



Santa Clara University
University Operations
500 El Camino Real, Santa Clara, CA 95053

COOPERATIVE MANAGEMENT AGREEMENT

between

SANTA CLARA UNIVERSITY, 500 El Camino Real, Santa Clara, CA 95053

and

**GUADALUPE COYOTE RESOURCE CONSERVATION DISTRICT,
800 N. 1st Street, Suite 204, San Jose, CA 95112**

and

**LABORATORIES OF MOLECULAR ANTHROPOLOGY, AND MICROBIOME RESEARCH, UNIVERSITY OF
OKLAHOMA, 101 David L. Boren Boulevard, Norman, Oklahoma 73019**

Agreement No. _____

I. STATEMENT OF JOINT OBJECTIVES

A. Purpose

The purpose of this cooperative agreement is to develop and implement an ancient DNA sequencing protocol designed to determine the genetic similarity of historic and prehistoric elk (*Cervus canadensis*) in the south and west San Francisco Bay Region to contemporary populations of tule elk (*C. c. nannodes*) and Roosevelt elk (*C. c. roosevelti*) by sampling elk bone and antler specimens collected from local archaeological and museum collections. Although some of the specimens are dated by stratigraphic or radiocarbon dating.

Abundant archaeological and historical observer records, and several museum specimens confirm that elk were present historically in the Santa Cruz Mountains region, including the lands to the west and south of San Francisco Bay (McCullough¹)(CDFW 2018²).

¹ McCullough, Dale R., *The Tule Elk: Its History, Behavior, and Ecology*, University of California Publications in Zoology, Vol. 88 (Berkeley: Univ. of Calif. P, 1971), 88 (6).

² California Department of Fish and Wildlife (CDFW), *Elk Conservation and Management Plan* (California Department of Fish and Wildlife, December 2018), p. 481
<<https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=162912&inline>>

B. Benefits and Justification

This proposed cooperative agreement will provide interpretive data for the academic, professional, and public arenas in numerous disciplines, including biology, genetics, botany, and archaeology, hydrology, and natural resource management.

Natural resources management

California is the only North American state or province occupied by three elk (*Cervus canadensis*) subspecies: Roosevelt, Rocky Mountain (*C.c. nelsoni*), and tule (*C.c. nannodes*), the lattermost an endemic (Meredith et al. 2007³; CDFW 2018). California's elk occupy suitable habitat unevenly distributed both spatially and temporally, requiring maintenance of demographic and genetic connectivity to promote population persistence (Meredith et al. 2007; Batter et al. 2021⁴). Maintaining and improving landscape connectivity for tule elk populations is of particular importance. All contemporary tule elk are descended from as few as three individuals and possess low levels of genetic diversity (Sacks et al. 2016⁵; CDFW 2018). Although having rebounded to nearly 6,000 individuals to date, these genetically depauperate populations persist in a metapopulation format and, in the absence of connectivity, remain vulnerable to stochastic events that could lead to extinction of isolated populations (Newmark 1987⁶; Crooks et al. 2017⁷) or, at minimum, further inbreeding depression and lower fitness as well as reduced adaptability to changing environments (Williams et al. 2004; Frankham et al. 2017).

Specifically, this cooperative agreement seeks to determine which of California's three elk subspecies historically inhabited the south and west San Francisco Bay region, in order to guide re-introduction via translocation and/or improvement of wildlife linkages to enable range expansion and connection between fragmented populations.

³ Meredith, E. P., J. A. Rodzen, J. D. Banks, R. Schaefer, H. B. Ernest, T. R. Famula, and others, 'Microsatellite Analysis of Three Subspecies of Elk (*Cervus Elaphus*) in California', *Journal of Mammalogy*, 88.3 (2007), 801–8 <<https://doi.org/10.1644/06-MAMM-A-014R.1>>

⁴ Batter, Thomas J., Joshua P. Bush, and Benjamin N. Sacks, 'Assessing Genetic Diversity and Connectivity in a Tule Elk (*Cervus Canadensis Nannodes*) Metapopulation in Northern California', *Conservation Genetics*, 22.6 (2021), 889–901 <<https://doi.org/10.1007/s10592-021-01371-0>>

⁵ Sacks, Benjamin N., Zachary T. Lounsberry, Tatyana Kalani, Erin P. Meredith, and Cristen Langner, 'Development and Characterization of 15 Polymorphic Dinucleotide Microsatellite Markers for Tule Elk Using HiSeq3000', *Journal of Heredity*, 107.7 (2016), 666–69 <<https://doi.org/10.1093/jhered/esw069>>

⁶ Newmark, William D., 'A Land-Bridge Island Perspective on Mammalian Extinctions in Western North American Parks', *Nature*, 325.6103 (1987), 430–32 <<https://doi.org/10.1038/325430a0>>

⁷ Crooks, Kevin R., Christopher L. Burdett, David M. Theobald, Sarah R. B. King, Moreno Di Marco, Carlo Rondinini, and others, 'Quantification of Habitat Fragmentation Reveals Extinction Risk in Terrestrial Mammals', *Proceedings of the National Academy of Sciences*, 114.29 (2017), 7635–40 <<https://doi.org/10.1073/pnas.1705769114>>

II. PROJECT MANAGEMENT PLAN

A. Santa Clara University (SCU) agrees to:

1. Make available archaeological specimens of elk bone and/or antler specimens to serve as the subject sample for this project. Samples will be packaged for transport and will be shipped to Dr. Brian Kemp at the University of Oklahoma. A list of submitted specimens will be included as Appendix A.

B. The Guadalupe Coyote Resource Conservation District (GCRCDD) agrees to:

1. Reimburse the University of Oklahoma, upon receipt of proper billings, for such services, supplies, travel, and facilities in support of the objectives of this agreement, as mutually agreed upon by all parties.

C. University of Oklahoma, Dr. Brian Kemp agrees to:

1. Conduct of genetic and related laboratory analysis and procedures, data review and translation, and manuscript draft.
2. Act as central repository of obtained elk specimens, and coordinate radiocarbon dating with outside laboratories as required on specimens with adequate ancient DNA sequencing results
3. Arrange for return to appropriate museum and university collections any unused specimens or related materials (although the DNA analysis method is understood to be destructive in nature).

D. The GCRCDD, SCU and UNIVERSITY OF OKLAHOMA mutually agree that:

1. Research under this Agreement shall be jointly planned, designed and conducted and all data shall be collected, stored, and analyzed according to procedures that are to be developed and included in this agreement.
2. A SOW including a time-frame to complete specific project tasks shall be developed jointly between all parties.
3. A budget itemizing reimbursable costs shall be developed jointly between all parties, in an amount not to exceed \$20,000.00.
4. All parties (GCRCDD, SCU and University of Oklahoma) shall be given proper recognition in any published material, including co-authorship rights based on contribution levels consistent with generally accepted publication standards.
5. The parties will provide to each other copies of all materials, original photographs, and a complete copy of all generated paperwork.
6. All specimens remaining after the conclusion of destructive testing will be returned to the appropriate museum and university collections.

III. TERMS OF AGREEMENT

This Agreement shall become effective when executed by all signatories and shall remain in effect until June 30, 2024, at which time all parties will meet and assess the project status to determine if the agreement shall be extended.

GCRCD will work with respective museum and university collections to provide the faunal samples, prepare them for transport, and ship them to Dr. Kemp's laboratory at the expense of the GCRCD. All remaining tasks to complete this project will be funded by GCRCD.

IV. SCOPE OF WORK (SOW)

A. Design

A best case scenario would be to be able to "prove" or "confirm" that the faunal samples are in fact elk, with comparison to California's three contemporary elk subspecies. The aDNA analysis should determine the degree of similarity and whether the region's historic and prehistoric elk were intermediate, i.e. shared genetic traits of multiple contemporary elk subspecies. We will certainly test for subspecies identification, but for credibility's sake, we have set up various alternative hypotheses to take into account different results:

Hypothesis 1: Historic and prehistoric elk in the region most closely resemble today's tule elk genetics, as the latter occur today (via translocation) in closest proximity to the study region.

Hypothesis 2: Historic and prehistoric elk in the region most closely resemble today's Roosevelt elk genetics, the latter today inhabit coastal temperate rainforest most similar to much of today's study region.

Hypothesis 3: Historic and prehistoric elk in the region shared genetics of both Roosevelt and tule elk, with greater genetic variability than today's genetically depauperate tule elk.

B. Lab Work

The project involves the extraction, purification, and analysis of DNA from up to 20 archeological elk specimens. UNIVERSITY OF OKLAHOMA will decide which samples are adequate for ancient DNA sequencing and for radiocarbon dating (if not previously dated by stratigraphic or radiocarbon dating). Work is anticipated to be completed in two phases:

- The initial screening of mitochondrial DNA is the critical first step that will allow the parties: 1) to determine if DNA is preserved in the samples; and 2) determine if these specimens are of elk (i.e., that the specimens have been properly identified by zooarchaeological analysis based on their shape and form). (Estimated at \$300.00 per sample.)
- The second step involves analysis of nuclear DNA, which will permit the parties to assess the subspecies designation of the specimens and determine which, if any, were hybrids. Nuclear DNA analysis could take one or more of a few possible forms, and this decision will be made following determination of how intact is the preserved DNA in each specimen. The level of DNA degradation (with regards to how long are the recovered DNA molecules), will dictate the method of analysis. Importantly it's known that various short tandem repeat (STR) and single nucleotide polymorphism (SNP) markers can be used to address the questions posed by the research proposal, so it will be a future decision on how screen these markers in the most economical manner regarding time and resources. (estimated at \$620.00 per sample)
- Radiocarbon dating may be needed for approximately 20% of the samples. (Estimated at \$400.00 per sample.)

C. Report Preparation

University of Oklahoma will prepare a final report of the results of this project to SCU and GCRCD. This internal report will be the basis for co-writing a professional publication (e.g. journal article), which will include UNIVERSITY OF OKLAHOMA, SCU and GCRCD as coauthors as consistent with generally accepted publication standards. The article will integrate UNIVERSITY OF OKLAHOMA, and GCRCD and SCU research objectives as outlined above.

D. Curation (to be completed)

V. DELIVERABLES AND REPORTS

- A. Laboratory Analysis, Data Review and Translation, Manuscript Draft to be completed by University of Oklahoma

VI. FINANCIAL SUPPORT

- A. GCRCD will fund the project in an amount not to exceed 20,000.00. Costs per unit are estimated as follows:
- mitochondrial DNA testing estimated at \$300.00 per sample.
 - nuclear DNA testing estimated at \$620.00 per sample.
 - radiocarbon testing estimated at \$400.00 per sample.

VII. KEY OFFICIALS

Brian M. Kemp, Ph.D., Associate Professor bmkemp@ou.edu Department of Anthropology, and Laboratories of Molecular Anthropology and Microbiome Research University of Oklahoma 101 David L. Boren Blvd., Norman, OK 73019	Rick Lanman MD, Associate Director ricklanman@gmail.com Stephanie Moreno, Executive Director smoreno@gcrcd.org Guadalupe Coyote Resource Conservation District 800 N. First Street, Suite 204, San Jose, CA 95112
Linda Hylkema, MA, RPA Director, Cultural Resource Management lhylkema@scu.edu Santa Clara University University Operations 500 el Camino Real Santa Clara, CA 95053	

VIII. GENERAL PROVISIONS

Nothing in this agreement shall abrogate the statutory responsibility of authority of any party signatory to this non-competitive agreement.

This Agreement may be modified as necessary upon mutual written agreement. Without the written agreement of SCU, this agreement is not assignable by UNIVERSITY OF OKLAHOMA or GCRCD either in whole or in part.

UNIVERSITY OF OKLAHOMA and GCRCDC agree to indemnify and hold harmless each other's officers, agents, and employees from any and all claims, demands, costs, or liability arising from or connected with the services provided hereunder due to negligent acts, errors, or omissions of UNIVERSITY OF OKLAHOMA.

IN WITNESS THEREOF, THE PARTIES HERETO HAVE CAUSED THIS Agreement to be executed.

Lynda Hylkema, MS, RPA, Director, Cultural Resource Management
Santa Clara University

Stephanie Moreno, Executive Director
Guadalupe Coyote Resource Conservation District

Brian M. Kemp, PhD, Professor
University of Oklahoma

APPENDIX A
Catalogue of Specimens

DRAFT