = 0.07 turtles per trap night), possibly as a consequence of the alligators. In contrast, outside of the wildlife refuges the habitat appeared degraded and had been almost entirely converted to agriculture fields, including draining many ponds. Nevertheless, we did not observe any alligators and had high turtle capture rates (5.4 turtles per trap night). Based on these results and our experiences detecting *D. r. miaria* in other parts of its range, we do not think it is likely that the subspecies has persisted in the areas we surveyed in Mississippi; however, eDNA surveys could be useful to corroborate (or refute) our conclusion.

Documented Declines: Oral

Autecological Study of Gulf Coast Box Turtles (*Terrapene carolina major*) in the Florida Panhandle Reveals Unique Spatial and Behavioral Characteristics**JESSICA R. MECK^{1,2}, MICHAEL T. JONES³, LISABETH L. WILLEY^{1,3}, AND JONATHAN D. MAYS^{3,4}**¹*Department of Environmental Studies, Antioch University New England, Keene, New Hampshire 03431 USA*²*Smithsonian Conservation Biology Institute, Front Royal, Virginia 22630 USA*³*American Turtle Observatory, New Salem, Massachusetts 01355 USA*⁴*Florida Fish and Wildlife Conservation Commission, Gainesville, Florida 32601 USA*

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Terrapene carolina major (Gulf Coast Box Turtle), similar to other *T. carolina* lineages, is vulnerable to the consequences of the rapidly growing anthropogenic pressures on the landscape, but no intensive studies have been published to provide information on how this lineage compares to its conspecifics. Therefore, we conducted a radio-telemetry study on 21 adult *T. c. major* in the Florida panhandle in 2016 and 2017 to evaluate seasonal home range, habitat use and selection, and behavior. We calculated summer home range size using minimum convex polygons (MCP) and fixed kernel density estimators (KDE). Habitat use was evaluated using Geographic Information System (GIS) to determine proportions of different habitat types within individual's 100% MCPs. Habitat selection was determined by generating 100 random points within each individual's 100% MCPs to compare to the telemetry locations using logistic regression models. Contrary to most *T. carolina* studies, females had significantly larger home ranges than males. Female home ranges averaged eight times larger than males in 2016, and 11 times larger than males in 2017. Males, however, demonstrated significantly higher home range fidelity than females and displayed frequent fighting behavior with other males both years, suggesting the possibility of territoriality. Logistic regression models indicated males utilized forested wetlands significantly more than wet coniferous forests whereas females utilized wet coniferous forests significantly more than forested wetlands. Approximately 25% of total radio-location observations for both sexes were in aquatic environments. While the phylogeny of this lineage remains unclear, we recommend *T. c. major* be considered a unique, distinct conspecific of *T. carolina* when evaluating conservation decisions based on the ecological characteristics we observed.

Field Studies: Oral**Characterization of Innate Immunity of Eastern (*Terrapene carolina*) and Ornate (*Terrapene ornata*) Box Turtles****MARK MERCHANT¹, LAURA ADAMOVICZ², AND SARAH BAKER^{3,4}**¹*Department of Chemistry, McNeese State University, Lake Charles, Louisiana 70609 USA*²*Wildlife Epidemiology Lab, University of Illinois College of Veterinary Medicine, Urbana, Illinois 61802 USA*³*Illinois Natural History Survey, 1816 S Oak Street, Champaign, Illinois 61820 USA*⁴*Present address: Arizona Game and Fish Department, 5000 W Carefree Highway, Phoenix, Arizona 85086 USA*

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The innate immune system functions as a nonspecific first line of defense against pathogenic challenge and is likely the major component of immunity for ectothermic vertebrates. The serum complement system of proteins is typically considered the primary constituent of the innate immune system and is responsible for a large portion of immunity in many lower vertebrates. We assessed the antibacterial activities and serum complement activities of the plasma two species of box turtles (Eastern *Terrapene carolina* and Ornate *Terrapene ornata*). We found that the plasma from both species of turtles exhibited moderately strong antibacterial activities against two species of Gram-positive and four species of Gram-negative bacteria. The antibacterial capacities of plasma from Ornate and Eastern Box Turtles was very similar. Upon examination of the serum complement activities, we found that the hemolytic activity toward sheep red blood cells (SRBCs) was much stronger in Ornate than Eastern Box Turtles. Treatment with inhibitors of the serum complement cascade indicated differences in the mechanisms of complement activation between the turtle species. We subjected plasma from both turtle species to mannan affinity chromatography and analyzed the eluate with SDS-PAGE and MALDI-TOF, which revealed that plasma from the Ornate Box Turtles contained only small amounts of one C-type lectin protein while the Eastern Box Turtle plasma contained high concentrations two C-type lectins (25.6 and 34.7 kDa). Thus, the Ornate Box Turtle appears to rely more heavily on the alternative mechanism of serum complement activation, while the Eastern Box Turtle appears to rely more on the lectin-mediated pathway, which is a pattern recognition response to prokaryotes not activated by the SRBCs. Interestingly, these results are similar to our previous studies in common and alligator snapping turtles, which also utilize different mechanisms of complement activation.

A Look Under the Shell: Oral

A Preliminary Examination of Codon Bias in Turtles

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After the genetic code was deciphered it was determined that many amino acids (AA) were degenerate i.e., coded for by multiple codons. With the advent of DNA sequencing technology it became apparent that all codons were not utilized with equal frequency and there is codon bias. A variety of hypotheses have attempted to explain this disparity including variable rates of mutation or selection for increased translational efficiency. A variety of studies have investigated codon bias. However, many groups are still unstudied. Turtles were chosen for this study based on their unique physiology and life history. Three diverse turtle lineages (softshell, pond, and sea) were utilized. Initially, 3rd codon positions were examined across all lineages. This analysis suggested a preference towards codons ending in A or C ($p < 0.01$). If lineages are examined individually, only soft shells show a similar pattern. Next, the 6-fold degenerate AA, Leucine and Serine, were examined. Each AA shows a similar patterns of codon usage across groups ($p = 0.899$). If Leucine codons are analyzed separately, all lineages preferentially utilize CTA ($p < 0.01$). A similar result is observed in Serine with TCA utilized preferentially ($p < 0.01$). If all codons are examined, 3 codons (GAC, GGA, CTA) are utilized preferentially in sea turtles ($p < 0.01$). Four additional codons (ATC, ACT, CTT, ATT) are utilized preferentially in sea turtles and soft shells ($p < 0.01$). Overall, these results suggest a bias in codon usage exists in turtles. Investigations are currently underway to determine whether this bias reflects genomic rates of mutation or selection regarding translational efficiency.

Genetics: Oral**A Spatial Assessment of Resident and Translocated Gopher tortoises (*Gopherus polyphemus*) using GPS Loggers**

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The unfortunate but ever-increasing need to translocate chelonians for various anthropogenic reasons, necessitates thorough cost-effective monitoring methods which provide a more remote approach to assessing translocation outcomes. At the 15th Annual Symposium on the Conservation and Biology of Tortoises and Freshwater Turtles I presented preliminary results from this study of the first field season of my Master's research. Here, we report on 32.5 months of continuous spatial data derived from modified recreational GPS loggers deployed on 20 translocated and 20 resident gopher tortoises (*Gopherus polyphemus*) at a Georgia Department of Natural Resources Wildlife Management Area recipient site in southeast Georgia. Using fine-scale movement data we sought to assess the behavioral responses of translocated tortoises relative to resident tortoises. After data screening, over 203,000 location fixes collected from 35 individuals were included in the analyses. The ZoaTrack.org platform was used to conduct 95% fixed-nearest neighbor local convex hull (k-LoCoH) home ranges. We also determined how individual resident tortoises' home ranges were impacted (i.e. shifted in space) following the introduction of translocated tortoises to the site. This was accomplished by comparing their home ranges both prior to and following the introduction of translocated individuals to the study site population. Additionally, we determined the extent to which translocated tortoises dispersed across the study site following ~7 and ~14 month temporary penning treatments. Translocated and resident tortoises' home ranges were significantly different and furthermore the release of translocated individuals at the site significantly influenced the distribution of resident tortoises' home ranges. We also observed greater dispersal from the temporary penning sites than expected with a ~15.5-fold increase of cumulative home range area used by translocated individuals in the surrounding habitat. This finding demonstrates the need for expansive high-quality recipient sites for translocations such as this to be successful in the long-term. Habitat management involving planted pine tree thinning and regularly applied prescribed fire appear to be necessary to restore and maintain quality habitat in order to reduce site abandonment by tortoises, particularly where suitable habitat is restricted to relatively small areas.

Population Manipulations: Oral

Use and Traditional Knowledge of the Bolson Tortoise (*Gopherus flavomarginatus*) at the Mapimí Bolson in Mexico**ROSALINDA PALOMO-RAMOS¹, LILIA-SUSANA CARMONA-GARCÍA², ANA B. GATICA-COLIMA¹ AND JUDITH V. RÍOS-ARANA¹**¹*Universidad Autónoma de Ciudad Juárez, Instituto de Ciencias Biomédicas, Anillo Envolvente del PRONAF y Estocolmo s/n, 32315 Ciudad Juárez, México*²*Universidad Autónoma de Ciudad Juárez, Instituto de Ciencias Sociales y Administrativas, Av. Universidad y Av. Heroico Colegio Militar S/N, Zona Chamizal, 32300 Ciudad Juárez, México*
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The Bolson Tortoise (*Gopherus flavomarginatus*), has a long history of harvesting, both for human consumption and for trade. This species plays an important role in the ecosystem as a habitat engineer, because it serves as seed disperser and the burrows it creates provide shelter for other animals and allow soil aeration. Therefore, we researched the local beliefs on the protection status of this endemic and critically endangered tortoise in different localities of its current range. We conducted 91 semi-structured interviews during three periods: from May to September 2015, from June to July 2016 and from July to November 2017 throughout the Mapimí Bolson in northern Mexico. Our aim is to 1) examine the local traditional knowledge, 2) document the use and historical trade of the species and 3) understand the level of awareness and openness to protection of this chelonian. Our results indicate that men and women are equally able to identify this species and no significant difference was found among the age groups of 46-60 and 61-79 ($F = -0.156$, $P = 1.00$). Despite conservation efforts by the Federal Government agencies, poaching still occurs in a small degree. Tortoises are being used as pets, and on a lower scale for food. Harvesting practices are unsustainable, and the local communities believe there are less tortoises now than the last 15 years, and that it is important to protect tortoises and international participation is welcome.

Organic Conservation: Oral (student)

Distribution and Abundance of the Alligator Snapping Turtle (*Macrochelys temminckii*) in Mississippi**LUKE PEARSON, LUCAS HARALSON, GABRIELLE BERRY, AND CARL QUALLS***School of Biological, Environmental, and Earth Sciences, University of Southern Mississippi, Hattiesburg, Mississippi 39406 USA*
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The alligator snapping turtle (*Macrochelys temminckii*) is under review by the US Fish and Wildlife Service and other regulatory and management agencies to determine if populations have declined sufficiently to warrant federal listing as a threatened species. Despite having a presumed near-statewide distribution, there was a paucity of records for *M. temminckii* in Mississippi, thus leaving a void of knowledge at the core of this species' geographic range. Therefore, our goal was to assess the status of *M. temminckii* within the Pascagoula, Pearl, Big Black, and Tombigbee river systems. We systematically trapped 17 sites within the Pascagoula River, 14 sites within the Pearl River, and 3 sites within the Big Black River producing 18 new county records. In 2019, approximately 20 sites will be surveyed within the Tombigbee River drainage to determine relative abundances, distributions, and population demographics. In the Pascagoula River drainage, 124 *M. temminckii* were captured, averaging 0.16 turtles per trap night (0 – 0.30 TTN), while 92 *M. temminckii* were captured in the Pearl River drainage (mean = 0.11; TTN: 0 – 0.21 TTN). The Big Black River had the highest capture rates of the drainages sampled so far, averaging 0.38 TTN (0.19 – 0.62 TTN) and 63 *M. temminckii*, with high abundances of both available microhabitat and small juvenile *M. temminckii* (14 – 18 cm CL). Alligator snapping turtles were captured at all but two of the 34 aforementioned sampling sites, and the abundance of juveniles captured at most sampling locations in the Pascagoula, Pearl, and Big Black river drainages is an encouraging sign of ongoing recruitment in these populations. In contrast, the lack of adults is concerning, as this could be a legacy effect of historical commercial harvest and/or current by-catch mortality on fishing equipment (e.g. trotlines).

Population Assessments: Oral (student)

Conservation Genetics of Two Imperiled *Graptemys* species (*G. gibbonsi* and *G. pearlensis*) Petitioned for Federal Listing**LUKE PEARSON, WILL SELMAN, BRIAN KREISER, PETER V. LINDEMAN, AND ROBERT L. JONES***School of Biological, Environmental, and Earth Sciences, University of Southern Mississippi, 118 College Drive
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Graptemys gibbonsi and *G. pearlensis* were part of the *G. pulchra* “species complex” until their description in 1992 and 2010, respectively. Both species have relatively small and declining populations compared to the sympatric federally threatened *Graptemys* species; *G. flavimaculata* (Pascagoula River drainage) and *G. oculifera* (Pearl River drainage). In response to this, *G. gibbonsi* and *G. pearlensis* are now candidates for federal listing, and the Association for Zoos and Aquariums recently received approval from the U.S. Fish and Wildlife Service to establish captive assurance colonies for both species. However, because no genetic data currently exists for either species, there is a limited ability to understand if the captive population’s genetic diversity will mirror the wild genetic diversity. To fill this knowledge gap, our objectives were to determine if population structure exists throughout the ranges of *G. gibbonsi* and *G. pearlensis*, assess the rates of gene flow among populations, compare levels of genetic diversity among sites, and characterize the demographic history through testing for genetic bottlenecks and estimating effective population size. Currently, 240 *G. gibbonsi* tissue samples from 11 sites have been genotyped at 11 microsatellite loci, while 125 *G. pearlensis* tissue samples from 14 sites have been genotyped at 10 microsatellite loci. STRUCTURE suggests that there are two genetic groups of *G. gibbonsi* within the Pascagoula River drainage (Leaf and Chickasawhay Rivers), as well as increasing genetic differentiation with increasing geographic distance between sites (e.g., isolation by distance). However, STRUCTURE assigned *G. pearlensis* to only one genetic group throughout the Pearl River drainage, and, although genetic differentiation does occur among sites, this differentiation is not correlated with geographic distance. We are in the process of genotyping more tissue samples for both species to inform captive management decisions and reintroduction strategies, should they become necessary.

Genetics: Oral (student)**Preliminary Results of a Long-term Freshwater Turtle Population Study in New Jersey****JOE PIGNATELLI^{1,2}, ERIC MUNSCHER^{1,3}, AND MAURICE RODRIGUES⁴**¹*Turtle Survival Alliance, 1030 Jenkins Road, Charleston, South Carolina 29407 USA*²*EcolSciences Inc., 75 Fleetwood Drive, Suite 250, Rockaway, New Jersey 07866 USA*³*SWCA Environmental Consultants, 602 West Little York, Houston Texas 77040 USA*⁴*The Turtle Conservancy, 49 Bleecker St. # 601, New York, New York 10012 USA**[Jpignatelli@EcolSciences.com]*

With over half of the known turtle populations in decline, it is imperative that researchers establish long-term population monitoring study sites. In 2018 a long-term aquatic turtle population study transect was established along the South Branch of the Raritan River, in Hunterdon County, New Jersey. The sampling consisted of snorkeling to hand capture all turtles during surveys in July, August, and September. The preliminary results of the first year of the study identified five species and 81 captures. The species collected were the common map turtle (*Graptemys geographica*), eastern painted turtle (*Chrysemys picta picta*), common musk turtle (*Sternotherus odoratus*), common snapping turtle (*Chelydra serpentina*), and northern red bellied cooter (*Pseudemys rubriventris*). Going forward the sampling will focus on *G. geographica*, the most frequency captured species in the sample site. Surveys will be conducted during additional times of year, utilize additional survey techniques, and additional survey transects will be established. Hopefully, the data collected from this study will help determine population health, assess ecosystem health, identify potential threats, and help mitigate these threats.

Presentation type: Poster

Lessons learned in restoring *Batagur trivittata* to the Chindwin River of Myanmar

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The remaining wild population of Burmese Roofed Turtles (*Batagur trivittata*) consists of less than 10 adult females inhabiting the upper Chindwin River in Myanmar. *Batagur trivittata* has been the focus of an intense conservation program since the mid-2000s; nesting sites are monitored, eggs are collected and incubated under natural conditions, and hatchlings head-started for eventual release. Four assurance colonies have been established, although only one is yet producing offspring. Our first reintroduction of head-started *B. trivittata* was undertaken during the dry season of 2015. Turtles were released at two sites: 1) a stretch of the Chindwin River near Limpha Village hosting the remaining wild population; 2) lower reaches of a tributary, Nam Thalet Chaung. One hundred head-started subadult turtles (equal sex ratio) were selected, screened for infectious diseases, and transported by road to our basecamp in Limpha Village. Temporary bamboo holding pens were constructed in shallow water at both release sites. All turtles were implanted with microchips for permanent identification and VHF transmitters were attached to a subset of 30 turtles (approximately equal sex ratio). Fifty turtles (15 telemetered and 35 without transmitters) were transferred to temporary holding pens at each release site in February-March. Turtles were maintained in the pens and then released one month later (late March-April). Most turtles remained near the release site through the remainder of the dry season. Preferred habitat appeared to be deep holes. Even during low water periods turtles proved difficult to relocate. Contact with most turtles was lost when water levels rose dramatically at the onset of the wet season (July), and some turtles that could be relocated had moved great distances (>20km). The single greatest cause of mortality was entanglement in monofilament fishing nets. Although the fate of most turtles remains unknown, released males may be responsible for fertile clutches produced by wild females in 2016 and 2017 (no viable eggs were produced in 2014 and 2015). Future reintroductions should focus solely on the Chindwin River near Limpha Village. VHF transmitters appear unsuitable for post-release monitoring of river turtles; the use of sonic or satellite transmitters should be considered. Community-based fisheries management might ameliorate incidental loss to fishing gear by creating fish conservation zones encompassing critical turtle habitat.

Batagur Conservation: Oral**New Funding Opportunities for Freshwater Turtles and Tortoises with U.S. Fish and Wildlife Service**

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Public Law 116-9 “John D. Dingell, Jr. Conservation, Management, and Recreation Act” was enacted on March 12, 2019, reauthorizing Marine Turtle Conservation Act of 2004 (MTCA). Section 7001 amends and expands the MTCA to include freshwater turtles and tortoises making them eligible for funding of conservation projects in foreign countries and U.S. territories. Priorities for funding, timelines and the process for applications are discussed.

Opening Plenary: Oral**Why Didn't the Tortoise Cross the Road? The Effect of Roads on the Distribution and Behavior of Desert Tortoises in Joshua Tree National Park**SHELLIE R. PUFFER¹, JEFFREY E. LOVICH¹, TERENCE R. ARUNDEL¹, KIRSTEN IRONSIDE¹, LAURA A. TENNANT¹,
AMANDA L. SMITH², KATHLEEN BRUNDIGE³, AND MICHAEL VAMSTAD⁴¹*U.S. Geological Survey, Southwest Biological Science Center, 2255 North Gemini Drive,
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Road effects on wildlife are numerous and include direct effects such as road mortality, population isolation, and decreased habitat quality as well as indirect effects such as habitat fragmentation, inhibited gene flow, and altered population structure. The edge effects of roads can alter the distribution, density, and diversity of wildlife present. In California, the federally protected Agassiz's desert tortoise (*Gopherus agassizii*) cannot escape the effects of roads even in areas designated as critical tortoise habitat where, on BLM lands alone, over 3,000 km of roads impact nearly 11,000 km² of habitat. In southern California, within the boundaries of Joshua Tree National Park where tortoises are afforded an extra layer of protection, there is still yearly tortoise road mortality from visitor traffic. Near the park's southern border, a desert tortoise population exists near the mouth of Cottonwood Canyon that is bisected from north to south by the paved, two-lane Cottonwood Springs Road. This road is the only entry/exit to the park on its south side, and traffic has increased significantly over the past decade. Here we outfitted a subset of tortoises (n = 12) with radiotransmitters and tracked them biweekly to monthly during 2015–2016. We never observed a radiotelemetered tortoise crossing the road (either directly or indirectly), and all but one tortoise location were > 200 m from the road. We used the tortoise GPS locations to assess home ranges in relation to Cottonwood Springs Road and determine if road crossing was occurring in the population. We used the GPS data to generate 1000 simulated random paths within each tortoise home range using ArcGIS, and calculated a metric called Proportion of Road Crossings (PRC) to reflect the potential of a tortoise to cross Cottonwood Springs Road. All tortoises except one were found to have the potential to cross Cottonwood Springs Road, with PRC ranging from 0.01–0.36. However, the tortoises in our study appeared to avoid Cottonwood Springs Road as well as a buffer zone on each side of the road, indicating that current road mortality may be low but the road acts as a strong barrier to movement within the population.

Field Studies: Oral

Global Conservation Status of Turtles and Tortoises (Order Testudines)

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We present an analysis of the conservation status and IUCN threat levels of all 360 currently recognized species of turtles and tortoises, and review organizational efforts to document and address the global turtle conservation crisis. Our analysis is based on the 2018 IUCN Red List status of 251 listed species augmented by provisional Red List assessments by the IUCN Tortoise and Freshwater Turtle Specialist Group (TFTSG) of 109 currently unlisted species of tortoises and freshwater turtles as well as re-assessments of several outdated IUCN Red List assessments. Of all recognized species of turtles and tortoises, this combined analysis indicates that 20.0% are Critically Endangered (CR), 35.3% are Critically Endangered or Endangered (CR+EN), and 51.9% are Threatened (CR+EN+Vulnerable). Adjusting for the potential threat levels of Data Deficient (DD) species indicates that 56.3% of all data-sufficient species are Threatened. We calculated percentages of imperiled species and modified Average Threat Levels (ATL; ranging from Least Concern = 1 to Extinct = 8) for various taxonomic and geographic groupings. Proportionally more species in the subfamily Geoemydinae (Asian members of the family Geoemydidae) are imperiled (74.2% CR+EN, 79.0% Threatened, 3.89 ATL) compared to other taxonomic groupings, but the families Podocnemididae, Testudinidae, and Trionychidae and the superfamily Chelonioidae (marine turtles of the families Cheloniidae and Dermochelyidae) also have high percentages of imperiled species and ATLs (42.9–50.0% CR+EN, 73.8–100.0% Threatened, 3.44–4.06 ATL). The subfamily Rhinoclemmydinae (Neotropical turtles of the family Geoemydidae) and the families Kinosternidae and Pelomedusidae have the lowest percentages of imperiled species and ATLs (0–7.4% CR+EN, 7.4–13.3% Threatened, 1.65–1.87 ATL). Turtles from Asia have the highest

percentages of imperiled species (75.0% CR+EN, 83.0% Threatened, 3.98 ATL), significantly higher than predicted based on the regional species richness, due to much higher levels of exploitation in that geographic region. The family Testudinidae has the highest ATL (4.06) of all Testudines, due to the extinction of several species of giant tortoises from Indian and Pacific Ocean islands since 1500 CE. The family Testudinidae also has an ATL higher than all other larger polytypic families (≥ 5 species) of Reptilia or Amphibia. The Order Testudines is, on average, more imperiled than all other larger Orders (≥ 20 species) of Reptilia, Amphibia, Mammalia, or Aves, but has percentages of CR+EN and Threatened species and an ATL (2.96) similar to those of Primates and Caudata (salamanders).

Opening Plenary: Oral

An Overview of the Pennsylvania Amphibian and Reptile Survey: with a Special Focus on Turtles

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Pennsylvania is home to 14 species of native chelonians, including one incidental species. These 14 species represent four families and 12 genera and inhabit a wide variety of aquatic and terrestrial habitats. Two non-native species have also established breeding populations in the state. Current distributional information is vital to determining species status, ultimately informing conservation agency efforts to protect and enhance populations and habitats. In a state with nearly 13 million people, which is home to state and federally-threatened species, as well as several species of concern, the importance of conservation cannot be understated. To this end, The Pennsylvania Amphibian and Reptile Survey (PARS) was launched in 2013. PARS is both a 10-year atlas project that will substantially increase our understanding of all species of amphibians and reptiles occurring within the state, and a repository for historical records from a multitude of sources. The PARS atlas utilizes the U. S. Geological Survey 7.5-minute quadrangles and blocks to lay a grid across the state. A user-friendly internet database was created that allows users to submit records in an efficient manner. With almost 2000 individual contributors, PARS takes advantage of a dedicated group of citizen scientists. The ultimate goal is that records are submitted of all species that occur within each quadrangle and block. To date, PARS has nearly 150,000 total species records, 13,563 of these are of chelonians. The knowledge gained through this atlas has resulted in range expansions and will continue to inform conservation and management decisions for years to come.

Presentation type: Poster

Population Viability Analysis and the Role of Head-starting for a northern Illinois Blanding's Turtle

(*Emydoidea blandingii*) Population

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The Blanding's Turtle (*Emydoidea blandingii*) is a long-lived species that was once common in the prairies and wetlands of northern Illinois, but now only occurs in scattered populations. To aid the recovery of Blanding's Turtle populations the Forest Preserve District of DuPage County maintains a head-starting and release program to alleviate high mortality in younger age-class turtles and increase population size. We previously conducted trapping and analysis at the main release site to determine basic demographic parameters under the current head-starting program. We found moderately high head-start survival, fairly high adult female survival, and an increasing population size suggesting that head-starting is working as a conservation strategy. To investigate future population trajectory and the outcome of continued head-starting we conducted a population viability analysis (PVA) in the program VORTEX incorporating updated demographic data from surveys in 2018. Updated models continue to indicate moderately high head-start survival that may increase with body size. Though population size continues to increase, the PVA indicates some form of ongoing management is necessary to avoid a negative stochastic growth rate. Ceasing head-starting could result in extinction (within 100 years) if no natural recruitment is occurring. Head-starting 50 eggs/year did not result in extinction for any of the scenarios modelled, and head-starting 100 eggs/year

would maintain or increase population size. Head-starting 200 eggs/year would increase population size even if no natural recruitment is occurring or juvenile mortality is higher than current estimates indicate. Alternatively, maintaining high natural age 0-1 survival would increase growth rate, but may be difficult because current egg and hatchling mortality are unknown (but likely very high based on lack of juveniles prior to head-starting). Maintaining high adult survival will be important regardless of other management practices. We conclude that for this population the best management strategy is to head-start at least 100 eggs/year until the threat of road mortality can be mitigated and other management can demonstrate adequate natural recruitment.

Population Manipulations: Oral

Effects of Constant Incubation Temperature on Life History Traits of the Six-Tubercled Amazon River Turtle (*Podocnemis sextuberculata*) Pre- and Post-hatching

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Temperature affects embryonic physiology and rate of embryonic development, with visible and quantifiable effects on incubation duration, hatching success, and hatchling phenotype. We evaluated how constant incubation temperatures affect life history traits pre-hatching (incubation duration and hatching success) and post hatching (hatchling sex, size and growth) of the Six-tubercled Amazon River turtle, *Podocnemis sextuberculata*. We incubated eggs collected from natural nests in the Amazon river at ten temperatures ranging from 22°C to 37.5°C in 2013 and six temperatures ranging from 26°C to 36°C in 2016 (maternal effects were evaluated only in 2016). In 2013, we raised hatchling for 90 days to evaluate effects of temperature on early hatchling growth. Six-tubercled Amazon river turtles have temperature-dependent sex determination pattern IA (TSDIa). The pivotal temperature was calculated as 33.73±0.15°C, the highest ever documented for a turtle species, and the transitional range temperature is 1.16±0.59°C. This reaction norm model is tentative because only one treatment produced both sexes. Constant temperatures below 26°C and above 38°C are lethal. Temperature effects on hatching success and on hatchling size were normally distributed, with intermediate temperatures being optimal (32.25°C and 31.5°C, respectively). Mean incubation duration decreased with mean incubation temperature, but at the highest temperatures it increased slightly. Temperature had no effect on hatchling post-hatching growth trajectory. Higher temperatures induced lower growth and mass gain rates post-hatching. Therefore, incubation temperature effects on hatchling size disappeared by 3 months of age, but the data precluded accounting for maternal and residual yolk effects. Future incubation experiments at a finer scale between 33°C-36°C are warranted to re-evaluate the effects of temperature on hatchling phenotype, and data should be collected to test for the effect of temperature on residual yolk and subsequent growth and mass gain rates while accounting for maternal and clutch effects. Additionally, field studies to evaluate thermal reaction norms and offspring sex ratio in a natural setting are imperative to develop additional conservation measures, considering female-biased illegal hunting pressure and global warming threats.

Reproductive Studies: Oral (student)

The Role of Gut Microbial Symbionts in Alligator Snapping Turtle Hatchling Growth and Digestive Efficiency

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The ability for vertebrates to exploit plant matter for energy largely relies on complex associations with fermentative microbes. Coprophagy as a behavioral means of microbial acquisition and maintenance has been observed most frequently in mammals; however, there is growing evidence that herbivorous reptiles associate with kin or conspecifics for brief periods in their lives to obtain species-specific microbes that are functionally tailored to their

diet. Despite specializations for carnivory that include a sharp, recurved beak and a unique lingual lure, the alligator snapping turtle (*Macrochelys temminckii*) is a dietary generalist that frequently consumes aquatic vegetation and detritus. Based on their dietary habits, we hypothesized that providing hatchlings with adult feces upon hatching would improve digestive efficiency and growth. As predicted, assimilation efficiency of neutral detergent fiber was significantly greater in turtles supplemented with feces than those exposed to either creek water or deionized water, but there was no difference among groups in assimilation of acid detergent fiber or crude protein. Growth rates were equal among treatments, although the short duration of the experiment may have been insufficient for differences in size to emerge. The microbial community structure of *M. temminckii* hatchlings differed between the start and end of the 42-day experiment. Inoculation material had no effect on the turtles' core microbiomes at the end of the experiment; however, hatchlings provided with adult conspecific feces had higher abundances of fermentative bacterial groups.

A Look Under the Shell: Oral

Uniting Genomics to Provide an Integrative Solution for *Pseudemys* Systematics

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The genus *Pseudemys* a group of relatively abundant freshwater turtles distributed throughout the eastern half of the United States. However, this genus has long presented as a taxonomic conundrum, where both species boundaries and relationships have been subject to conflict and instability in the literature. Recently, a multi-locus genetic study provided little support for any of the described taxa in this group of turtles. As two described taxa receive federal protection under the Endangered Species Act and *Pseudemys* turtles are ecologically abundant in many aquatic ecosystems, providing a stable taxonomy is necessary for ensuring conservation management resources are properly used as well as providing the necessary context for ecological and evolutionary work. We sequenced 76 low-coverage *Pseudemys* genomes representing range-wide samples for all described taxa to answer outstanding questions in species limits and relationships for the genus. We carried out *de novo* discovery of operational taxonomic units using PCAs, genetic clustering analyses, and phylogenetic tree-based approaches. We also present a summary of the results of an informal *Pseudemys* taxonomic working group meeting in 2019, where ~20 experts convened to discuss our genomic results while considering the morphology, distributions, and ecology of these turtles. This meeting resulted in broad agreement on biologically meaningful taxonomic units and their nomenclatural history, and a proposed resolved taxonomy for *Pseudemys*. We will present this integrative taxonomy and species tree, and discuss future research needs in *Pseudemys* systematics.

Closing Plenary: Oral

Using Stable Isotopes to Study Freshwater Turtle and Tortoise Ecology: Caveats, Assumptions, and Implications for Field Research

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Stable isotope analysis (SIA) is a powerful tool for addressing questions relating to the trophic ecology and life history patterns of freshwater turtles and tortoises. Dietary inferences based on isotopic profiles of turtle tissues are possible because the isotope compositions of a consumer's tissues are ultimately derived from those in its diet and water resources. Stable isotope analysis is particularly useful when an organism's diet is difficult to establish with conventional techniques (e.g., observation, lavage, fecal analysis). By providing information on nutrients assimilated over a variety of time periods depending on the type of tissue analyzed, stable isotopes are much less affected by short-term temporal change in diet, which is a major limitation of traditional methods that only provide dietary 'snapshots' of recently consumed food items. When integrated with these traditional field techniques, SIA can provide a greater understanding about turtle diet and life history; however, it has been relatively under-applied relative to other vertebrate taxa, perhaps owing to challenges relating to freshwater turtle and tortoise metabolism.

Yet there is great potential to evaluate ecological aspects such as inter- and intra-population trophic niche dynamics and overlap, individual diet specialization, long-term resource use, reproductive strategies, and even physiology. In this talk we introduce SIA and describe its application for freshwater turtles and tortoises. We review current knowledge about isotopic discrimination and turnover, discuss approaches to study trophic ecology, and propose new SIA-based research directions for freshwater turtles and tortoises. In the end, our hope is that researchers gain a better perspective about the pros and cons of this research tool and walk away thinking about how they can apply SIA in their own studies.

Techniques: Oral

Five Years of Reproduction: Raising Captive Born Central American River Turtles (*Dermatemys mawii*) in Belize

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The Central American River Turtle (*Dermatemys mawii*), known locally as the Hicatee, is the largest freshwater river turtle in Belize and the only living species of the family Dermatemydidae, an ancient lineage of turtles dating back sixty-five million years. Once widespread, they now exist as remnant populations in parts of eastern Mexico, northern Guatemala and Belize and are ranked as Critically Endangered by the IUCN and one of the top twenty-five most endangered turtles in the world by the Tortoise and Freshwater Turtle Specialist Group. Overexploitation as a food resource for human consumption has resulted in drastic declines and extirpation of local populations. The Hicatee Conservation and Research Center (HCRC), which is a joint project of the Turtle Survival Alliance and Belize Foundation for Research and Environmental Education (BFREE), serves as a captive breeding facility for the species. The goals of the HCRC are to conduct research on the reproductive biology and nesting ecology while building a large assurance colony to aid in reintroductions. In this talk, we will describe the phenotypical features of *D. mawii* neonates through their first four years of growth and share behavioral aspects and biological traits observed. We will share our methods for captive management including egg incubation, hatch success, juvenile care, herbivorous diet preferences, and the effects of seasonal temperature shifts which appear to be linked to hatchling well-being. We will also discuss some of the challenges that have been encountered as we develop and modify our husbandry protocols. Finally, we will give an account of Hicatee Health Assessments which occur at the HCRC two times per year in order to monitor overall health, and document growth.

TSA Partners: Oral

Investigating Reproductive Output of Crowned River Turtle (*Hardella thurjii*) in Saryu River in Tarai Arc Landscape (TAL), India

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The Crowned River Turtle (*Hardella thurjii*) is a large freshwater turtle found throughout major river systems of the Indian sub-continent. Unfortunately *H. thurjii* has experienced significant declines in numbers resulting in an uplisting of population status from vulnerable to endangered by the IUCN. Little is known about the nesting behaviour and ecology of this elusive species. This communication comprises observations from a study conducted in 2015 to 2018, barring 2016 to investigate critical aspects of reproductive behaviour and ecology of *H. thurjii*, which may eventually lead to a larger head-starting program, to recover the decimated populations. This long-term study is ongoing along Saryu River, which originates near Indo-Nepal border. Monitoring was carried out during the known nesting period (September-October). It is thought that females deposit eggs underwater, so information on clutch and egg size is difficult to determine. To investigate reproductive output, artificial oviposition was induced using in selected gravid female exceeding carapace length of 35 cm. Females were captured and radio-graphed within 12 hours of sampling to confirm gravidity. A total 25 out of 81 radio-graphed females were found positive for calcified eggs. They were further induced with 7.5- 10 units/kg (body weight) of Oxytocin in 2015 and 2017 and

doses of Lutalyse (Prostaglandin F2 alpha) 1.2 to 1.8 mg/kg and Xylazine 8 mg/kg with 23 mg/ml concentration in 2018. Resulted clutches compared with Female SCL and clutch size, which shows positive correlation with $r = 0.13$. The study will continue examining the nesting behaviour using the radio-telemetry.

Reproductive Studies: Oral (student)

Protecting the Red-crowned Roofed Turtle, *Batagur kachuga* on the Chambal River

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The National Chambal Sanctuary (NCS) contain the last known wild population of the critically endangered *Batagur kachuga*. With fewer than 250 adult females remaining in the Chambal system, the program for their conservation has proven essential for the survival of this beautiful turtle. Since 2006, TSA's Chambal conservation program was able to protect over 5,000 *B. kachuga* nests through riverside hatcheries and release over 10,000 hatchlings back to the river. Moreover, we reared and released more than 1,500 headstarted juveniles from our semi-permanent facilities developed during inception of the project. We were able to deploy 20 sonic transmitters on captive raised and wild individuals (10 each) to understand survival, dispersal/ home range, as well as habitat/conservation requirements. This study documented over 70 percent survival of captive raised individuals and very limited movement in wild males. Additionally, we were able to develop three assurance colonies in range states such as MP and UP under this project. Over 25,000 riparian community members and school children were educated about the plight of this turtle species through developing two conservation awareness and interpretation centers. This communication will summaries the results over the last 14 years and details the future direction which involves expansion of project in upper Chambal and re-introduction program based on the experience gained through this project.

Batagur Conservation: Oral

Recovering Northern River Terrapin, *Batagur baska* in Indian Sunderbans

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Batagur baska is one of the top 25 most threatened turtle species globally, and India's most endangered turtle species. The species is considered functionally extinct from its distribution in the Sunderbans and eastern India. The project began when we encountered 13 specimens in 2008 residing in a pond at the Sunderban Tiger Reserve (STR) and we immediately initiated a conservation-breeding program. We were successful in year 2012, when 33 hatchlings emerged, representing the first known nests from this group in over 20 years. Since then, we have been successfully breeding this species. Currently, we are headstarting over 300 juveniles in captivity, and we were able to develop three additional conservation colonies within the park, thus distributing our adult breeders and juvenile animals in case of disease or disturbance. We released 10 individuals with sonic-transmitters, but were unable to get any locations post-release. The next phase of project will involve the satellite telemetry of sub-adults for survival and dispersal studies, genetic management of the existing colonies, protection of historical nesting banks near the ocean, as well as a fishermen awareness program coupled with a "buy back" initiative. This communication will details all the achievements since the inception of the project and future directions for saving this enigmatic species in this obscure landscape.

Batagur Conservation: Oral

Sonora Mud Turtle (*Kinosternon sonoriense sonoriense*) - An Example to Promote Multidisciplinary Science and Collaboration**AUSTIN B. SMITH¹, KENT R. MOSHER², AND CRISTINA A. JONES¹**¹Arizona Game and Fish Department, 5000 W. Carefree Hwy., Phoenix, Arizona 85086 USA²U.S. Bureau of Reclamation-Phoenix Area Office, 6150 West Thunderbird Rd., Glendale, Arizona 85306 USA
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The Gila River Basin Native Aquatic Conservation Program (GRBNACP) is dedicated to recovering native fishes within the Gila River Basin of Arizona and New Mexico. Between 2007 and 2016, Arizona Game and Fish Department (AGFD) GRBNACP-funded staff conducted various native fish recovery projects, including habitat assessments, nonnative fish removals, native fish introductions, and population monitoring within Arizona. During these activities, observations of non-target species, such as the Sonora Mud Turtle (*Kinosternon sonoriense sonoriense*), were routinely recorded. In 2012, the AGFD listed the Sonora Mud Turtle as a Tier 1B Species of Greatest Conservation Need as this species ranked as vulnerable in demographic and fragmentation status. Due to the extensive number of Sonora Mud Turtle observations documented, we compared this data to the current species distribution. We discovered that very little observational data is readily available for this common species within Arizona's Heritage Data Management System (HDMS), which is used to determine species status and distribution, and to evaluate potential development, economic growth, and environmental projects within Arizona. We found that by adding GRBNACP observations to the HDMS database, we increased the number of Sonora Mud Turtle observations by 9.1%. Observations of common or non-target species are often not recorded or reported upon during surveys; however, this information is valuable in order to keep common species common. We strongly encourage biologists from all disciplines to work collaboratively and record data on all taxa encountered during surveys and monitoring efforts.

Turtles of the Southwest: Oral**Data from Post-Release Monitoring Improves Conservation of *Batagur affinis* in the Sre Ambel River System, Cambodia****SITHA SOM, PHUN THORN, AND HUL IN**Wildlife Conservation Society, #21, Street 21, Tonle Basac, Chamkar Morn, Phnom Penh
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The population of the Critically Endangered Southern River Terrapin (*Batagur affinis*) in Cambodia is extremely small and threatened by illegal capture, sand mining, and degradation of riparian habitat. Since 2002, all nests have been protected by former egg collectors employed by WCS. However, all nesting sandbars in one of the only two nesting rivers have been lost due to sand mining, and only one nest has been found and protected for each of the last three years. All hatchlings are taken into captivity for head-starting. There are two assurance colonies in Cambodia: 27 adults are kept at the Angkor Center for Conservation of Biodiversity (ACCB) and 197 individuals are kept at the Koh Kong Reptile Conservation Center (KKRCC), managed by WCS and the Fisheries Administration. A total of 66 *B. affinis* have been released back into the Sre Ambel River System over the past four years: 21 (aged 8-9 years), 25 (aged 5-11 years), and 20 (aged 12-13 years) individuals were released in 2015, 2017, and 2019 respectively. All captive *B. affinis* are microchipped and fitted with coded Sonotronic acoustic transmitters (CT-05-48-E) with the lifespan of 48-month. In 2015 and 2017 we released equal numbers of males and females, although in the 2019 cohort the ratio of released males to females was 1:19. Released turtles were maintained in a soft-release pen for at least one month and then swam free when the river water rises from the monsoon rain. All three cohorts were released in the same location. Data from acoustic monitoring indicates that when the water level is high, most turtles dispersed downstream, returning back upriver when the water level dropped during the dry season. Three individuals travelled out of the Sre Ambel River System, across the coastal area into another river system, travelling at least 97 km from the release location. The turtles used habitats ranging from nipa palm (*Nypa fruticans*), floating vegetation (*Melaleuca*, *Sonneratia* sp.), and mangrove (*Rhizophora macronata*). Stomach contents of one dead released *B. affinis* included *Sonneratia* sp. and one shrimp. Five were captured by fishermen, of which two were returned by fishermen to project staff, one was confiscated from local restaurant and two were handed over to the project staff by local businessman. Other than these captured turtles, there was a high survival rate (82%) of released animals. Data from post-release monitoring was used by project staff to advocate to government for the cancellation of sand mining licenses in critical areas for turtles, and for a ministerial proclamation to establish a Fisheries Management Zone. The acoustic tags worked well, although they lasted only 16–20 months, rather than the 48 months stated in

the manual. Over the next year we plan to use data from the acoustic transmitters to delineate Community Fisheries and a Protected Area, which will reduce threats to *B. affinis* from illegal capture, habitat degradation and sand mining. In late 2019 we plan to release turtles of age three to five years to compare survivorship with the older animals already released in 2015–2019.

Batagur Conservation: Oral

Successful Methods of Captive Management and Reproduction of the Bowsprit Tortoise, *Chersina Angulata*
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The captive management and reproduction of *Chersina angulata* within the United States has classically proven to be prohibitively difficult. Wild caught specimens have been plagued with chronic issues generally resulting in death. Those that have successfully maintained adults long enough to produce eggs have been challenged with fertility issues and embryos that develop nearly full-term only to perish prior to hatching. The *Chersina Angulata* Working Group was created to research these issues and provide successful captive management and reproductive guidelines for these fascinating tortoises. Following an inventory of the *C. angulatas* in the United States, a breeding group was assembled. During the subsequent twelve months, this group produced 15 eggs, with three successful hatchings. Specific and non-typical incubation methods were employed and successfully implemented leading to this quick reproductive success. This presentation will outline the research methods, results and prescription used for the successful management and reproduction of *Chersina angulata* within the United States.

Captive Husbandry: Oral

Preliminary Range Wide Assessment of Sonoran Mud Turtle (*Kinosternon sonoriense*) Populations

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Range-wide population surveys of relatively common turtles are needed as baselines for conservation. Sonoran Mud Turtles have a small geographic range and specialized habitat requirements in a region heavily impacted by humans, where predicted effects of climate change are severe. Two subspecies are recognized, the critically endangered *Kinosternon sonoriense longifemorale* in the Rio Sonoyta Drainage, and the nominate subspecies, which is Near Threatened on the IUCN Red List and of conservation concern in Arizona and New Mexico. Using geopolitical boundaries partially supported by genetic data, we divided the geographic range into five regions: Rio Sonoyta drainage, other drainages in Mexico, western Colorado River drainage, Mogollon Rim, and Madrean Sky Islands. Except for one population (Quitobaquito Springs) in the Rio Sonoyta drainage, little is known about populations in the first three regions, and intensive sampling is needed. Several large populations on the Mogollon Rim were identified in the 1980's. However, except for Montezuma Well, these populations have not been sampled recently, and follow-up sampling is needed. Several studies have focused on ranges in the Madrean Sky Islands, documenting large populations in the Peloncillo, Chiricahua, Santa Catalina, and Rincon ranges. During 2009-2019, we sampled seven other Sky Island ranges. Partly due to access limitations, we had limited or no success in four ranges: Dragoon, Whetstone, Winchester, Pinaleno. We captured 20 or more adults from multiple populations in three ranges: Galiuro, Huachuca, and Pajarito. Body size variation was large, both within and among mountain ranges, and appeared correlated with habitat permanence. Sexual dimorphism was weak, and sex ratios appeared balanced. In most cases, populations were centered on anthropogenic aquatic habitats. We identified numerous threats to surveyed populations. The majority of aquatic habitats in the Peloncillo Mountains need restoration because of siltation or dam failure, and this threat is prevalent in other ranges. In addition, many surveyed sites have been invaded by bullfrogs and crawfish, exotic predators that threaten recruitment of mud turtles. Sonoran mud turtles remain common in the Madrean Sky Islands, but aquatic habitat restoration and eradication of exotic predators are warranted.

Turtles of the Southwest: Oral

Seasonal Activity Patterns and Reproductive Cycles in a Captive Population of Alligator Snapping Turtles
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We characterized seasonal activity and sex steroid hormone patterns in a captive population of alligator snapping turtles (*Macrochelys temminckii*) maintained under semi-natural conditions at Tishomingo National Fish Hatchery in southeastern Oklahoma. Monthly plasma samples were collected over a period of one year and used to quantify concentrations of estradiol, progesterone, and testosterone. Ultrasonography was simultaneously used to evaluate seasonal changes in ovarian reproductive structures. Activity indices were generated using automated radio telemetry and the signal change method, whereby changes in signal strength reflect position or location changes of the turtle. Our results indicate there are seasonal and sex-based differences in relative activity levels over the course of an annual cycle. We discuss these results in the context of seasonal sex steroid patterns and thermal conditions. Males and females exhibited different seasonal patterns with respect to sex-steroid hormone production. Female annual sex steroid concentrations were congruent with observed patterns of ovarian follicular development.

Reproductive Studies: Oral

**Rescue and Conservation of Tortoises and Freshwater Turtles at the Turtle Conservation Centre, Cuc
Phuong National Park, Vietnam****NGUYEN THU THUY***Asian Turtle Program (ATP) of Indo Myanmar Conservation (IMC), Cuc Phuong Turtle Conservation Centre, Cuc
Phuong National Park, Ninh Binh Province, Vietnam**[nthuy@asianturtleprogram.org]*

In recent years, the number of tortoises and freshwater turtles rescued from illegal trade has increased significantly in Vietnam. One reason for this has been recent changes to national laws and CITES appendix listings, seeing species up listed. Since its establishment in 1998, the Asian Turtle Program (ATP) of Indo Myanmar Conservation (IMC) has worked with the Turtle Conservation Centre (TCC) at Cuc Phuong National Park to rescue endangered species from the illegal trade and establish captive assurance populations for priority species. Since 2015, animals of 19 native species have been rescued in 34 separate confiscations but species composition, and the time and conditions in the trade strongly influenced the survival chances of these animals. A period of quarantine is undertaken immediately for all animals arriving at the centre, with veterinary care and intensive treatment provided for sick animals. In 2018, a program of screening for Mycoplasma and Herpes virus started, initially focused on Big-Headed Turtles (*Platysternon megacephalum*) as part of a pilot project for release and survival monitoring. The long-term objective is to release more animals back into the wild after more stringent health screening to more closely follow IUCN guidelines for reintroduction and ensure healthy, disease-free turtles are released back into suitable habitat. During 2017 and 2018, a total of 171 individuals were released, including Keeled Box Turtles (*Cuora mouhotii*), Yellow-Headed Temple Turtles (*Heosemys annandalii*), Giant Asian Pond Turtles (*Heosemys grandis*), Elongated Tortoises (*Indotestudo elongata*), and Big-Headed Turtles (*Platysternon megacephalum*). Conservation breeding since 2015 has also produced 400 hatchlings of 11 species and these animals also need a program of screening before being released, if they do not become part of their respective species' breeding program. Recent improvements in both facilities and staffing have further improved the situation at the TCC, but large numbers of often significantly compromised and difficult to care for species provide an ongoing challenge. Ultimately, supporting the ongoing confiscations of critical tortoise and freshwater turtle species by providing placement and release options to the authorities in Vietnam is critical to combating the illegal trade.

Conservation Planning: Oral

Chelonian Conservation in Bangladesh – Program Updates**SCOTT TRAGESER***Creative Conservation Alliance, Avenue 3, Road 13 A, House 925, Mirpur DOHS, Dhaka-1207, Bangladesh
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Over the course of the last year, the Creative Conservation Alliance has made significant progress towards enhancing protection for the threatened chelonian species of the Chittagong Hill Tracts, Bangladesh. Continued support has been provided for the recently established ten Indigenous Community Conservation Areas which provide protection for 500 hectares of the last old growth tropical forests of Bangladesh. These protected areas are providing the only safe habitat in the country for seven chelonian species including: *Manouria emys*, *Heosemys depressa*, *Cuora mouhotii*, *Cuora amboinensis*, *Indotestudo elongata*, *Cyclemys gemelli*, and *Amyda ornata*. Our chelonian breeding center, established in 2017, is also well on its way to bolstering wild populations of *M. emys* with its recent success in producing the first captive bred *M. emys* in the country. Together, these activities are creating a bright future for the threatened turtles and tortoises of Bangladesh.

TSA Partner: Oral**Viability Analysis of a Sustainable Egg Harvest Program of *Podocnemis expansa* by the Community of La Virgen, Meta River, Arauca (Colombia)****IGOR FELIPE VALENCIA^{1,2} AND GERMAN FORERO-MEDINA¹**¹*Wildlife Conservation Society – Colombia, Avenida 5 Norte # 22N-11, Cali, Valle del Cauca, Colombia*²*Turtle Survival Alliance, 1030 Jenkins Road, Charleston, South Carolina 29407 USA**[ivalencia@wcs.org]*

In the Meta River in Cravo Norte, Arauca, Wildlife Conservation Society, and Turtle Survival Alliance had been working since 2014 with the local community to preserve and protect the South American River Turtle (*Podocnemis expansa*). In Colombia, the consumption of this species is forbidden, but the community of la Virgen wants to extract eggs for local consumption, an analysis had been made to see if this harvest could be sustainable and possible without affecting the turtle population. A study was made that includes a Socioeconomic and demographic description of the community of Santa Maria de la Virgen, an evaluation of the consumption demand, the nutritional value of the eggs, a population viability analysis for the species simulating different harvesting levels, and a nests survival probability to flooding events. These studies were performed aiming to determine the viability of an egg harvesting program and the best way to implement it. Our results indicate that the population of *Podocnemis expansa* in the Meta river is vulnerable to adult female harvesting but the egg harvesting may be sustainable as long as it is controlled and do not exceed a number of nests. Also, the needs of the community can be satisfied with low levels of extraction (30 to 60 nests per season) and these nests can be achieved by selecting those laid in the month of March or later since those are the ones more likely to be affected by flooding.

TSA Partners: Oral**The Bolson Tortoise Ecosystem Preserve: a Simple Concept with Not-So-Simple Implementation****PETER PAUL VAN DIJK***Turtle Conservancy, Ojai, CA 93024 USA and Global Wildlife Conservation, Austin, Texas 78767 USA**[ppvandijk@globalwildlife.org]*

Habitat loss is one of the greatest causes of decline for turtle populations and species, and thus the logical response is to protect habitat in its natural state. Government designation of National Parks and other protected sites and landscapes has occurred for over a century, with varying degrees of biodiversity coverage and conservation effectiveness. Land acquisition for biodiversity conservation by non-governmental entities, such as charitable organizations, corporations, or private individuals, can be a valuable complementary measure. This is especially relevant where and when specific priority sites or priority species risk being overlooked by government processes that focus on more general metrics and non-biodiversity values. There are many challenges and surprises that may be encountered in the process of identifying, acquiring and designating a private protected area, and managing it long-term for biodiversity conservation; they can include tax and governance requirements, staff recruitment and retention issues, language barriers, local community relationships, and/or climate change impacts. The experiences gained from the creation of the Bolson Tortoise Ecosystem Preserve in Durango, Mexico, by the Turtle Conservancy

and its partners are used to illustrate the prospects and challenges of establishing private protected areas for tortoise and biodiversity conservation.

Habitat Protection: Oral

Assessing Suitability of Alligator Snapping Turtle Reintroduction Sites in Eastern Oklahoma

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Reintroduction has been employed to reestablish extirpated populations of alligator snapping turtles at locations throughout the Mississippi River drainage, and may eventually expand to other parts of the species' range. Selection of suitable reintroduction sites is a critical factor in reintroductions, but past site selections have primarily relied on qualitative site descriptions and 'gestalt' assessments by biologists with varying levels of experience with the species. A broadly applicable, data-driven approach is needed to standardize the selection of future reintroduction sites and ensure that reintroduction efforts are not handicapped by poor site selection. To this end, we developed a standardized model to quantify key habitat features for both adult turtles and nests based on previously published habitat preferences and requirements of the species. The output of the model is an overall habitat suitability score. This model was then used with habitat survey data to identify locations for future reintroductions in Oklahoma. We identified two potential sites for future reintroductions. We were able to successfully classify habitat of rivers where alligator snapping turtles were found as Good, which lends support to the applicability of the model. A site that was surveyed and superficially rated as lower quality – and where no existing population of alligator snapping turtles was identified – was classified as Fair, suggesting that our model has the capacity to appropriately rank potential reintroduction sites. Our initial survey efforts focused exclusively on locations that were a priori deemed potentially appropriate for reintroductions; as a result, even the lowest-ranked sites were scored as Fair. Additional sites with qualitatively poorer habitat should be surveyed to further assess the utility of the model for differentiating sites of varying suitability.

Ecology: Oral (student)

Clinal Variation in Shell Morphology in a Musk Turtle Species (*Sternotherus peltifer*)

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With six species currently recognized, musk turtles (Genus *Sternotherus*) make up a significant component of the turtle diversity in the Southeastern US. However, much is currently unknown about their ecology and evolution. There is substantial variation in morphology within the genus, with each species represented by an area along a continuous axis of shell shape, varying from highly flattened to highly domed. This divergence in body shapes is thought to be a consequence of local adaptation, with increasing flatness in species from streams with ample bedrock (e.g., *S. depressus*). One species, the Stripe-necked Musk Turtle (*S. peltifer*), occupies a variety of stream habitats from Mississippi to extreme southwestern Virginia. Since the 1950s, a remarkable intraspecific variability in morphology, including a flattened phenotype reminiscent of *S. depressus*, has been noted in *S. peltifer* in the Cahaba River of central Alabama. This variation is apparently associated with location relative to the Fall Line, a geological boundary that demarcates a rapid change in river bottom from bedrock to sand. A similar cline in shell shape has been demonstrated for several species of Emydid turtles, but whether this convergent shell phenotype has come about in *S. peltifer* through a similar adaptive process remains to be determined. We trapped *S. peltifer* throughout the Cahaba River drainage in the Spring and Summer of 2019. Here we present preliminary results on trapping success and shape variation. This study will contribute to a growing body of knowledge regarding the ecology and evolution of bottom-walking turtles.

Presentation type: Poster (student)

Long-term Changes in Population Structure and Space use in three Spotted Turtle Populations in Massachusetts: Revisiting Graham and Milam and Melvin**LISABETH WILLEY^{1,2}, MICHAEL JONES^{1,3}, H. PATRICK ROBERTS^{1,3}, AND JOAN MILAM³**¹American Turtle Observatory, 90 Whitaker Road, New Salem, Massachusetts USA²Antioch University New England, 40 Avon St., Keene, New Hampshire USA³University of Massachusetts, Amherst, Massachusetts USA

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Spotted Turtles (*Clemmys guttata*) are a species of regional conservation concern throughout their range, are under consideration for listing under the U.S. Endangered Species Act, and are considered “Endangered” under the Canadian Species at Risk Act (SARA) and by the IUCN Red List of Threatened Species. Many populations are vulnerable to decline as a result of habitat loss and elevated anthropogenic mortality. We reassessed three populations on conserved properties in central Massachusetts that were initially studied in the late 1980s and early 1990s by T. Graham (1995) and J. Milam and S. Melvin (2001). During the initial studies, the three populations were estimated to support 98 ± 56 , 18 ± 2 , and 43 ± 3 turtles, respectively, and a subset turtles were radio-tracked at each site to evaluate habitat use and home range size. Between 2014 and 2019, as part of regional conservation planning for the species, we resampled the same areas using mark-recapture techniques comparable to the initial studies. We estimated current population size and evaluated changes in habitat and space use by radio-tracking 10 of the animals initially tracked over 20 years ago at two of the sites. Initial comparisons of population models suggest declines of 37–51% over the 20 years or 2.4–4.2% per year at two of the sites and shifts in habitat use as wetlands and water levels changed over time (due to beavers, habitat management, and other factors). Our results indicate that even protected Spotted Turtle populations may be vulnerable to a suite of variable external threats and support the idea that conservation should occur at scales that account for dynamic landscape processes and allow populations to respond to natural disturbance regimes including wetland and habitat succession.

Documented Declines: Oral**Large-Scale Poaching of Northern Diamondback Terrapins (*Malaclemys terrapin terrapin*) along the Atlantic Coast of Southern New Jersey****ROGER WOOD***The Wetlands Institute, 1075 Stone Harbor Boulevard, Stone Harbor, New Jersey 08247 USA*

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Diamondback terrapins (*Malaclemys terrapin*) occur only in salt marshes and mangrove forests along the Atlantic and Gulf coasts of the United States. In the late 1800’s and early 1900’s terrapins were intensively hunted throughout much of their entire range, resulting in the severe diminution of terrapin populations. Terrapins were saved from imminent extinction by two sequential events in the early 1900’s: (1) the advent of Prohibition, followed by (2) the onset of the Great Depression in 1929. Subsequent to these events, it took about a half century for Southern New Jersey terrapin populations to recover to some semblance of what their numbers are likely to have been prior to the calamitous terrapin food fad. In New Jersey several recent court cases involving terrapin poachers may signify that current illegal exploitation of wild populations may once again threaten the long-term survival of terrapins. In 2013, a commercial fisher in Atlantic County dredged up 3,522 overwintering adult terrapins and sold them to a Maryland aquaculture facility for transshipment to Asia. Several members of a family were charged in 2014 with illegally harvesting 550 adult terrapins from salt marshes just north of Atlantic City. Over a four-year period, (2014-2017), a resident of Pennsylvania trafficked some 3,500 New Jersey terrapins both domestically and internationally over the internet, which resulted in a financial windfall of more than \$530,000. A search of his home found an additional 3,442 terrapins (mostly hatchlings) and 21 box turtles. In July, 2018, two men from Pennsylvania were caught poaching 21 adult terrapins from salt marshes separating Sea Isle City from the mainland of the Cape May Peninsula. These examples represent a total of 11,035 poached terrapins. Almost assuredly, other poachers in Southern New Jersey went undiscovered during the six-year period represented by the cases summarized here. New Jersey’s illegal harvest is thus likely to be substantially greater than 11,035. The kind of poaching documented here may well be occurring range-wide. If poaching cannot be curtailed, terrapins may soon experience the same dramatic population crash that occurred back in the late 1800’s.

Documented Declines: Oral

Comparison of Body Size of Turtles in Different Habitats

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Body size is important to animals because it can affect the habitat use of animals. We collected body size (maximum carapace length) data of 331 turtle species from published literature which accounted for 98.8% of all 335 turtle species (van Dijk *et al.*, 2014). To understand the evolution of body size, the turtle species were divided into four habitat types (marine, freshwater, mainland and island). The freshwater species were further divided into five subtypes (large lentic, large lotic, small lentic, small lotic, and all water bodies) and the mainland species were divided into three subtypes (wilderness, lowland and highland). The results of generalized linear mixed model (GLMM) showed that sea turtles had the biggest body size on average (134.86 cm \pm 70.14 cm), while freshwater turtles (32.6 cm \pm 20.57 cm) and mainland tortoises (27.08 cm \pm 15.77 cm) had the smallest. Island tortoises were intermediate in body size (80.05 \pm 37.11 cm). There were no significant differences of body size between the freshwater turtles and mainland tortoises. Moreover, body size was positively correlated with the total area of water bodies in habitat subtypes for freshwater turtles, because the body size of turtles from large lentic (50.30 cm \pm 27.03 cm) and large lotic water bodies (39.86 cm \pm 20.34 cm) were bigger than that from small lentic (23.78 cm \pm 7.47 cm) and small lotic water bodies (23.79 cm \pm 10.57 cm). There were no significant differences between the large lotic and lentic body sizes, not between the small lotic and lentic body sizes. However, the freshwater turtles inhabited in all water bodies were intermediate in body size (41.50 cm \pm 32.65 cm) compared to the four habitat subtypes as described above. Although there was a trend towards bigger body size from highland (24.86 cm \pm 10.09 cm) to lowland (26.15 cm \pm 20.12 cm), and from lowland to wilderness (39.11 cm \pm 19.43 cm) in mainland tortoises, there were also no significant differences among these habitat subtypes. This study indicated that conservation strategies for turtles should be considered in relation to their body size and habitat area.

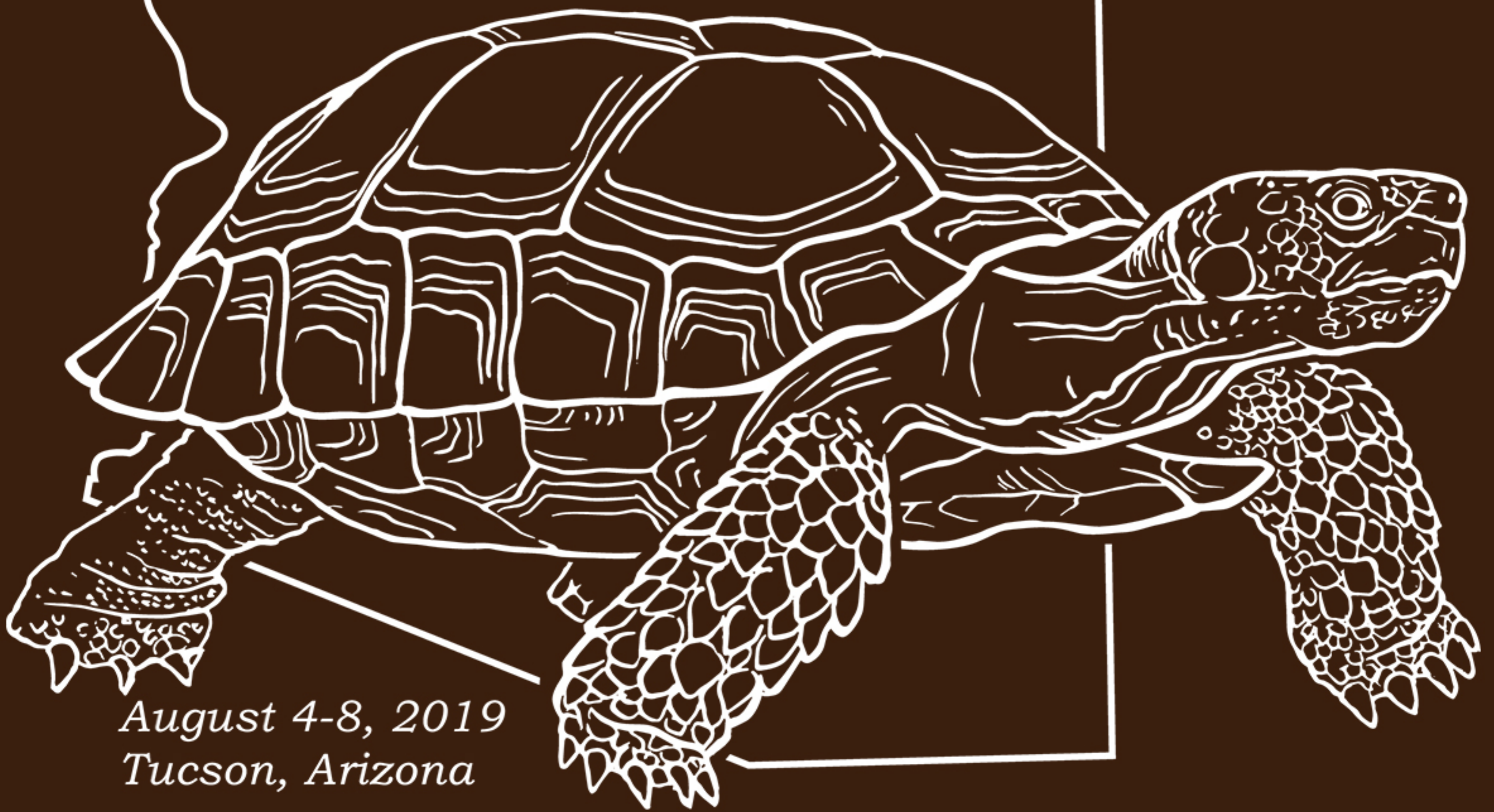
Presentation type: Poster**Exploring Demographic Strategies of Yellow Mud Turtles in Texas: Evidence of Bet-Hedging in a Southwestern Kinosternid**J. AARON ZENOR¹, RICHARD T. KAZMAIER¹, MARK J. LANGE², AND TREVOR J. MCVAY¹¹*Department of Life, Earth, and Environmental Sciences, West Texas A&M University, Canyon, Texas 79016 USA*³*Texas Parks and Wildlife Department, Columbus, Texas 78934 USA**[jazenor1@buffs.wtamu.edu]*

Understanding demography is integral to understanding the ecology of any population. Given global concerns over declining turtle populations, having a better understanding of demography could have significant implications for the management and conservation of at-risk populations. Although demographic research has been increasing amongst turtles, we still lack an understanding of variation in demographic parameters amongst most turtle species. Without such an understanding, it becomes difficult to evaluate if a management strategy developed for one population or species could or should be applied to other populations or species. We explored patterns in survival and reproduction for yellow mud turtles (*Kinosternon flavescens*) by examining 9 populations in Texas from 2007-2018. We used age-structured regression from 3132 captures of 1973 individuals across the sites to produce survival estimates for each population and used x-rays to determine average clutch size and estimate both egg volume and clutch volume for each site. Annual survival varied from 62.2% to 87.6% across the 9 populations. Across 5 sites, clutch size varied from 3.4 to 5.0, egg volume varied from 3716 mm³ to 4388 mm³, and clutch volume varied from 13991 mm³ to 17667 mm³. Variation in survival and reproduction did not appear to be related to a clinal gradient across the populations we examined. We detected no significant relationships between survival and reproduction within our populations. For both variables, within-site differences in habitat might be more significant drivers of demography than among-site differences, and the observed variation suggests this species has adopted a bet-hedging strategy rather than a more traditional K-selected strategy. Continued data collection in these and other populations should help clarify these relationships. With the anticipated effects of climate change in the southwestern United States, continuation of this study could provide an interesting opportunity to explore adaptive shifts in demography in response to increased climate variability.

Turtles of the Southwest: Oral (student)

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