New Hampshire Fish and Game Department

11 Hazen Drive, Concord, NH 03301-6500
Headquarters: (603) 271-3421
Website: www.WildNH.com

TDD Access: Relay NH 1-800-735-2964
Fax: (603) 271-1438
Email: info@wildlife.nh.gov

Scott R. Mason
Executive Director

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April 14, 2022

His Excellency, Governor Christopher T. Sununu
and the Honorable Council
State House
Concord, New Hampshire 03301

REQUESTED ACTION

Authorize the New Hampshire Fish and Game Department to enter into a **Sole Source** Cooperative Project Agreement with the University of New Hampshire (Vendor No. 315187), Durham, NH, in the amount of $312,404 to conduct a research project in support of moose management effective upon Governor and Council approval through June 30, 2025. 100% Federal Funds.

Funds are available in the following account for Fiscal Years 2022 and 2023, and are anticipated to be available in Fiscal Years 2024 and 2025, upon the continued appropriation of funds in the future operating budget with the authority to adjust encumbrances between fiscal years within the price limitation through the Budget Office, if needed and justified:

03 75 75 751520-21580000 - Wildlife Program - Game Management

	FY2022	FY2023	FY2024	FY2025
20-7500-21580000-304-500841 Research and Management	$49,563	$145,043	$107,276	$10,522

EXPLANATION

The Department proposes to enter into a Cooperative Project Agreement with the University of New Hampshire to conduct this research. Sole source is requested because of the University's past experience and success conducting moose research and working with the Department. The University will be conducting the work as a sub-recipient under an approved federal award from the Fish and Wildlife Service and is contributing the required non-federal matching funds for the federal funding received.

Moose are an iconic and ecologically and economically important species in New Hampshire. They are part of the functioning ecosystem and moose-related tourism, from viewers and hunters, generates substantial revenue for the state. However, the moose population has declined approximately 50% since 2000 resulting in reduced recreational opportunity and public concern over their population status. Recent research identified parasitism by winter ticks as the primary cause for moose population declines in northern areas of the state, and a primary factor influencing winter ticks is moose abundance (i.e. more moose, more winter ticks). Current and emerging methods for monitoring moose abundance need to be evaluated for informed management of this species moving forward.

Moose abundance is currently monitored using sighting rates by deer hunters (deer hunter survey) which was developed as an index of the moose population through research in 1998. The research correlated moose observations by deer hunters from a specific area of the state, and the total number of moose in that same area counted using an infrared aerial survey. This allowed a moose observation rate by deer hunters to be developed and act as an efficient index of the moose population. However, researchers cautioned that this relationship must be assessed and recalibrated periodically because changes in moose or deer hunters could alter the relationship. Unfortunately the deer hunter survey has not been calibrated since 1998 due to the high cost and scarcity of contractors to conduct aerial infrared surveys.

Two emerging methods that offer promise to recalibrate the deer hunter survey and offer an alternative technique for monitoring abundance are remote cameras and aerial infrared surveys using unpiloted aerial systems (UASs). Technological advancements have resulted in widespread adoption of trail cameras to monitor wildlife populations and moose are an ideal species for this method because their large size results in high detection rates. UAS surveys of wildlife populations have also become increasingly common due to technological advances in reliability and sensor capabilities. This represents an option to conduct infrared aerial surveys to calibrate other indices like the deer hunter survey and trail camera estimates. Although challenges exist (e.g., flight distance regulations). UASs represent an opportunity to survey moose aerially, at acceptable costs, without the danger of traditional flights.

It is clear that moose population abundance data is important for continued successful management. How to monitor New Hampshire's moose population effectively and accurately over broad spatial and temporal scales, given the uncertainty associated with the deer hunter survey, and the financial constraints of aerial surveys is a critical knowledge gap. This research will partner New Hampshire Fish and Game with the unique expertise of researchers at the University of New Hampshire who are leaders in the fields of monitoring wildlife with cameras and UAS surveys. End products will inform Fish and Game selection of a method to monitor moose abundance long-term and benefit all users by providing accurate data for management decisions.

Respectfully submitted,

Scott R. Mason
Executive Director

Kathy Ann LaBonte
Chief, Business Division

COOPERATIVE PROJECT AGREEMENT
between the
STATE OF NEW HAMPSHIRE, **Fish and Game Department**
and the
University of New Hampshire of the UNIVERSITY SYSTEM OF NEW HAMPSHIRE

A. This Cooperative Project Agreement (hereinafter "Project Agreement") is entered into by the State of New Hampshire, **Fish and Game Department**, (hereinafter "State"), and the University System of New Hampshire, acting through **University of New Hampshire**, (hereinafter "Campus"), for the purpose of undertaking a project of mutual interest. This Cooperative Project shall be carried out under the terms and conditions of the Master Agreement for Cooperative Projects between the State of New Hampshire and the University System of New Hampshire dated November 13, 2002, except as may be modified herein.

B. This Project Agreement and all obligations of the parties hereunder shall become effective on the date the Governor and Executive Council of the State of New Hampshire approve this Project Agreement ("Effective date") and shall end on **6/30/25**. If the provision of services by Campus precedes the Effective date, all services performed by Campus shall be performed at the sole risk of Campus and in the event that this Project Agreement does not become effective, State shall be under no obligation to pay Campus for costs incurred or services performed; however, if this Project Agreement becomes effective, all costs incurred prior to the Effective date that would otherwise be allowable shall be paid under the terms of this Project Agreement.

C. The work to be performed under the terms of this Project Agreement is described in the proposal identified below and attached to this document as Exhibit A, the content of which is incorporated herein as a part of this Project Agreement.

Project Title: **Developing and Evaluating Novel Techniques for Moose Monitoring in New Hampshire**

D. The Following Individuals are designated as Project Administrators. These Project Administrators shall be responsible for the business aspects of this Project Agreement and all invoices, payments, project amendments and related correspondence shall be directed to the individuals so designated.

State Project Administrator	**Campus Project Administrator**
Name: Kathy LaBonte	Name: Kimberly Becker
Address: NH Fish and Game Department 11 Hazen Dr. Concord, NH 03301	Address: University of New Hampshire/Keene Sponsored Programs Administation 229 Main St. Keene NH 03435
Phone: 603-271-2741	Phone: 603-358-2443

E. The Following Individuals are designated as Project Directors. These Project Directors shall be responsible for the technical leadership and conduct of the project. All progress reports, completion reports and related correspondence shall be directed to the individuals so designated.

State Project Director	**Campus Project Director**
Name: Dan Bergeron	Name: Remington Moll
Address: NH Fish and Game Department 11 Hazen Drive Concord, NH 03301	Address: University of New Hampshire Natural Resources James Hall Rm 266 Durham, NH 03824
Phone: 603-271-1439	Phone: 603-862-3054

Campus Authorized Official KJ
Date 4/1/22

F. Total State funds in the amount of **$312,404** have been allotted and are available for payment of allowable costs incurred under this Project Agreement. State will not reimburse Campus for costs exceeding the amount specified in this paragraph.

Check if applicable

☒ Campus will cost-share **25 %** of total costs during the term of this Project Agreement.

☒ Federal funds paid to Campus under this Project Agreement are from Grant/Contract/Cooperative Agreement No. **F22AF00929 (W-114-R-1)** from **Department of Interior / Fish and Wildlife Service** under CFDA# **15.611**. Federal regulations required to be passed through to Campus as part of this Project Agreement, and in accordance with the Master Agreement for Cooperative Projects between the State of New Hampshire and the University System of New Hampshire dated November 13, 2002, are attached to this document as Exhibit B, the content of which is incorporated herein as a part of this Project Agreement.

G. Check if applicable

☐ Article(s) of the Master Agreement for Cooperative Projects between the State of New Hampshire and the University System of New Hampshire dated November 13, 2002 is/are hereby amended to read:

H. ☒ State has chosen **not to take** possession of equipment purchased under this Project Agreement.
☐ State has chosen **to take** possession of equipment purchased under this Project Agreement and will issue instructions for the disposition of such equipment within 90 days of the Project Agreement's end-date. Any expenses incurred by Campus in carrying out State's requested disposition will be fully reimbursed by State.

This Project Agreement and the Master Agreement constitute the entire agreement between State and Campus regarding this Cooperative Project, and supersede and replace any previously existing arrangements, oral or written; all changes herein must be made by written amendment and executed for the parties by their authorized officials.

IN WITNESS WHEREOF, the University System of New Hampshire, acting through the **University of New Hampshire** and the State of New Hampshire, **Fish and Game Department** have executed this Project Agreement.

By An Authorized Official of:
University of New Hampshire
Name: Karen M. Jensen
Title: Director, Pre-Award Compliance
Signature and Date: Karen Jensen 4/1/2022

By An Authorized Official of:
NH Fish and Game Department
Name: Scott R. Mason
Title: Executive Director
Signature and Date: Scott R Mason 4/18/22

By An Authorized Official of: the New Hampshire Office of the Attorney General
Name: Joshua Harrison
Title: Asst Atty General
Signature and Date: 5/16/2022

By An Authorized Official of: the New Hampshire Governor & Executive Council
Name:
Title:
Signature and Date:

Campus Authorized Official KJ
Date 4/1/22

EXHIBIT A

A. Project Title: Developing and Evaluating Novel Techniques for Moose Monitoring in New Hampshire

B. Project Period: May 1, 2022 – June 30, 2025

C. Objectives: The overarching goal of this proposed project is to develop and evaluate novel noninvasive methods, camera traps and unpiloted aerial system (UAS) surveys, for monitoring moose abundance and assess the accuracy of the current method, sighting rate by deer hunters.

Objective 1. To estimate moose density using camera trap data.

Objective 2. To develop an efficient moose monitoring technique using unpiloted aerial systems (UASs).

Objective 3. To estimate moose density using UASs.

Objective 4. To quantify moose-habitat relationships and produce spatially explicit predictions of moose density.

Objective 5. To compare moose density estimates from camera traps and UASs with those obtained by deer hunter surveys.

D. Scope of Work:

Objective 1. To estimate moose density using camera trap data.
Approximately 140 sites will be established throughout the study area using a Generalized Random Tessellation Stratified design, which results in a spatially random and balanced sampling scheme (Stevens and Olsen 2003, Moll et al. 2018). To maximize efficiency, sites will be established in clusters of 7-10, with sites within a cluster separated by approximately 1-2 km, with adjustment allowable according to prevailing landscape features that limit accessibility. Each of the 11 WMUs will receive at least one cluster of cameras, and the larger WMUs (A2, D2, F) will receive two clusters each. This spatial study design represents a trade-off in maximizing efficiency while reasonably meeting the assumptions of the statistical modeling procedures (Nakashima et al. 2018, Gilbert et al. 2020, Loonam et al. 2021).

In the summer of 2022, a motion-triggered camera trap will be deployed at each site using previously established methods, camera models, and camera settings shown to optimize detection rates (Moll et al. 2018, 2020, Lepard et al. 2019). The camera will be placed at approximately knee-height (50 cm) and affixed to a tree or other suitable vegetation. The camera trap will record images of wildlife passing in front of it. After the initial installation, cameras will be maintained in the spring and fall each year. Maintenance will involve adjusting camera height to maintain 0.5 m above ground or snow level, collecting data from the previous 6 months, and refreshing batteries.

The summer image data will be used to fit a Random Encounter model to estimate species density (Nakashima et al. 2018, Garland et al. 2020). This data collection process will also contribute to a

paired ongoing collaborative research effort between NHFG and UNH to monitor furbearers. The data collected during the winter period will be used to estimate moose density at each site via time-to-event modeling (Moeller et al. 2018, Loonam et al. 2021). These estimates of moose density at each camera, will be used in spatial models to evaluate the effects of environmental covariates and make spatial predictions of moose density across the landscape (see Objective 4 below).

In addition, a protocol will be developed for data analysis that will enable efficient image data processing for monitoring wildlife beyond the timeframe of this proposal using programs such as Timelapse (https://saul.cpsc.ucalgary.ca/timelapse) and the Microsoft Megadetector artificial intelligence program (https://github.com/microsoft/CameraTraps). This protocol will include analysis scripts written in the R programming language that can fit population density models to the processed camera trap image data (R Core Team 2017). In addition to scripts related to population density models, scripts that provide important population health and demographic data (such as calf:cow ratios and adult bull:cow ratios) will be considered.

Objective 2. To develop an efficient moose monitoring technique using UASs.
In the winter of 2022-2023, initial UAS surveys will be conducted in three WMUs: A2, B, and C1. These WMUs will be targeted due to relatively high moose densities and suitable vehicle access. Each survey will involve flying a UAS, which is equipped with infrared and optical sensors, 100 m above ground level in parallel transects spaced apart 150 m to cover 1.7 km2 (170 ha) of ground area surveyed by the sensors. Surveys will primarily be based off roads or snowmobile trails, but some surveys will also be completed away from roads/trails to investigate this influence of this factor. UAS operation will comply with Federal Aviation Administration regulations.

The surveys will use a single UAS equipped with two thermal Forward Looking Infrared (FLIR) sensors and one optical Red-Green-Blue (RGB) sensor. This dual-FLIR sensor system will be used to detect the thermal signatures from moose, which will provide a local density estimate that accounts for moose sightability, which is the probability that a moose is present in the survey unit but not detected by the UAS (McMahon et al. 2021). The RGB camera will be used to collect overlapping geolocated images. These images will be used to develop an overall canopy closure amount and a map of deciduous and coniferous regions which will improve our ability to discern visible and hidden moose probability. These RGB images will also be used to take stills from the FLiR video to develop a thermal image that is geolocated.

UAS surveys will proceed as often as weather allows over a six-week period, with a target of 40 survey units. The initial UAS survey data will be analyzed by reviewing video from the UAS and double-observer statistical models that account to quantify moose sightability (Arnason et al. 1991, Kantar and Cumberland 2013). Spatial covariates previously shown to influence moose sightability in FLIR drone surveys will inform this model, such as cloud cover, forest composition, and canopy closure (McMahon et al. 2021). These initial drone surveys will result in optimized protocols for subsequent UAS surveys and a sightability curve to account for the imperfect detection of moose as a function of environmental conditions and habitat.

Objective 3. To estimate moose density using UASs.
For the winter of 2023-2024, UAS surveys will be designed and conducted to maximize aerial coverage based upon the analysis of the initial UAS surveys in the previous year (e.g., by adjusting flight speed, UAS height, and survey pattern). These UAS surveys will be conducted by two teams employing identical protocols to maximize coverage across the three WMUs (A2, B, and C1), with a target of 30 survey units per WMU (90 survey units total). The resultant data will be analyzed using

the methods described above and will produce spatially explicit moose density estimates for each survey unit.

Objective 4: To quantify moose-habitat relationships and produce spatially explicit predictions of moose density.
The output from Objectives 1 and 3 will be spatially explicit moose density estimates for each camera site and UAS survey unit. These estimates will then be used in a spatial modeling procedure to extrapolate predictions of moose density to all WMUs throughout the study area. To do so, spatially-explicit generalized linear models will be fit to density estimates in a hierarchical Bayesian framework (Kéry and Royle 2015, Nakashima et al. 2018, Loonam et al. 2021). These spatial models will include a suite of environmental covariates hypothesized to influence moose density, including but not limited to elevation, distance to roads, forest composition and configuration, and distance to optimal forage vegetation (i.e., young or recently cut forests; Millette et al. 2014, Andreozzi et al. 2016). The models will also control for potential nuisance variables such as snow depth and temperature. The result of this analysis will be moose density heat maps that extend across the study area. The desired accuracy and uncertainty for moose population density estimates is a 90% confidence interval that has an uncertainty of ±25% of the mean estimate (Gasaway et al. 1986).

Objective 5. To compare density estimates from camera traps and UASs with those obtained by deer hunter surveys.
The density estimates provided by the camera and UAS methods described above will be compared to indicators of moose density as provided by the current method used to inform management, namely, the number of moose observed by deer hunters. This comparison will take the form of a generalized linear regression and will be conducted at two spatial scales (each WMU and each moose management region) and across both years (winters of 2022-2023 and 2023-2024).

E. **Deliverables Schedule:** Campus shall submit quarterly progress reports in a format acceptable to the State and due within 30 days of the end of each calendar year quarter. Reports shall include a comparison of actual accomplishments during the reporting period against the established project objectives, and include any significant developments that either result in problems, delays, or adverse conditions or which favorably impact the project. Campus shall submit an overall final report detailing activities and results of the project no later than 60 days after the Project Period end date (06/30/25). The final report shall also include: camera trap locations and media; GIS layers depicting moose located with sensors on the UAS; spatially explicit moose density estimates for each camera site and UAS survey unit; sightability curve to account for the imperfect detection of moose by sensors on the UAS as a function of environmental conditions and habitat; spatially-explicit generalized linear models for both camera traps and UAS surveys using habitat and detection covariates fit to density estimates; comparison of camera trap, UAS, and deer hunter survey moose density estimates. Campus shall also provide the State with any graduate thesis completed as a result of the project. Any articles, publications, or media regarding the project and project results shall reference the funding support provided by the New Hampshire Fish and Game Department and the Wildlife Restoration program under federal grant F22AF00929 (NH W-114-R-1).

F. **Budget and Invoicing Instructions:** Campus will submit invoices to State on regular Campus invoice forms no more frequently than monthly and no less frequently than quarterly. Invoices will be based on actual project expenses incurred during the invoicing period, and shall show current and cumulative expenses by major cost categories. Invoices shall also document eligible cost share recorded during the period by category (e.g. PI salary, fringe, and cost share portion of F&A), as well as cumulative cost share through the end of the invoicing period. Campus shall provide supporting documentation for the amount of any invoiced payment requests and matching costs upon

request by State, which may include invoices for supplies, equipment, or services, and reports of personnel, travel, and Facilities and Administration (indirect) costs. State will pay Campus within 30 days of receipt of each invoice. Campus will submit its final invoice not later than 60 days after the Project Period end date. Payment of final invoice shall be contingent upon receipt of deliverables and the final report.

Acquisition of small Unmanned Aerial System (sUAS) equipment with project funds must be from the approved list provided by U.S. Department of Defense, Defense Innovation Unit (DIU) "Blue sUAS project. Campus shall request prior approval for purchase of any item of equipment with cost of $5,000 or more.

Budget Items	State Funding	Cost Sharing	Total
1. Salaries and Wages	109,659	49,419	159,150
2. Employee Fringe Benefits	10,602	18,609	29,211
3. Travel	7,500	0	7,500
4. Supplies and Services	63,553	0	63,533
5. Equipment	36,000	0	36,000
6. Facilities and Admin Costs	85,090	36,139	121,229
Subtotals:	312,404	104,239	416,643
Total Project Costs:			416,643

Budget Justification Narrative

1. Salaries and Wages: $109,659
   The budget provides 1.5 months per year for each of two years for a Research Scientist in Dr. Palace's research group (Franklin Sullivan) who will lead UAS operations. The budget also provides 0.5 months of total summer support for Dr. Palace and 0.75 months of total summer support for Dr. Moll.

   The budget provides two academic years and two summers of sponsor support for a M.S. student (Level 1) who will be responsible for conducting the proposed work under the supervision of the PI Dr. Remington Moll. The graduate student stipend is based upon the current University of New Hampshire Rate Sheet.

   The budget provides for 1,400 hours of undergraduate research technician support over the three-year period to assist with field and image and video data analysis efforts at a rate of $12/hour. Roughly, this supports one technician for initial UAS surveys, two technicians for year two UAS surveys, and two technicians for camera field work and image processing.

2. Fringe Benefits: $10,602
   Fringe benefits will be charged according to UNH's current federally-approved benefits rates for the project period, at the "partial fringe benefits" rate for faculty and graduate student summer salary, and at the "full fringe benefits" rate for other full-time staff. Rates are 37.6% for full benefits, and 7.9% for partial benefits.

3. Travel: $7,500
   The travel value reflects travel required to visit study sites to conduct camera and UAS field work over three years (~12,000 miles at the current UNH mileage rate of $0.585/mile). The budget also provides $500 for travel and fees to offset costs for conferences (e.g., North American Moose Conference, the Wildlife Society Conference).

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4. Supplies & Services: $63,553
The budget provides for 140 camera traps (at a rate of ~$170 per camera) and associated supplies, including batteries, lock boxes and python cables (at a rate of ~$60 per site). The budget also provides for field gear associated with camera deployment. The budget also provides for field gear associated with camera deployment, including replacement supplies – total $1700.

The budget provides $1,000 for page charges for peer-reviewed publications in Year 3.

The proposed tuition covers costs credit hours, health care, and fees for a graduate student based upon the current University of New Hampshire Rate Sheet over two years.

5. Equipment: $36,000
The budget provides for a professional-quality unpiloted aerial system (UAS) with a thermal and red-green blue sensors. The proposed model is a FREEFLY Alta X with a FLIR Thermal Sensor, plus the required associated batteries and flight gear.

6. Facilities and Administrative Costs: $85,090
Facilities & Administrative (indirect) costs are calculated according to UNH's current negotiated rate agreement with the Federal government. For the proposed budget, an on-campus rate with a Modified Total Direct Costs base is applied. The applicable fiscal year rates, as shown on our Federal agreement are 50.5% (7/1/20-6/30/21) 51.5% (7/1/21-6/30/22), 52.5% (7/1/22-6/30/23), and 53.5% (7/1/23-until amended). As this project crosses fiscal years a composite rate is applied. The US Department of Health and Human Services is UNH's cognizant federal agency.

Matching funds will be provided from the PI and Co-PI's salaries plus UNH fringe rates and associated indirect costs (F & A). These funds include 0.55 months/year of Dr. Moll's salary and 0.89 months/year of Dr. Palace's salary. Total match funds $104,643.

Campus Authorized Official KJ
Date 4/1/22

EXHIBIT B

This Project Agreement is funded under a Grant/Contract/Cooperative Agreement to State from the Federal sponsor specified in Project Agreement article F. All applicable requirements, regulations, provisions, terms and conditions of this Federal Grant/Contract/Cooperative Agreement are hereby adopted in full force and effect to the relationship between State and Campus, except that wherever such requirements, regulations, provisions and terms and conditions differ for INSTITUTIONS OF HIGHER EDUCATION, the appropriate requirements should be substituted (e.g., OMB Circulars A-21 and A-110, rather than OMB Circulars A-87 and A-102). References to Contractor or Recipient in the Federal language will be taken to mean Campus; references to the Government or Federal Awarding Agency will be taken to mean Government/Federal Awarding Agency or State or both, as appropriate.

Special Federal provisions are listed here: ☐ None or **Uniform Requirements for Federal Awards issued by the Office of Management and Budget (OMB) at 2 CFR Part 200 in lieu of Circulars listed in paragraph above. See 200.216 Prohibition on certain telecommunications and video surveillance services or equipment, as applicable to this project. The federal regulations applicable to Department of Interior, Fish and Wildlife Service recipients, subrecipients and contracors are icorporated by reference and are listed by recipient type in the Service Financial Award Terms and Conditions posted on the Internet at http://www.fws.gov/grants/** .

Campus Authorized Official KJ
Date 4/1/22