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Developing Strategies to Improve Educational Programs For Wildlife Forensic Laboratory Careers

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Developing Strategies to Improve Educational Programs

for

Wildlife Forensic Laboratory Careers

By: Stephanie Harrison

University of Central Oklahoma

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"Commit yourself to lifelong learning. The most valuable asset you'll ever have is your mind and what you put into it." -Albert Einstein.

Abstract

There is a necessity for wildlife forensic programs to uniformly provide a comprehensive curriculum that includes the requirements desired by employers in the growing field of wildlife forensics. Programs need to be created based on societal needs, industry requirements (Avargil et al., 2020), within accreditation standards, and with a broad enough knowledge base for a shifting job market (Hardy et al., 2021). Programs created hastily based on popular demand can result in graduates unprepared for careers (Welsh et al., 2011). Planning programs around how students select classes (Othman et al., 2019) and improving degree roadmaps can result in financial gains (Su et al., 2019). By determining the requirements for the various wildlife forensic careers, wildlife forensic programs can individualize their programs to best prepare wildlife forensic students. The most current entry level job descriptions for Wildlife Forensic Chemist, Geneticist, and Morphologist, were obtained from the world's most prominent laboratory, The National Fish and Wildlife Forensics Laboratory. Course objectives, lessons, and labs from current University of Central Oklahoma degrees were evaluated to see if and how the knowledge, skill, and ability requirements were met. The results were arranged into tables and requirements that were not met or partially met were identified. This project developed strategies in the form of short, middle, and long-term goals that can be implemented to meet all job requirements for the three wildlife forensic careers looked at in this project. The methods of this project could be used as a template for how to evaluate or develop programs that align with job requirements for respective careers. The job requirements in this study could be used as a guide to create wildlife forensic education standards to standardize wildlife forensic programs. The design of this project along with surveys of students, employers, and employees can be used in future projects to evaluate the effectiveness of other programs at meeting job requirements for respective careers.

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Chapter 1 - Introduction

Throughout the world there is a need for well-educated and well-trained scientists to fill careers in the diverse and ever-changing field of wildlife forensic science. To date there is not a forensic science undergraduate program designed to meet the needs of employers seeking qualified candidates for wildlife forensic science careers. There is a unique set of skills employers require depending on the area of specialization of the wildlife forensic career. Since there is not a specific degree that includes all the wildlife forensic career requirements, the time it takes for a student to obtain the necessary education, skills, and abilities is often equivalent to that of a doctorate degree. By determining the requirements for the various wildlife forensic careers, wildlife forensic programs can individualize their programs to best prepare wildlife forensic students. This will enable the next generation of wildlife forensic specialists to tackle the ever growing need to protect the earth's flora and fauna.

The next generation of wildlife forensic specialists will be tasked with protecting wildlife facing the increasing threats associated with an increase in population. Wildlife crimes against flora and fauna threaten the biodiversity that is necessary to balance our ecosystems. Smuggling, poaching, illegal logging, and other types of exploitation of flora and fauna can be detrimental to conservation of species. Since all species in an ecosystem are linked, when one species in an ecosystem is reduced or eliminated by illicit activity, the equilibrium of the entire ecosystem is disturbed. Extinction is occurring at a faster rate while biodiversity is decreasing due to human activity (Johnson et al., 2017; Ripple et al., 2017; Tilman et al., 2017). To compound the matter further, the human population is expected to increase by 2.5 billion people by the year 2100 (Figure 1: United Nations 2022).

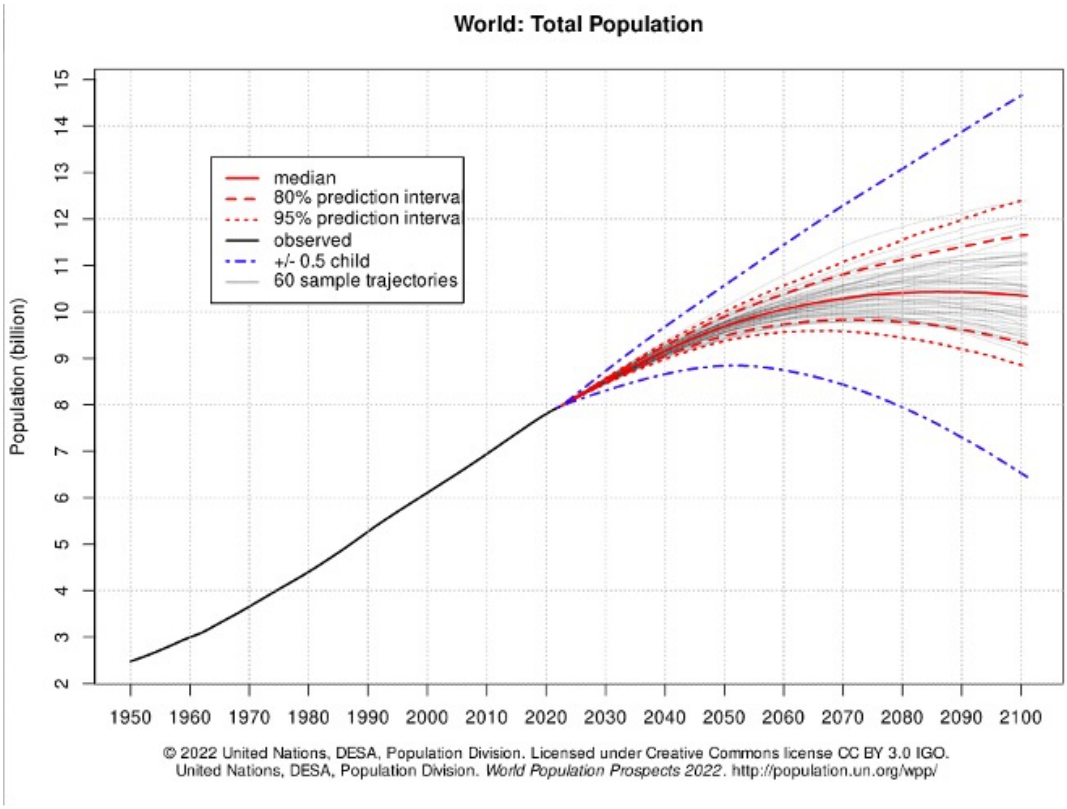

Figure 1: Predicted World Total Population by the year 2100.

Future economic and population growth is expected to lead to a larger negative impact on the environment, ecosystem, and biodiversity. With an increase in human population, the environment will be impacted through changes in land use, an increase in pollution, and ecosystems will be threatened as human pressure causes the extinction of plant and animal species that are important to the ecosystem's balance (Newbold et al., 2015, Tilman et al., 2017). Ecosystems provide clean air/water, food security, extreme weather mitigation, and health benefits (Rhodes 2018). Biodiversity can benefit human health by providing medicine, improving attention, reducing pollution, decreasing stress, encouraging outdoor exercise, and delivering spiritual experiences (Marselle et al., 2021). As ecosystems become unbalanced more extinctions could occur, further decreasing the biodiversity along with the benefits it provides (Brondizio et al., 2019; Ripple et al., 2017; Tittensor et al.,

2014). As the human population accelerates and the need to protect earths flora and fauna intensifies, the important role of wildlife forensics will be magnified in defending wildlife.

Collaboration between science disciplines and conservation education are essential to increasing conservation and reducing the loss of biodiversity. Wildlife protection laws are based on the work of conservation biologists and other scientists. Conservation Biology has become more recently named conservation science due to a need to include other disciplines when seeking conservation solutions (Williams et al., 2020). When looking at research within conservation science, Ecology can investigate the status and threat, however exploring the origin and influences as well as designing responses requires interdisciplinary research. Interdisciplinary research may include economics, political science, human geography, psychology, along with others (Tilman et al., 2017; Fisher et al., 2009). Conservation Crime Science is defined as a branch of criminology that studies crime events and their contexts to prevent conservation problems (Moreto & Pires, 2018). An article seeking promising solutions to track, prove, and prevent wildlife crimes included an example where a conservation crime scene approach was used on the issue of human-animal conflict by bringing rural farmers and government together in a collaborative effort to seek solutions to the killing of leopards (Pires & Olah, 2022). The future role of conservation success includes networking, collaboration, and an end to parachute science, where funded researchers travel to and conduct research in underfunded regions without sharing their findings. Parachute science is becoming a thing of the past in an effort to strengthen the science being done (Stefanoudis et al., 2021; de Vos 2022). Collaborating and equipping local scientists on conservation and protection techniques can increase the impact of conservation efforts. An end to parachute science means sharing knowledge and skills with local scientists within the areas that need protection. Employers of science careers desire applicants capable of working

and communicating with professionals from a variety of disciplines to determine the best solution for problems (Blickley et al., 2012; Hardy et al., 2021).

Wildlife forensic scientists are tasked with preserving, collecting, processing and analyzing evidence for crimes against flora and fauna at the state, national and international level. Both government and private companies rely on institutions to produce qualified wildlife forensic scientists with the knowledge and skills to determine which evidence has the highest value in a particular case. In some cases, wildlife forensic technicians may need to give courtroom testimony on how the chain of custody and integrity of the evidence in their area of expertise was maintained along with the results of the analyses. Expert testimony is vital to the prosecution of those that violate laws created to protect the Earth's flora and fauna. Equally important is the need for wildlife forensic programs that provide the knowledge, skills and ability required for graduates to become wildlife forensic experts that do their part to help enforce these laws. Wildlife Forensics is a vital tool for tackling wildlife crimes by identifying the victim, determining if a crime was committed, and linking the evidence to a suspect(s) through investigating illegal activities and deaths related to endangered, trafficked or illegally harvested species. Based on the growing field of wildlife forensics, the University of Central Oklahoma (UCO) is committed to ensuring graduates with an interest in wildlife forensics have access to a program or plan that includes the requirements that can be fulfilled to gain confidence that they will be highly qualified for entry level positions in their chosen career. The Center for Wildlife Forensic Science and Conservation Studies at UCO provides the ideal opportunity to create a wildlife forensic program that provides students with a broad education through collaborative efforts of conservation and forensic faculty that includes opportunities to gain essential skills for a successful career.

Statement of Problem

Wildlife protection agencies are seeking job candidates to fill positions in the growing field of wildlife forensics, and these agencies are looking for individuals that possess specialized knowledge, abilities, and skills. A cursory search of universities in the United States determined that there are only a few universities that offer certification and degree programs for Wildlife Forensics. Additionally, there are no current education standards to guide a university while creating a wildlife forensic science program. Without educational standards and with little consistency between these programs, the question arises, are current wildlife forensics programs producing qualified applicants? There is a necessity for forensic programs that provide a comprehensive curriculum that includes the requirements desired by employers seeking to hire graduates for wildlife forensic careers. The time it takes students to obtain the necessary knowledge and training for some of the wildlife forensic careers extends beyond that of a four-year undergraduate degree. A Wildlife Forensic Degree comprised of courses that are designed to provide students with the opportunity to gain knowledge, and abilities necessary to be highly competitive at entry level positions, in the most efficient amount of time, would be beneficial to students, employers, and protection of wildlife. The University of Central Oklahoma's Forensic Science Institute within its Mission Statement aspires to provide the best educational, research, and professional training opportunities through a multidisciplinary program unlike any other, and a program like this would be ideal for implementing a wildlife forensic degree.

The UCO FSI Mission Statement states:

> *The Forensic Science Institute is devoted to providing a world-class academic experience to all students, through a unique multidisciplinary program. The Institute is a comprehensive training and research organization in all aspects of evidence*

> *collection, preservation, analysis, reporting, and testimony. Our mission is to provide the best educational, research, and professional training opportunities to both undergraduate and graduate students and practicing professionals ("Forensic Science Institute," 2023).*

UCO students interested in a career in wildlife forensics currently do not have a wildlife forensic degree option and must choose from the four forensic degree options available to them. The current Forensic Science Education Programs Accreditation Commission (FEPAC) degree options include a Bachelor of Science in Forensic Science – Molecular Biology, Forensic Science – Chemistry, Forensic Science – Digital Forensics, and Forensic Investigations. To obtain a bachelor's in forensic science degree at UCO, a second bachelor's degree must also be completed. It is recommended that the second bachelor's degree align with the student's career goals. UCO students have a unique opportunity not available anywhere else through an existing cooperative, multi-disciplinary relationship between the W. Roger Webb Forensic Science Institute (FSI) and the College of Mathematics and Sciences (CMS). This collaboration, the Center for Wildlife Forensic Science and Conservation Studies (C-FACS) at the University of Central Oklahoma, provides a multitude of opportunities for faculty and students interested in environmental conservation and wildlife protection. The C-FACS partnership is composed of a group of diverse experts in their fields that can provide the teaching and collaborative learning experience for the successful creation of a Wildlife Forensic Degree.

Identifying the Need for Improved Wildlife Forensic Programs

Wildlife forensics, the application of science to legal cases involving wildlife, is essential in the effort to protect and preserve the world's biodiverse flora and fauna. Without national and international wildlife protection laws designed to protect wildlife by location,

species, origin, or age there would be no legal cases for wildlife forensic to apply science to. In addition to laws designed to protect wildlife, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), established in 1963, is tasked with monitoring trade in wild animals and plants. In order to tackle illegal activities against wildlife, wildlife forensic specialist that are knowledgeable and trained in their area of expertise are needed to identify the wildlife specimen (animal, plant or their parts/derivatives). Wildlife specialist is a career field among a group of forensic specialist careers that are expected to increase by as much as 11% - 18% over a ten-year period that will end in 2031 (U.S. Bureau of Labor Statistics 2022). The wildlife specialist seeks to answer one or more of the following questions important to CITES implementation: the species involved; the geographic origin of the specimen; whether the specimen was domesticated/undomesticated or cultivated/uncultivated; the origin of the specimen; the age of a specimen; the sex of the specimen. This information is needed in order to determine if a wildlife protection law was broken and a crime was committed. When evidence is linked to a crime and suspect, the forensic wildlife specialist that examined the evidence provides the expert courtroom testimony that is crucial to defending wildlife. To improve employability of wildlife forensic graduates there is a need to increase awareness of wildlife forensic careers, align degree plans with expectations of employers, and design courses to reach their objectives.

There is a shortage of college Science, Technology, Engineering, and Math (STEM) graduates to fill the need for scientifically qualified employees in these fields, and a science education crisis fueled by a lack of qualified science teachers to introduce and encourage students interested in STEM (Avargil et al., 2020). Although wildlife forensics has been around for some time, there is still a lack of awareness that wildlife forensic careers exist, especially among minorities with limited exposure to outdoor activities and/or embedded

stereotypes based on historically being underrepresented in Environmental and Conservation Sciences (Haynes & Jacobson, 2015; Morales & Jacobson, 2020). Women make up approximately 70% of forensic graduates according to statistics from the National Center for Education from 2012-2016. This indicates a need for universities to attract and prepare a diverse student population for an expected 14% increase in forensic jobs by 2028 (Erhart et al., 2020).

When evaluating a need for a new college degree plan, faculty and administration must take numerous elements into consideration. The societal demand for the degree (Welsh & Hannis, 2011), student career interest, student behavior in degree selection (Avargil et al., 2020), expected time to completion (Su, 2019), availability of faculty, and finances available to support implementation of the degree (Othman et al., 2019). When developing a new degree program, stakeholders must be utmost aware of the necessary education, skills, abilities, certification, and experience requirements for careers in the degree field (Avargil et al., 2020). The degree plan should be comprised of courses with clearly written objectives (Othman et al., 2019) that reflect the requirements graduates need to fulfill to transition to the workforce as a qualified employee. Employers of science careers have requested universities better prepare graduates for the knowledge and skills essential to the positions they are seeking qualified candidates to fill (Byrne et al., 2018; Maina et al., 2022).

Courses should be designed with diverse learning activities that benefit a variety of learning styles (O'Connor, 2015). These courses should encourage collaboration, with assessment types that are designed for students to reflect, improve, accomplish goals, and showcase their skills to employers. In addition to lectures, presentations, videos, guest speakers, and literature (Sokhanvar et al.,2021; Sutadji et al., 2021), students benefit by developing skills through hands-on learning through labs, experiments, simulations, research, projects, writing assignments, and presentations (Wurdinger & Allison, 2017). Authentic

assessments of communication, collaboration, critical thinking, and problem-solving skills has become increasingly popular (Sokhanvar et al., 2021; Sutadji et al., 2021). Employment Skills Micro-credentialing (ESMC) is certification that a learning objective was met based on quality assurance standards. Adding micro-credentialing along with an explanation of how the objective was met in an ePortfolio, can demonstrate mastery of desired skills to employers (Maina et al., 2022).

An example of micro-credentialing may show a graduate has gone through training and has mastered the skill of properly handling evidence and keeping the chain of custody intact. A wildlife forensic specialist can evaluate individual case factors and identify which evidence will demonstrate the highest evidential value for that case. To distinguish the specific aspects of flora or fauna in determining if a crime was committed in a case the forensic specialist needs have the education, skills, and abilities to be highly qualified in their field of expertise. By investigating and detecting criminal activity, wildlife forensics is an important part of the species protection and conservation implements that the balance of our ecosystem and natural environment depends on. Wildlife forensic specialists need a broad education that includes the required knowledge, skills, and abilities desired by employers specific to their area of expertise. There is a need for a wildlife forensic program that incorporates assessments that authenticate proficiency of real-life skill objectives in courses that are aligned with current specific job requirements for wildlife careers.

Purpose of the Project

The purpose of this project is to align the job descriptions for entry level career from the world renowned National Fish and Wildlife Forensic Laboratory to existing courses within the best current UCO degree plans. Many labs look to the Wildlife Forensic Laboratory as setting the standards when it comes to job requirements. Suggested short,

middle, and long-term improvements to courses, labs, and/or degrees will be given to fill education, skills, and abilities that are not met or partially met. A long-term goal of this project is the necessity for a wildlife forensic degree that is designed to best prepare graduates for an entry level career in wildlife forensics. This ideal degree plan would include Society for Wildlife Forensic Science SWFS ethics/standards throughout a comprehensive UCO curriculum that provides students with the broad knowledge, skills, and abilities desired by current employers. This degree program would provide graduates with a diverse depth of education that will make them highly qualified for wildlife forensic careers as well as other STEM related fields. In addition to a degree, there may be experience and wildlife forensic certification requirements associated for wildlife forensic careers that students need to be made aware.

Scope of the Project

This project will determine current UCO Forensic Science Institute recommended degrees and courses for forensic wildlife biologist geneticist, forensic wildlife biologist morphologist, and forensic wildlife chemist. UCO Forensic Science Institute has degree and course recommendations for forensic wildlife biologist investigator. For a Forensic Wildlife Biologist career that investigates illegal activities and deaths related to endangered, trafficked or illegally harvested species it is recommended that a student acquire a degree in Forensic Science paired with a degree in Biology. Recommended or suggested courses for Forensic Wildlife Biologists include Comparative Vertebrate Anatomy & Lab, Mammalian Physiology 1, Forensic & Biological Anthropology, and Wildlife Forensics. The best current degree paths and courses were selected for the wildlife forensic careers in this study and Career & Major Planning Guides were created. The courses within the degree plans were compared to recent entry level wildlife forensic job descriptions from the National Wildlife

Forensic Lab and suggested short, middle, and long-term goals were provided to fill any gaps in order to provide the most comprehensive education experience.

Significance to the field

This study can be used as a guide for how to evaluate or develop programs that align with job requirements for respective careers. By aligning UCO wildlife forensic degree paths and course designs to updated job requirements provided by the world recognized National Fish and Wildlife Forensic Laboratory, this study could be used as a template to create wildlife forensic education standards. Standardizing wildlife forensic programs would help ensure graduates of wildlife forensic programs have had the opportunity to learn knowledge and acquire the skills for the careers employers are seeking to fill. Graduates that are qualified potentially require less on the job training and can advance in their career at a quicker pace. Wildlife forensic education standards would be broad enough that graduates would be qualified for numerous STEM fields. By improving employment rates, institutions with wildlife forensic programs could improve student satisfaction and increase interest in the field.

Chapter 2 - Literature Review

To reduce the societal and environmental impacts that crimes against flora and fauna have, qualified wildlife forensics scientists are needed to collect, analyze, document, and provide courtroom testimony for evidence believed to be related to a wildlife crime. In order for a university to provide a graduate with all the knowledge, skills, and abilities they need to be competitive in the wildlife forensic field, the university needs to inform them that these types of careers exist for all students, create a clear degree plan for students to follow, and design courses within that degree plan that encompass the needs of employers seeking to fill wildlife forensic positions. This literature review addresses three areas of research related to preparing students to be competitive in their careers. In the first section, research about the existence of issues preventing students from pursuing careers in (STEM), including Environmental Conservation, and possible ways to reduce these problems. The second section discusses why universities should create degree plans with the needs of the employers in mind and how to create a plan that reduces the time required to complete the degree. The final section focuses on the evaluation of current curriculum trends, assessments, and methods to improve visibility of graduates mastered skills to employers.

Student Career Awareness

When preparing students for careers in wildlife forensic and environmental conservation, universities need to be aware of obstacles that exist that may be limiting the number of students that are exploring degrees in these fields. A student's lack of awareness that a career path exists, lack of representation, or stereotypes they have associated with a field can influence a student's decision whether to pursue a certain career.

Universities could look for ways to inform students of new and unfamiliar careers that are available. A 2020 study by Morales and Jacobson suggested that Junior college students

had a more positive perception of Environmental Conservation careers on their survey than freshmen and sophomores in college. The discrepancy in Environmental Conservation career awareness between upper and lower classmen in the Morales et al. (2020) study was thought to be the result of increased awareness as their education advanced. Since Juniors are already set on their career paths, introducing freshmen to possible Environmental Conservation careers could spark more interest in these majors. Inadequate representation of minorities in Environmental Conservation careers was found to be in part due to lack of experience with nature and perceptions about discrimination in the field (Morales & Jacobson, 2020).

Minority professionals continue to be underrepresented in STEM related fields (National Science Foundation 2019; Avargil et al., 2020) including Forensic Anthropology (Erhart & Spradley, 2020). Haynes and Jacobson (2015) conducted a qualitative study that found, in addition to minorities, students pursuing other majors had a lack of knowledge about natural resource professions. The study by Haynes and Jacobson suggested support from academic institutions through mentorships, scholarships and increasing awareness of career paths through partnership with minority organizations could lay the foundation to increase diversity in natural resource careers (Haynes et al., 2015). For example, cooperative efforts to establish a formal forensic anthropology mentorship program that aids in increasing diversity was made after a majority (90% of the 123 of the professional and graduate forensic anthropologist respondents) to an elective survey identified themselves as white (Winburn et al., 2020). Avargil, Kohen, and Dori (2020) found early interventions, shattering stereotypes, and connecting science to everyday lives could improve factors that discourage women and minorities from STEM fields. Additionally, role models and reducing academic barriers could improve support for minorities (Avargil et al., 2020).

The research literature indicates freshmen students may be unaware of the conservation career options that are available to them, while minorities, are underrepresented.

The CSI effect, created from television programs on the subject, has made Forensic Science and Crime Scene degrees popular which has led to an increase in minority ethnic students being introduced to college level Sciences (Welsh & Hannis, 2011). By creating wildlife forensic career & major planning guides for Wildlife Forensic Chemist (Figure 2), Wildlife Forensic Biologist/Geneticist (Figure 3), and Wildlife Forensic Biologist/Morphologist (Figure 4) this project provided UCO career specialists and advisors more information about wildlife forensic careers with outlined degree paths and recommended courses. Mentorships and reaching out to minority groups may increase awareness and diversify the wildlife forensic program in the future.

UNIVERSITY OF CENTRAL OKLAHOMA
Forensic Science Institute

Career & Major Planning Guide

Wildlife Forensic Chemist
Examine physical evidence, identify, and conduct chemical analyses on a wide variety of wildlife forensic samples utilizing established methods and procedures.
Skills/Attributes
Critical thinking, excellent written and communication skills, and attention to detail
Major Suggestion
Forensic Science - Chemistry degree + Chemistry - Environmental Chemistry degree
Class Suggestions
FRSC 2823 - Wildlife Forensics
Related Clubs/Organizations
Related clubs/organizations at UCO and beyond SAFS & DDE | https://www.uco.edu/fsi/student-organizations SWFS | https://www.wildlifeforensicscience.org/become-a-student-swfs-member/
Forensic Faculty Expert
name | email

JOB OPPORTUNITES
https://www.fws.gov/law-enforcement/clark-r-bavin-national-fish-and-wildlife-forensics-laboratory
https://www.wildlifeforensicscience.org/jobs_studentships/
https://webdata.aafs.org/public/jobs/postings.aspx
https://www.usajobs.gov/Search/Results?k=forensic
https://www.uco.edu/student-resources/career-development-center/

Figure 2: Career & Major Planning Guide Wildlife Forensic Chemist

UNIVERSITY OF CENTRAL OKLAHOMA
Forensic Science Institute

Career & Major Planning Guide

Wildlife Forensic Biologist (Geneticist)	
Examine physical evidence, identify, and conduct DNA analyses using modern molecular genetics techniques on a wide variety of wildlife forensic samples utilizing established methods and procedures.	
Skills/Attributes	
Critical thinking, excellent written and communication skills, and attention to detail	
Major Suggestion	
Forensic Science-Molecular Biology degree + Biology - Biomedical Sciences degree	
Class Suggestions	
BIO 3311 Intro to Genetics Lab Methods BIO 4743 Population Genetics & Lab	BIO 3703 Evolution BIO 4012 Intro to Biological Research
FRSC 2823 - Wildlife Forensics	
Related Clubs/Organizations	
Related clubs/organizations at UCO and beyond SAFS & DDE | https://www.uco.edu/fsi/student-organizations SWFS | https://www.wildlifeforensicscience.org/become-a-student-swfs-member/	
Forensic Faculty Expert	
name | email	

JOB OPPORTUNITES
https://www.fws.gov/law-enforcement/clark-r-bavin-national-fish-and-wildlife-forensics-laboratory
https://www.wildlifeforensicscience.org/jobs_studentships/
https://webdata.aafs.org/public/jobs/postings.aspx
https://www.usajobs.gov/Search/Results?k=forensic
https://www.uco.edu/student-resources/career-development-center/

Figure 3: Career & Major Planning Guide Wildlife Forensic Biologist (Geneticist)

UNIVERSITY OF CENTRAL OKLAHOMA
Forensic Science Institute

Career & Major Planning Guide

Wildlife Forensic Biologist (Morphology)
Examine physical evidence, identify, and conduct analyses of a wide variety of wildlife forensic samples utilizing established methods and procedures. This career has one of three organizational titles depending on whether a person works as a Wildlife Forensic Scientist (Herpetologist), Forensic Scientist (Mammalogist), or a Forensic Scientist (Ornithologist).
Skills/Attributes
Critical thinking, excellent written and communication skills, and attention to detail
Major Suggestion
Forensic Investigation degree + Ecology & Conservation Biology degree
Class Suggestions
FRSC 2823 - Wildlife Forensics BIO 4012 - Introduction to Biological Research BIO 4124/4124L Herpetology and Laboratory BIO 4264/4264L - Mammalogy and Laboratory BIO 4734/4734L - Ornithology and Laboratory
Related Clubs/Organizations
Related clubs/organizations at UCO and beyond SAFS & DDE | https://www.uco.edu/fsi/student-organizations SWFS | https://www.wildlifeforensicscience.org/become-a-student-swfs-member/
Forensic Faculty Expert
name | email

JOB OPPORTUNITES
https://www.fws.gov/law-enforcement/clark-r-bavin-national-fish-and-wildlife-forensics-laboratory
https://www.wildlifeforensicscience.org/jobs_studentships/
https://webdata.aafs.org/public/jobs/postings.aspx
https://www.usajobs.gov/Search/Results?k=forensic
https://www.uco.edu/student-resources/career-development-center/

Figure 4: Career & Major Planning Guide Wildlife Forensic Biologist (Morphology)

Degree Plan Creation

Changes in higher education have occurred over the years due to a rapidly changing world and the requests by employers for a labor force that is more qualified (Byrne et al., 2018; Maina et al., 2022). When creating a new degree plan or program, universities need to be aware of societal needs and the industry requirements graduates must achieve to obtain careers successfully (Avargil et al., 2020). A case where a program was designed without this in mind resulted in graduates from forensic programs in the United Kingdom needing a considerable amount of on the job training to make up for a degree created hastily to meet popular demand sparked by forensic television shows (Welsh & Hannis, 2011). Degrees should also stay within accreditation standards and include a broad enough knowledge base to ensure employment outside of the intended career when there is a shift in the job market (Hardy et.al, 2021). Availability of courses, when they are offered, course prerequisites and availability of faculty are important to consider in degree development. A quantitative survey of 396 students in Malaysia suggested university administrators could improve cost effectiveness by scheduling course offerings based on how students select courses (Othman et al., 2019). The study by Othman and others found “class and lecturer”, course and person teaching the course, to be the greatest factor when students evaluated which course they would take followed by “time and space” and “ease and comfort”. Providing clear information about the program structure and other pertinent details can help students in their decision making process (Othman et al., 2019).

The amount of time it takes to earn a degree is an important element to consider in the design process. Course offerings, class capacity, and prerequisites are some of the aspects that influence the amount of time it takes for a student to acquire their degree. A study focusing on solutions within the universities control that administrators could implement examined more than 93,000 class sessions and 2,000,000 student records at California State

University Long Beach (CSULB) over an eight year time period ending in 2017 (Su et al., 2019). The CSULB study by Su et al., (2019) introduced a probabilistic model-based method to improve degree roadmaps and was able to quantify graduation rates when given a degree roadmap. By analyzing different simulation outcomes based on the action taken within the roadmap, financial resources can be devoted to the action with the greatest impact. Limiting factors of the restructuring degree roadmaps study included looking at only full time students and not factoring in variables due to student behavior (Su et al., 2019).

According to the research, creating a degree plan based on requirements for careers in wildlife forensics which comprises a wide range of knowledge and aligns with forensic accreditation standards will result in a degree that best prepares University of Central Oklahoma graduates for a career even in an unpredictable job market. A new wildlife forensic degree that considers how students select courses would provide a cost benefit for both the university and the student.

Curriculum Design

It is necessary for a degree plan to have a variety of courses that are taught with a mixture of teaching methods (O'Connor, 2015). Including a mix of teaching methods provides students who have diverse learning styles the opportunity to amass the requirements to be highly competitive and successful in their careers. Students may receive educational information through lectures, presentations, videos, guest speakers, and literature (Sokhanvar et al., 2021). Students, particularly those in science education, can benefit from experimental learning through hand-on experiences (Wurdinger & Allison, 2017). Hands-on learning can provide students with abilities and skills through labs, experiments, simulations, research, projects, writing assignments, and presentations.

For students to be successful in courses they need a good foundation of soft skills. Soft skills are skills students need to successfully complete their degree. Soft skills include computer skills, communication skills, presentation skills, organizational skills, and analytical skills, to name a few. One way to improve on how soft skills are taught at UCO would be to include a new way of teaching them based on the scientific method in an introductory course or a summer mentoring program. Teaching these necessary skills in the beginning of a student's education experience would give them confidence in scientific communication that would benefit them throughout their science education. To improve the soft skills of Chemistry students, professors from several colleges collaborated to design a summer mentoring program that teaches soft skills based on six steps associated with the scientific method (Montgomery et al., 2022). These six steps included Background: Global and Local Scientific Problem, Hypothesis, Objectives, Methods, Results/Discussion, and Evaluation. The phases were designed to keep students focused on the different aspects of each phase through written and oral assignments. Students' written and oral communication skills were developed by determining the skill/confidence level of each student known as their zone of proximal development, and building on the zone with the guidance of mentors. Using this educational process not only gave students' confidence with scientific communication, it also improved their understanding of the scientific method. Although this method was applied with chemistry students, it can easily be applied to any area of science.

Higher education assessment methods have seen a shift from traditional to authentic assessment due to the effectiveness to create qualified candidates through evaluation of essential career skills like communication, collaboration, critical thinking, and problem-solving skills (Sokhanvar et al. 2021; Sutadji et al., 2021). Based on a systematic literature review concerned with graduate employability, Sokhanvar et al., (2021) found some advantages of authentic assessment were students being more reflective, self-aware of their

strengths/weaknesses, and having improved confidence. With authentic assessment, students apply their knowledge and skills to real life situations through presentations, projects, exhibitions, portfolios, case studies, reflective journals, interviews, and group collaborations (Sridharan & Mustard, 2015). Although authentic assessment can accompaniment existing assessment methods (Dunsmuir, Atkinson, Lang, Warhurst, & Wright, 2017), extensive educational resources can be required to ensure expected outcomes are achieved (Jopp, 2019). In addition to learning the basics through lectures and presentations, natural science fields require skills and applied experience for students to be successful at their chosen career. Based on interviews with senior conservation scientists with hiring experience, employers use the interview, resume and references to determine competency for skills they are looking for including indicators of management, leadership, and interpersonal skills (Martinich, Solarz, & Lyons, 2006). Adding Employment Skills Micro-credentialing (ESMC), certified document of a learning objective achieved following quality assurance standards and containing additional information through ePortfolios, to resumes can give employers a clearer understanding of a job candidates qualifications (Maina et al., 2022). While looking at using ESMC to improve recognition of higher education employability, Maina (2022) found students gained improved self-assessment, confidence, and writing/editing skills from recognizing and communicating their skills to lecturers and then employers. Martinich (2006) found universities have implemented project-based learning in addition to lectures and presentations in the classroom in response to educators being asked to better prepare graduates due to their little to none real-world experience. These projects allow students to gain project management experience and practice collaboration, a vital part to success in local and global research and conservation efforts. Universities can incorporate interdisciplinary projects to provide students from different degree fields collaboration experience (Hardy et al., 2021). Learning from leaders through guest speakers, internships,

research opportunities, and seminars give students the opportunity to acquire leadership and written communication skills (Blickley et al., 2012).

Although UCO forensic, biology, and chemistry courses are already designed well with a variety of teaching methods, there is always room for improvement. Teaching soft skills utilizing the scientific method in a freshmen level science course or summer program can benefit students in courses throughout their educational experience. Creating real life interdisciplinary projects that give students collaboration experience that can be assessed authentically and using a form of Employment Skills Micro-credentialing to express to employers the skills achieved are all possible ways to improve the scientific professionalism of graduates.

A degree plan, made up of courses designed with well-rounded, real life learning experiences that encompasses education, skills, applied experience, and opportunities to learn from experts, provides graduates with the best opportunity to be successful in environmental conservation careers, including wildlife forensics. Seeking ways to educate freshmen about the existence of the wide variety of careers available in environmental conservation while debunking stereotypes that exist among STEM fields will increase the number and diversity of students interested in pursuing degrees in this area. The University of Central Oklahoma, with the Center for Wildlife Forensic Science and Conservation Studies (C-FACS), has the potential to provide the diverse expert teaching and collaborative learning experience necessary to best prepare students for a career in Wildlife Forensics.

Chapter 3 - Methodology

The goal of this project was to create strategies to improve wildlife forensic programs by aligning curriculum of degrees to ensure the requirements for entry level positions are included. To determine the education, skills, and abilities desired by potential employers, the most current version job descriptions for wildlife forensic entry level careers were obtained from the National Fish and Wildlife Forensics Laboratory. The National Fish and Wildlife Forensics Laboratory is known to be the world's most prominent laboratory dedicated to the investigation of crimes against wildlife and falls under the Office of Law Enforcement. The Office of Law Enforcement is responsible for the protection of domestic and international fish and wildlife resources. The Office of Law Enforcement also provides law enforcement assistance to federal, state, and international agencies that have signed the United Nations Convention on International Trade in Endangered Species (CITES) Treaty. Since it is recognized as a leading wildlife forensic science lab in the world, the job descriptions provided by the National Fish and Wildlife Forensics Laboratory serve as a guide for other government, private, and public employers seeking to hire wildlife forensic specialists. Current degrees offered at UCO were reviewed and compared to job descriptions to determine which degree paths would include the unique requirements for the individual careers looked at in this study. Once the most logical degree paths were determined, course syllabi from the two degree plans were procured. In total 40 course syllabi were evaluated during this study. The teaching objectives, lessons, research projects, written/oral assignments and labs taught in courses were read and organized in a course evaluation table by the entry level job requirement that was met. Figure 5 shows an example of a course evaluation table for FRSC 4513/5513 Forensic Chemistry with Lab.

FRSC 4513/5513: Forensic Chemistry with Lab		
Knowledge/ Skill/Ability #	Description	How the course meets
Knowledge 1	chemical principles, theories, practices and established methodology To perform duties involved in analyzing biological and environmental samples amd to make various chemical determinations.	• principles, techniques and instrumentation currently used in forensic labs.
Knowledge 2	analytical methods and scientific instrumentation relevant to chemical analysis of solids and liquids. mass spectrometry, X-ray fluorescence, Fourier Transform infrared spectrometry, Thin Layer Chromatography	• Be able to employ the concepts and instrumentation associated with chromatography, elemental analysis, and spectroscopy methods applied in modern forensic chemistry; • principles, techniques and instrumentation currently used in forensic labs.
Knowledge 6	laboratory quality assurance programs, chemical safety, record-keeping, and laboratory health and safety as applied to a forensics laboratory environment	• quality-assurance/quality-control paradigms supporting the analytical methods, as well as the accreditation of, forensic analytical laboratories Lab #1 – Overview of the Forensic Chemistry Lab, Lab Safety, Integrity of Evidence
Knowledge 7	proper methods for collection, preparation, verification, documentation, and storage of known reference specimens (comparison standards) necessary for the development and verification of forensic evidence processing, identification and comparison protocols	• chain of custody, and the legal standards associated with the introduction of scientific evidence in a court room setting;
Knowledge 9	Familiarity with the application of standard statistical analysis to chemical data.	• apply the statistics, measurement uncertainties, and sampling restrictions associated with the analytical instrumentation and protocols of the forensic toxicology discipline; Oversight of forensic laboratories, metrology, statistics, sampling and data quality; metrology; propagation of error
Ability 1	Present analytical materials orally and in writing Associated facts and recommendations to varied audiences	Gunshot Residue Analysis Mock Court • Understand and interpret/explain the findings in professional forensic chemistry laboratory reports related to the topic areas covered in the course (lecture and laboratory). • Perform examinations and calculations related to the analytical methods and instrumentation associated with a professional forensic chemistry laboratory related to the topics covered in this course.
Ability 3	Ability to communicate scientific data to varied audiences orally and in writing	Gunshot Residue Analysis Mock Court

Figure 5: Course Evaluation Table for Forensic Chemistry with Lab. The table shows the knowledge, skills, and ability from the National Fish and Wildlife Forensic Lab that the course meets with a description of how the course meets that requirement.

A UCO course and requirement comparison table was created to display the UCO courses that best met the job requirements for the individual careers. The requirement and course comparison tables (Figures 6,7, and 8) are in the results section of this paper. The job requirements on the comparison tables were color coded green if met, red if not met, and yellow if partially met. Research was done to determine how suggested lessons, labs, courses, partnerships, and a degree could be incorporated over time to fulfill all job requirements. The suggested changes were ranked by whether they could be implemented in the short, middle,

or long-term. Curriculum changes like modifying lectures or adding a lab to an existing course could be made in the short term. Middle term modifications would include adding a laboratory section to an existing course, or changing a large aspect of a current course. Creating brand new classes and degree tracks for wildlife forensic would be long term changes.

The National Fish and Wildlife Forensics Laboratory relies on scientists/specialists to conduct crime scene investigations, examine submitted items of evidence, and provide expert testimony in court. This study focused on three entry level specialist positions including Forensic Biologist (Morphologist), Forensic Chemist and Forensic Biologist (Geneticist). The entry level positions provide a career ladder opportunity for advancement, as experience and technical skills are added to the professional knowledge gained through completion of a formal degree program. Each of the three entry level positions are seeking applicants with specific general, technical and other knowledge competencies. In addition to these knowledge requirements, Forensic Scientist certification under the requirements of the Society for Wildlife Forensic Science (SWFS) must be obtained and maintained. Through the direction and oversight of the Unit Supervisor, or senior Forensic Scientists, the entry level trainee conducts forensic examinations, or comparisons, on a wide range of evidence items submitted to the Lab, utilizing established methods and procedures. Descriptions for the three entry-level wildlife forensic positions are listed below, followed by suggested degree plans, and the comparison of course objectives to the required knowledge, skills, and abilities. The requirements for Forensic Scientist certification are available on the Society for Wildlife Forensic Science (SWFS) website. UCO will make wildlife forensic students aware of the need to obtain and maintain certification as a Forensic Scientist under the requirements of the Society for Wildlife Forensic Science. Certification criteria can be found on the Society for Wildlife Forensic Science website under, “become certified as a wildlife forensic scientist”.

Job descriptions

All three positions described are entry level with the trainee working under the direction and oversight of the Unit Supervisor or senior Forensic Scientists. Applicants do not necessarily need all of the listed knowledge, skills, and abilities when hired. However, more qualified applicants may require less training and be more desirable. There is an opportunity for advancement through on-the-job training, experience, and an increase in responsibility.

A Biologist (Morphologist) working at the grade 09 level receives on-the-job and classroom training to examine physical evidence and conduct analyses, of a wide variety of samples, utilizing established methods and procedures. A person working in the Biologist Morphologist position needs to be able to prepare and review analytical reports and related case notes that are necessary when analyzing evidence to solve wildlife crimes. The trainee is expected to participate in planning and assigning priorities to the tasks they are given. This position has one of three organizational titles depending on whether they work as a Wildlife Forensic Scientist (Herpetologist), Forensic Scientist (Mammalogist), or a Forensic Scientist (Ornithologist). For the entry level morphology position sixty percent of the job is forensic examination involving identifying and analyzing wildlife-related evidence; and applying appropriate scientific method to compromised evidence. Task assigned will increase in difficulty and complexity to develop the knowledge, skills and abilities required to carry out assignments. Assignments are typically a portion of a larger project overseen by the Unit Supervisor, or Senior Forensic Scientist(s). To work at the full performance level, skills to work independently to determine methodologies, milestones, goals, and termination points for all assignments need to be met. Internal controls and reporting makes up thirty percent of the task. This portion of the job includes task like testing, research, and/or development of new and/or modification of methods/procedures; preparing written reports, and other

technical documentation for various agencies; translating scientific concepts to make them clearer; using proper known reference sample protocols; and testifying in court. The last ten percent of job tasks are dedicated to networking/briefing. Networking/briefing includes planning, coordinating, and initiating contact with various government agencies and the private sector technical community.

A Forensic Chemist entry-level GS-07 works as a trainee to conduct visual, physical, chemical, and other scientific and instrumental examinations, as needed, for submissions of physical evidence in the primary area of forensic chemistry. Forensic examination makes up 60% of the duties and includes using basic knowledge of chemical principles, theories, practices and established methodology to conduct examinations involving chemical analyses and physical chemical test methods for solid and liquid complex matrices. Analysis and test include using standard and state of the art instrumentation on substrates such as ammunition, biological tissues (bile, blood, bone, or ivory), wood samples, and items composed of such materials. Work requires general knowledge and experience with analytical methods, and evaluating analytical methods that employ gas, liquid and ion chromatographic analyses. The entry level Chemist works with the Unit supervisor, or senior staff in the Criminalistics Unit to review background material submitted with samples, determine the best approaches to obtaining appropriate data, and select the specific analytical procedures to be used. They also participate in annual Proficiency Testing in Chemistry and provide expert witness testimony as required by forensic casework. Research studies make up 25% of the duties of this position which includes assisting with research, development, modification and verification of methods used to examine, identify and compare wildlife-related evidence. Evaluating and interpreting reports as well as preparing reports to be reviewed by senior staff or the Unit leader are assignments included in this category. Other expectations include: using proper protocols when handling known reverence sample(s); maintaining communication with team

members and professional colleagues to ensure a timely exchange of information; and overseeing volunteer assistants in the laboratory on occasion. The last 15% of the time is spent assisting with providing professional advice and technical assistance to various groups, arranging specimens in the reference collection, putting chemical data files into databases according to service data management criteria, and collaborating to establish standardized validated protocols.

The trainee Forensic Geneticist, working at the entry grade 09 level, will receive on-the-job and classroom training in the use of modern techniques of molecular genetics for the identification of wildlife evidence, as well as, training in obtaining and analyzing DNAs from such difficult plant and animal products as kiln dried wood, tanned leathers, pasteurized sturgeon caviars, antler, bone, and ivory. Additionally, the trainee will be exposed to the National Fish and Wildlife Forensics Laboratory Genetics Standards Collection that will become essential as movement towards independence in work assignments occurs. The Forensic Geneticist trainee participates in planning/assigning priorities to the tasks, and performs analyses in the area of molecular biology/genomics, as applied to wildlife forensics. Forensic Examinations make up 60% of the duties where appropriate genetic techniques are used (adapted techniques for non-standard evidence) to prepare samples, extract, quantify, and interpret DNA, as well as, report results. The DNA results may be used to identify a species or determine a genetic relationship. Expectations include operating, configuring, and maintaining laboratory equipment along with following proper protocol to handle evidence and reference material. Maintaining familiarity regarding genetic analyses/protocols through technical literature and working with the supervisor/senior staff to communicate methods, results, problems, and needs of special projects/assignments comprise 20% of the job. The last 20% of the time is spent on technical assistance, collection arrangements, and standardizing databases. Curation, maintenance, and expansion of the biological and genetic

databases including reference collections are examples of tasks included in this portion of the job. Conducting statistical analysis, generating graphical representation of the data, then creating written reports and/or scientific publications that can be presented to a variety of audiences are other tasks included within the last portion of Wildlife Forensic Geneticist position.

Degree Plans

The suggested degree plans for the students seeking a career in Wildlife Forensic Chemistry, Wildlife Forensic Genetics, and Wildlife Forensic Morphology were based on the review and comparison between job requirements provided by the National Fish and Wildlife Forensics Laboratory and current degrees offered at the W. Roger Webb Forensic Science Institute (FSI) and the College of Mathematics and Sciences (CMS) at UCO. UCO Forensic Science Institute Career & Major Planning Guides can be found under the heading, “Student Career awareness”. The Career & Major Planning Guides were created for Wildlife Forensic Chemist (Figure 2), Wildlife Forensic Biologist (Geneticist) (Figure 3), and Wildlife Forensic Biologist (Morphology) (Figure 4) by adding major and class suggestions along with a career description to a template obtained from the university.

For the Wildlife Forensic Chemist career where physical evidence on a wide variety of wildlife forensic samples is examined, identified, and chemical analyses are conducted, utilizing established methods and procedures, students are suggested to combine the Forensic Science - Chemistry degree with the Chemistry - Environmental Chemistry degree. The 139 total hours needed for graduating combine (33 to 34) University Core hours with 79 Chemistry - Environmental Chemistry degree hours and 27 Forensic Science - Chemistry degree hours. For students interested in a Wildlife Forensic Chemist career FRSC 2823-Wildlife Forensics is a suggested course.

Wildlife Forensic Geneticist examine physical evidence, identify, and conduct DNA analyses using modern molecular genetics techniques on a wide variety of wildlife forensic samples, utilizing established methods and procedures. For students interested in a career in Wildlife Forensic Biologist (Geneticist) the suggested Career & Major Planning Guide includes Forensic Science - Molecular Biology degree with the Biology - Biomedical Sciences degree. The required 139 total hours for graduating come from (33 to 34) University Core hours, 58 Biology - Biomedical Sciences degree hours, 42 Forensic Science - Molecular Biology degree hours and (five to six) free elective hours. Recommended electives for the Biology - Biomedical Science degree are BIO 3311 Intro to Genetics Lab Methods, BIO 3703 Evolution, BIO 4743 Population Genetics & Lab, and BIO 4012 Intro to Biological Research (a possible capstone course). FRSC 2823 - Wildlife Forensics would be an essential class to take, as well.

For the Wildlife Forensic Biologist (Morphology) career that examines physical evidence, identifies, and conducts analyses of a wide variety of wildlife forensic samples, utilizing established morphological methods and procedures students will combine the Forensic Investigations degree with the forthcoming Ecology and Conservation Biology degree. To achieve the required 139 total hours, students will obtain (33 to 34) University Core hours plus 74 Ecology & Conservation Biology hours and 33 Forensic Investigation hours. The recommended 29 hours of electives include BIO 2203 Cell Biology, BIO 2211 - Cell Biology Laboratory, FRSC 2823 - Wildlife Forensics, BIO 3254 Comparative Vertebrate Anatomy, BIO 3454 - Vertebrate Zoology Laboratory, BIO 4012 - Introduction to Biological Research, BIO 4124/4124L - Herpetology and Laboratory, BIO 4264/4264L - Mammalogy and Laboratory, BIO 4734/4734L - Ornithology and Laboratory. FRSC 2823 - Wildlife Forensics could be taken as an elective for the Forensic Investigator degree, as well. BIO 4012 - Introduction to Biological Research is a recommended course that could be a

capstone course with approval, however, the forensic capstone may count for the Ecology & Conservation Biology capstone. There are three organizational titles depending on whether a person works as a Wildlife Forensic Scientist (Herpetologist), Wildlife Forensic Scientist (Mammalogist), or a Wildlife Forensic Scientist (Ornithologist). Even if a student would like to specialize taken the Herpetology, Mammalogy, and Ornithology courses are recommended. Taking a less desirable but available morphology position may increase chances of getting the desired position when available.

The UCO Forensic Science Institute Career & Major Planning Guides are merely suggestions and there are additional degrees available. A student's Career & Major Planning Guide should be tailored to the interest, needs, and goals of the student. Students interested in Wildlife Forensic Chemistry, Wildlife Forensic Genetics, and Wildlife Forensic Morphology need to be aware of experience and Forensic Scientist certification under the Society for Wildlife Forensic Science, in addition to obtaining a degree.

Comparison

Course syllabi from the degree plans were acquired and the teaching objectives taught in these courses were read and organized into a table along with the National Fish and Wildlife Forensics Laboratory entry level positions job requirements (example: Course Evaluation Table Figure #5). A one to one comparison of UCO courses and job requirements was made to determine which courses best met that Knowledge, Skill, or Ability. Gaps or shortcomings where objectives did not meet the requirement were determined and the table was color coded to represent the degree of the shortcoming. Gaps were ranked by if they could be met by short, middle, or long term goals. Research was completed to determine how to best fill any shortcomings or gaps and a plan with short, middle, and long term goals was created. When applied, the plan, would best prepare UCO students for careers in Wildlife Forensic Morphology, Wildlife Forensic Chemistry, and Wildlife Forensic Genetics.

Chapter 4 - Results

Current UCO course syllabi for courses within the suggested degree plan for each of the three wildlife forensic careers, Wildlife Forensic Chemist, Geneticist, and Morphologist, were obtained and reviewed to see which courses best covered the individual requirements for the positions. A total of 40 syllabi were examined for this study. The results of the comparison can be found in Figure 6 for Wildlife Forensic Chemist, Figure 7 for Wildlife Forensic Geneticist, and Figure 8 for Wildlife Forensic Morphologist. The Knowledge, Skills, and Abilities colored orange are student learning objectives for a forensic science degree at the University of Central Oklahoma. The Skills and Abilities that are color coded blue are considered soft skills that are required to successfully complete courses required to graduate. The knowledge and course comparison tables are color coded to represent if the Knowledge, Skill, or Ability listed was met (green), partially met (yellow), and not met (red). Suggested short (one year), middle (three year) and long term (five year) goals to fill any gaps can be found in Figure 9.

Requirement and Course Comparison Table - Wildlife Forensic Chemist			
Requirement		UCO Course	
Knowledge			
Knowledge 1	chemical principles, theories, practices	FRSC 4323	Forensic Toxicology & Lab
	and established methodology	FRSC 4513	Forensic Chemistry & Lab
	To perform duties involved in	CHEM 3353	Environmental Chemistry
	analyzing biological and environmental samples		
	amd to make various chemical determinations.		
Knowledge 2	analytical methods and scientific instrumentation	CHEM 3454	Fund of Instr Anal & Lab
	relevant to chemical analysis of solids and liquids.	FRSC 4323	Forensic Toxicology & Lab
	mass spectrometry, X-ray fluorescence,	FRSC 4513	Forensic Chemistry & Lab
	Fourier Transform infrared spectrometry,	CHEM 3303	Organic Chemistry
	Thin Layer Chromatography	CHEM 3312	Organic Chemistry Lab
		CHEM 4454	Environmental Chemical Analysis & Lab
Knowledge 3	scientific method in applied biological		
	and biochemical research		
Knowledge 4	Familiarity with	BIO 1224	Biology for Majors: Diversity
	the principles of phylogenetic taxonomy		
knowledge 5	scientific method and its application to	FRSC 4253	Forensic Science Analysis & Lab
	the examination, identification, and comparison of	FRSC 3043	Crime Scene Processing
	biological evidence.	FRSC 4533	Forensic Microscopy & Lab
Knowledge 6	laboratory quality assurance programs,	FRSC 4323	Forensic Toxicology & Lab
	chemical safety, record-keeping, and laboratory health	FRSC 4513	Forensic Chemistry & Lab
	and safety as applied to	FRSC 4533	Forensic Microscopy & Lab
	a forensics laboratory environment		
Knowledge 7	proper methods for collection, preparation,	FRSC 4513	Forensic Chemistry & Lab
	verification, documentation, and storage	FRSC 4533	Forensic Microscopy & Lab
	of known reference specimens (comparison standards)	FRSC 3043	Crime Scene Processing
	necessary for the development and verification of	FRSC 4253	Forensic Science Analysis & Lab
	forensic evidence processing, identification	FRSC 4323	Forensic Toxicology & Lab
	and comparison protocols		
Knowledge 8	handling simple biological	FRSC 3043	Crime Scene Processing
	(bile, blood, bone or ivory, wood or plants)	FRSC 4253	Forensic Science Analysis & Lab
	and non-biological (e.g. ammunition, fibers)	FRSC 4533	Forensic Microscopy & Lab
	substrates and items composed of such materials.	FRSC 4513	Forensic Chemistry & Lab
Knowledge 9	Familiarity with the application of	STAT 2103	Intro to Stats for Science
	standard statistical analysis to chemical data.	CHEM 2104	Quant Anal & Lab
		FRSC 4513	Forensic Chemistry & Lab
		FRSC 4323	Forensic Toxicology & Lab
Skills			
Skill 1	basic computer hardware and software		
	To input/extract data into established databases		
	analyze problems and accomplish assigned task		
Ability			
Ability 1	Present analytical materials	FRSC 4323	Forensic Toxicology & Lab
	orally and in writing	FRSC 4513	Forensic Chemistry & Lab
	associated facts and recommendations	FRSC 4713	Forensic Pharmacology
	to varied audiences		
Ability 2	Ability to prepare research project results in the form of	FRSC 4323	Forensic Toxicology & Lab
	oral presentations and written publications	CHEM 4454	Environmental Chemistry
	for a variety of audiences	CHEM 3454	Fund of Instr Anal & Lab
		FRSC 4713	Forensic Pharmacology
		FRSC 4513	Forensic Chemistry & Lab
Ability 3	Ability to communicate scientific data		
	to varied audiences orally and in writing		
	Requirement that is met.		
	Requirement that is partically met.		
	Requirement that is not met.		
	Soft Skills Required to be successful in courses		
	and graduate		
	Student Learning Objective for Forensic Science degree		

Figure 6: Requirement and Course Comparison Table - Wildlife Forensic Chemist

Requirement and Course Comparison Table - Wildlife Forensic Geneticist			
	Requirement		UCO Course
	Knowledge		
Knowledge 1	molecular genetics techniques	BIO 4743	Population Genetics & Lab
	genotypic and sequence data	FRSC 4333	Forensic Molecular Biology & Lab
	terrestrial & aquatic populations	FRSC 4613	Advanced Forensic DNA Analysis & Lab
Knowledge 2	Scietific Method - applied biological research		
	to design, implement, conduct and		
	review complex investigations		
	To perform		
	A. forensic assignment		
	B. design projects utilizing		
	population genetic data analysis software		
Knowledge 3	Biology of terrestrial or aquatic species	BIO 3454 (?)	Vertebrate Zoology & Lab
	native or introduced to North America	BIO 3254 (?)	Comparative Vertebrate Anatomy & Lab
	phylogenetic taxonomy - current nomenclature	BIO 1224	Biology for Majors: Diversity
	of major vertebrate classes		
	To perform		
	wildlife forensics assignments		
Knowledge 4	Knowledge of and the ability to use	FRSC 4333	Forensic Molecular Biology & Lab
	populaiton genetic data analysis software for	FRSC 4613	Advanced Forensic DNA Analysis & Lab
	Sanger Sequencing	BIO 4743	Population Genetics & Lab
	STR fragment analysis		
	SNP		
	high-throughput sequence data		
	To design projects		
	A study design		
	B sample preparation		
	C quantitation		
	D evaluation		
	E Interpretation		
	F use of Lab DNA instruments		
Knowledge 7	Molecular genetic statistical techniques	FRSC 4333	Forensic Molecular Biology & Lab
	For analyzing	FRSC 4613	Advanced Forensic DNA Analysis & Lab
	genotypic and sequencing data files	BIO 4743	Population Genetics & Lab
Knowledge 8	General scientific practices	FRSC 4333	Forensic Molecular Biology & Lab
	record-keeping / laboratory health and safety	FRSC 4613	Advanced Forensic DNA Analysis & Lab
	For a forensics laboratory environment		
Knowledge 9	basic computer hardware and software		
	To input/extract data into established databases		
	analyze problems and accomplish assigned task		
Knowledge 10	relationship between biology, ecology, and	FRSC 2823	Wildllfe Forensics
	populaiton genetic characteristics of	BIO 1204	Biology for Majors - Principles
	fish and wildlife species of conservation interest		
Knowledge 11	project planning and design	BIO 4012	Intro to Biological Research
	for fish and wildlife conservation genetic analyses		
Knowledge 11	collection management	BIO 4743	Population Genetics & Lab
	of conservation genetics samples and data		
	Skills		
Skill 1	Communicate orally and in writing	FRSC 4333	Forensic Molecular Biology & Lab
	with a variety of audiences	FRSC 4613	Advanced Forensic DNA Analysis & Lab
Skill 2	Presenting		
	analytical materials, facts and recommendations		
	to varied audiences		
	Ability		
Ability 1	Apply the scientific method to design projects	FRSC 4333	Forensic Molecular Biology & Lab
	that utilize	FRSC 4613	Advanced Forensic DNA Analysis & Lab
	Sanger sequencing		
	STR fragment analysis	BIO 4012	Intro to Biological Research
	massively parrallel sequence analyses		
	Requirement that is met.		
	Requirement that is partically met.		
	Requirement that is not met.		
	Soft Skills Required to be successful in courses and graduate		
	Student Learning Objective for Forensic Science degree		

Figure 7: Requirement and Course Comparison Table - Wildlife Forensic Geneticist

Requirement and Course Comparison Table - Wildlife Forensic Morphology			
	Requirement		UCO Course
	Knowledge		
Knowledge 1	methods, procedures, and techniques applied in	FRSC 2823	Wildllfe Forensics
	fish and wildlife law enforcement	FRSC 2503	Intro to Forensic Science
	in order to	FRSC 4253	Forensic Science Analysis & Lab
	apply protocols for examining evidence	FRSC 4143	Advanced Crime Scene Processing
	and provide necessary scientific support		
	for prosecuting violations of law		
	simple, compound and comparison microscopes		
	monochromatic light sources	BIO 2203/2211	Cell Biology & Lab
	digital imaging systems, computerized image scanning	FRSC 3043	Crime Scene Processing
	or comparison equipment, and		
	UV or IR spectrophotometers		
	other advanced analytical computer hardware / software		
Knowledge 2	theories, principles, practices, and techniques	BIO 4264/5264	Mammalogy & Lab
	of fish and wildlife morphology	BIO 4124/5124	Herpetology & Lab
	herpetology, mammalogy, and ornithology	BIO 4734/5734	Ornithology & Lab
	to examine and identify minimum number of	BIO 3254	Comparative Vertebrate Anatomy & Lab
	individuals (MNI) and species involved	BIO 3454	Vertebrate Zoology & Lab
	from specimens submitted to the Lab	FRSC 2823	Wildllfe Forensics
Knowledge 3	theories, principles, practices, and techniques	FRSC 4253	Forensic Science Analysis & Lab
	of forensic science	Human	
	to analyze specimens submitted to the Lab	FRSC 2823	Wildllfe Forensics
	draft findings for use by law enforcement personnel		
	and potentially in a court of law		
Knowledge 4	basic health and safety policies and procedures	BIO 4734/5734	Ornithology & Lab
	to function in a safe and effective manner	BIO 2203/2211	Cell Biology & Lab
	in a laboratory environment.	BIO 3254	Comparative Vertebrate Anatomy & Lab
		FRSC 4613	Advanced Forensic Molecular Biology
	Skills		
Skill 1	work in a team fashion to develop, modify, and test		
	new or updated lab equipment, methods / procedures		
	Ability		
Ability 1	to use analytical methods	FRSC 4253	Forensic Science Analysis & Lab
	including sophisticated instrumentation	Human	
	to perform forensic analysis		
Ability 2	work with scientific and/or technical specialists		
	from a wide variety of disciplines		
	to coordinate the analysis of complex pieces of evidence		
Ability 3	present technical information in a clear, concise,	FRSC 4533	Forensic Microscopy & Lab
	and logical manner for a variety of audiences.		
Ability 4	to communicate both orally and in writing	BIO 4734/5734	Ornithology & Lab
	to convey scientific and/or technical information	BIO 4124/5124	Herpetology & Lab
	to both knowledgeable and uniformed audiences	FRSC 4143	Advanced Crime Scene Processing
		FRSC 4613	Advanced Forensic Molecular Biology
	Requirement that is met.		
	Requirement that is partically met.		
	Requirement that is not met.		
	Soft Skills Required to be successful in courses and graduate		
	Student Learning Objective for Forensic Science degree		

Figure 8: Requirement and Course Comparison Table - Wildlife Forensic Morphologist

Goals	
Short	Add a Wildlife Forensic Crime Scene Processing Lab to FRSC 3043 Crime Scene Processing or FRSC 2823 Wildlife Forensics that includes collecting bone or ivory, wood, or plants
	Forensic molecular biology course - add a massively parallel sequence analysis Lab.
	Forensic molecular biology course - add wildlife aspects (kiln dried wood, tanned leathers, pasteurized sturgeon caviars, antler, bone, ivory, and cooked food products).
	Forensic molecular biology course - add a phylogenetic tree aspect to lab.
	Wildlife forensic Lab that Incorporates knowledge - methods and procedures used to examine, identify, and compare wildlife-related evidence items.
Middle	Add a Wildlife Forensic Crime Scene Processing course
	Create a Molecular Wildlife Biology course.
	Create a Forensic Science - Morphology Major degree plan.
	Create an Advanced Wildlife Course or adding a lab to the current course and making it a 4000-level course.
Long	Add partner for experience - wildlife department, OKC Zoo, etc.
	Create a Wildlife Forensic Degree.

Figure 9: Table of Short, Middle, and Long-term Goals

Requirements met by Forensic Science Learning Objectives

The Knowledge, Skills, and Abilities colored orange in Figures 6, Figure 7, and Figure 8 are acquired through the student learning objectives for a forensic science degree at the University of Central Oklahoma. Requirements that are color coded orange for Wildlife Forensic Chemist (Figure 6) include Knowledge 3-scientific method in applied biological and biochemical research; Knowledge 6-laboratory quality assurance programs, chemical safety, record-keeping, and laboratory health and safety as applied to a forensics laboratory environment; and Ability 3-ability to communicate scientific data to varied audiences orally and in writing. For Wildlife Forensic Geneticist (Figure 7) the section of Knowledge 2-scientific method applied to biological research to design, implement, conduct, and review complex investigations to A. forensic assignment is color coded orange; Knowledge 7-general scientific practices record-keeping/laboratory health and safety for a forensics laboratory environment; and parts of Ability 1-apply the scientific method to design projects

utilizing sanger sequencing and STR fragment analysis are colored orange. Requirements that are covered in the forensic student learning objectives for Wildlife Forensic Morphology (Figure 7) include Knowledge 3-theories, principles, practices, and techniques of forensic science to analyze specimens submitted to the Lab and draft findings for use by law enforcement personnel and potentially in a court of law; Knowledge 4-basic health and safety policies and procedures to function in a safe and effective manner in a laboratory environment; and Ability 1-to use analytical methods including sophisticated instrumentation to perform forensic analysis. The following Forensic Science Institute student learning objectives for a forensic undergraduate degree were retrieved from the University of Central Oklahoma website.

Forensic undergraduate degree Student Learning Objectives:

> *"Acquire and retain foundational knowledge from the core discipline areas and apply it to an understanding of the continuum from crime scenes to courtrooms. Apply the scientific method to forensic science problems: review and interpret forensic science literature; develop well-reasoned, scientifically sound hypotheses; design experiments to test hypotheses; statistically analyze and interpret data and communicate results in written and oral formats. Communicate forensic science information clearly, concisely, logically, and accurately, to the general public both orally and in writing. Function as knowledgeable citizens with an understanding of the role of forensic scientists in society and offer ethical, well-reasoned arguments/solutions to societal concerns related to forensic science. Demonstrate global and cultural competencies (avenues for learning might include study tours, guest lectures featuring international experts in forensic science, reading materials, and community engagement activities). Comprehend and demonstrate a working knowledge of safe and healthy practices in*

> *forensic science through adherence to accepted quality assurance standards and health and safety procedure. ("Forensic Science Institute," 2023)*

Requirements met by Soft Skills

The soft skills (color coded blue on Figure 6, 7, and 8) are obtained throughout the education experience as a wildlife forensic student successfully completes courses and earns their degree. At UCO soft skills are taught within specific courses through critical thinking activities, written and/or oral assignments, experiments, and research. There are three required skills and abilities needed for Wildlife Forensic Chemist (Figure 6) that are color coded blue. Skill 1-basic computer hardware and software to input/extract data into established databases analyze problems and accomplish assigned task; Ability 1-ability to present analytical materials orally and in writing including associated facts and recommendations to varied audiences; and Ability 2-ability to prepare research project results in the form of oral presentations and written publications for a variety of audiences can all be achieved by accumulations of soft skills. There is one knowledge and two required skills color-coded blue for Wildlife Forensic Geneticist; Knowledge 7-knowledge of basic computer and software to input and extract data into established databases, analyze problems and accomplish assigned task; Skill 1-skill to communicate orally and in writing with a variety of audiences; and Skill 2-skill to present analytical materials, facts, and recommendations to varied audiences. For Wildlife Forensic Morphology there are two abilities color coded blue; Ability 2-ability to present technical information in a clear, concise, and logical manner for a variety of audiences; and Ability 4-ability to communicate both orally and in writing to convey scientific and/or technical information to both knowledgeable and uninformed audiences.

Requirements met by Suggested Goals

For Wildlife Forensic Chemistry the current suggested degree plan and courses would meet all but one of the knowledge requirements. Knowledge 8 is color coded yellow to indicate the need to incorporate the proper handling of bone or ivory, and wood or plants (Figure 6). The proper handling of bone/ivory, and wood/plants could be incorporated as a short-term goal by creating a wildlife forensic crime scene processing lab or as a middle term goal by adding a wildlife forensic crime scene processing course (Figure 9).

The Wildlife Forensic Geneticist requirement and course comparison table shows knowledge and ability marked yellow due to two main gaps (Figure 7). The first gap is a need to incorporate massively parallel sequencing, which can be done short term by adding a massively parallel sequence analysis lab (Figure 9). The second gap is the need to incorporate molecular techniques for terrestrial and aquatic species in addition to the human techniques being taught. Adding labs that include wildlife aspects like kiln dried wood, tanned leathers, pasteurized sturgeon caviars, antler, bone, ivory, and cooked food products often seen in wildlife cases. Additionally, phylogenetic tree labs are suggested short-term goals. A middle term goal for meeting these main two gaps for wildlife forensic geneticists is creating a wildlife molecular biology course.

Short term goals for filling gaps in the comparison table for wildlife forensic morphology (Figure 8) consist of creating a wildlife forensic lab that incorporates knowledge of methods and procedures used to examine, identify, and compare wildlife related evidence items. A middle term goal for morphology would be to create a forensic science - morphology major degree plan (Figure 9). The suggested forensic investigations degree plan has courses that may not benefit a morphology student as much as other forensic courses that are offered.

A middle-term goal that would benefit all wildlife forensic students would be creating an advanced wildlife course or adding a lab to the current course and making it a 4000 level course. Long-term goals consist of adding a partner to give students the experience they need and ultimately adding a wildlife forensic degree. A wildlife forensic internship with the Oklahoma Department of Wildlife Conservation, the Oklahoma City Zoo or another organization would greatly benefit wildlife forensic students by providing hands-on experience they could not achieve in the classroom.

Chapter 5 - Discussion

Wildlife Forensics is an emerging field that is vital to answer questions important to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the implementation and enforcement of other laws designed to protect and preserve wildlife. As human impact on Earth's geology and ecosystem increases and extinction and biodiversity loss occurs at a quicker rate, conservation and protecting Earth's biodiversity is critical. Collaboration between disciplines is essential to evaluating and implementing protection plans for wildlife. Creating and enforcing laws designed to protect flora and fauna is a critical aspect of protecting biodiversity. Prosecuting offenders of these laws requires evidence that the law was indeed violated. The vitally important evidence needed to successfully prosecute crimes against flora and fauna is provided through wildlife forensic investigation.

Discussion

In order to focus and summarize the findings associated with this project, suggested degree plans were chosen and Career + Major Planning Guides for Wildlife Forensic Chemist, Geneticist, and Morphologist with suggested degree paths and courses were created. The degree paths were created by using currently available and newly created degree plans at the University of Central Oklahoma. The degree paths may need to be reevaluated as new degree plans or courses are created in the future. The planning guides will be available on the UCO website for students and advisors to access and will bring awareness to the existence of these careers.

Achieving the student learning objectives while completing an undergraduate Forensic degree will prepare graduates with knowledge, skills, and abilities required for future careers in Wildlife Forensic Chemistry, Genetics, and Morphology. Soft skills for the

three Wildlife Forensic careers are similar and stress the importance of the ability to prepare written scientific information and clearly communicate the information to professionals in the wildlife forensic field, as well as nonprofessionals. Hard and soft computer skills and the ability to input/extract data into established databases was another important universal soft skill requirement. The majority, twenty-four out of the thirty-five, requirements for the three wildlife forensic careers in this project are met with teaching objectives, lessons, research projects, written/oral assignments, and labs from courses within the suggested degree plans. The remaining eleven requirements can be met by addition of the suggested short, middle, and long-term goals suggested in Figure 5.

The best solutions for strengthening the recognized weaknesses were determined by looking at each one individually. In some cases labs could provide hands-on experience to fill gaps, while other gaps would require changes to courses. These solutions were organized into how quickly they could be reasonably implemented. The suggested short (one year), middle (three year), and Long (five year) term goals were provided to improve the competitiveness of UCO graduates seeking entry level positions in the fields of Wildlife Forensic Chemistry, Genetics, and Morphology.

Recommendations for Future Research

Future research utilizing various surveys and additional studies could be done to ensure programs are designed to provide the education and skills sought by employers in the field. The best way to determine what attributes are needed in the workplace is to reach out to those working in and hiring for those positions. Conducting surveys of employees and or employers to determine the most beneficial education, skills, and abilities needed for different careers could help determine which short, middle, and long-term goals should be implemented. This project focused on three wildlife forensic lab positions. A future study

looking at wildlife forensic investigation careers could be done to ensure current curriculum aligns with the state, federal, and international job requirements. Including the international job requirements is important due to UCOs large international student population that will be seeking careers in their home country. Future studies looking at job descriptions specific to other types of wildlife, including the largest trafficked organisms like trees and fish could be conducted. Plants do not often come to mind when people think of wildlife crime, however crimes against plants can have a sizeable negative impact on the environment. Many students are unaware of the variety of environmental career options available. Especially when they arrive on campus as freshmen. A survey designed to match the interest of students with possible career opportunities could help students discover careers in wildlife forensics and other environmental careers. As technology advances and the way information is communicated evolves, universities should continually evaluate the effectiveness of their programs. The design of this project along with surveys of students, employers, and employees can be used in future projects to evaluate the effectiveness of other programs at meeting job requirements.

The establishment of education standards for Wildlife Forensic degrees by the Center for Wildlife Forensic Science and Conservation Studies (C-FACS) at the University of Central Oklahoma (UCO) or the Society for Wildlife Forensic Science (SWFS) would provide a guide for wildlife forensic programs and ensure consistency among accredited universities. Perhaps this study could be beneficial when creating these education standards.

Conclusion

This study found several ways dedicated administration and faculty at UCO could improve the necessary education, skills, and abilities that a student needs to be highly competitive when seeking a career in the wildlife forensic field. This includes implementing

suggested short, middle and long-term goals to fill gaps and improve wildlife forensic students' readiness for their career. Short-term goals like adding labs and/or new lessons to current courses can be implemented within the first year. Over the next three years suggested middle-term goals including adding new courses, advanced courses, and creating a laboratory course aspect for the Wildlife Forensic course can be incorporated into the program. Finally, five year long-term goals can be put in place where new degree plans can be created, the addition of a partner that can provide the needed experience for wildlife forensic certification, and the creation of a wildlife forensic degree that meets or surpasses requirements in the field of wildlife forensics. By implementing the suggested goals, the University of Central Oklahoma will create a wildlife forensic program that prepares graduates with the education, skills, and abilities sought by employers in the field.

By providing a program that produces qualified candidates for employers in wildlife forensics, both employers and graduates of the program will benefit. The trainee will potentially save the employer time and financial resources by requiring less training compared to less qualified candidates. The newly hired trainee will benefit from a quicker pace for acquiring required knowledge, skills, and abilities that lead to advancement. The time and money saved by hiring qualified candidates can be incorporated into furthering the goal of the organization that benefits wildlife. With a wildlife forensic program designed to meet job requirements in the shortest amount of time, the University of Central Oklahoma could benefit from the popularity of a successful wildlife forensics program that has satisfied students and graduates.

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