SEPT 23, 2016

Steven C. Pennings
University of Houston
Department of Biology and Biochemistry
34455 Cullen Blvd. Suite #342
Houston, TX 77204-5001

Re: Letter of Acknowledgement (LOA) for Research on the Effects of Feral Horses on Salt Marshes, Cumberland Island, Camden County, Georgia

Dear Mr. Pennings,

This Letter of Acknowledgment (LOA) is in response to your request, received August 29, 2016, for authorization to perform a long-term horse exclosure experiment within jurisdiction of the Coastal Marshlands Protection Act (CMPA) on Cumberland Island. The research project will investigate the effect of horse grazing on multiple ecosystem properties. According to your request, eight (8) grazing-exclosure plots (4m x 4m) will be will be randomly distributed within the mid-marsh Spartina alterniflora zone. Four (4) pine posts approximately 4in x 4in. extending up to 5ft. above the marsh grade will be installed for each exclosure plot. Up to four (4) post will be installed for paired control plots and will extend up to 3ft. above the marsh grade. There will be no more than 64 posts installed for the entire project. At the conclusion of the experiment, all new posts will be removed or cut flush with the marsh surface. The project will begin in October 2016 and will be completed no later than 2021.

The Department acknowledges the feral horse research as described in the submitted request and has no objection to the action provided Best Management Practices (BMP’s) are used. Any deviations from the submitted project scope and description may require further review. Upon completion of the proposed project all research material must be removed from jurisdiction and disposed of at an appropriate upland disposal area.

This LOA does not relieve you from obtaining any other required federal, state, or local permits. Tidal water bottoms and marshlands of coastal Georgia are public trust lands controlled by the State, except for such lands where a validated Crown Grant or State Grant exists. If you have any questions you may contact Skye Stockel at (912) 262-3127.

Sincerely,

Karl Burgess
Program Manager
Marsh and Shore Management Program

Enclosures: Description and Location Map
File: LOP20160196
Research proposal – Cumberland Island, GA

Investigation into the effects of feral horses on the Ecosystem Properties of a salt marsh through grazer exclusion.

Investigators
Ms Kate Davidson¹, Dr John Griffin¹, Prof. Steven Pennings², Prof. Elizabeth King³
¹Swansea University, UK, ²University of Houston, ³University of Georgia

Contacts: davidsonke@hotmail.co.uk; j.n.griffin@swansea.ac.uk; spennings@uh.edu; egking@uga.edu

Summary
Salt marshes provide valuable Ecosystem Services such as coastal protection, climate regulation, habitat provision, recreational space and pasturage. Grazing by livestock can profoundly alter the properties of these habitats (He & Silliman, 2016) with potential consequences for ecosystem functioning and service provision. Previous investigations on Cumberland island have confirmed that the feral horse population has a significant impact on the saltmarsh plant community (Dolan 2002, Turner 1987) but in these experiments grazing was either excluded for a short duration of 4-5 months (Dolan 2002) or was replicated by clipping and trampling (Turner 1987). Additionally, little or no evidence has been collected on the impact to soil properties and fauna. We plan to initiate a long-term horse enclosure experiment with a BACI (Before-After, Control-Impact) design, to investigate the effect of grazing on multiple ecosystem properties. These data will allow us to determine trade-offs between grazing and other Ecosystem Services. We will also conduct a disturbance-recovery experiment, to assess how grazing affects saltmarsh resilience.

Plan
Overview and timings
KD will visit Cumberland Island in October 2016 to set-up the grazing exclosures and take initial measurements (Table 1) from the experimental exclosures and paired control plots. She will return in October 2017 to resample the response variables and will also initiate a disturbance-recovery experiment. She will return again in October 2018 to resample variables following 2 years of grazing enclosure, and measure the results of the disturbance-recovery experiment. Throughout this period, SP and EK may also undertake investigations into properties not being measured by KD. Although the initial duration of this experiment is for 2 years (the timeframe of KD’s PhD), it is hoped that this may be extended to 3 or 4 years, under the supervision of JG, SP and EK, to allow long-term effects to materialise. The experiment will be terminated in 2021 at the latest.

Study design (Update: following consultation with National Park staff we intend to use Design A)
8 grazing-exclosure plots (4m x 4m) will be created using posts and barbed wire, each with a paired control grazed plot. Under Design A (we would prefer this design because statistical independence of replicates can be assured, but it will require permission to install new posts) experimental plots will be randomly distributed within the mid-marsh Spartina alterniflora zone. This design would use four 10 x 10cm (4 inch) pine posts each for exclosures (posts extending 4-5 feet above the ground) and 2-4 posts for controls (extending 2-3 feet above the ground), for a total of 48-64 posts. Under Design B, experimental plots will be located within the existing 40m x 40m enclosure area created by Dolan (2002) in the middle marsh site with paired control plots outside this area (Fig. 1). This design would not require any new posts to be installed, because the location of all plots could be determined by measuring from the existing posts, and barbed wire would be strung from existing posts. At the conclusion of the experiment, all new posts will either be removed or cut flush with the marsh surface. Exact location of plots will be decided in consultation with National Park staff.
Fig 1. Design of paired grazing exclosure (blue, n=8) and grazing control (red, n=8) 4m x 4m plots. In Design A, exclosure plots are distributed randomly in the mid-marsh S. alterniflora zone; in Design B, all experimental plots are located within a single existing 40m x 40m grazing exclosure.
### Data to be collected

**Table 1.** Response variables to be measured in experimental and control plots (n=8 each) after 0, 1 and 2 years of grazing exclusion.

<table>
<thead>
<tr>
<th>Response variable</th>
<th>Method</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canopy height</td>
<td>Average of 25 randomly placed measurements per plot; non-flowing stems only.</td>
<td>Canopy height can be used as a proxy for grazing pressure and is a good measure for aboveground biomass (AGB). Reductions in height and AGB have potential consequences for wave attenuation, carbon cycling, accretion rate, invertebrate and vertebrate communities.</td>
</tr>
<tr>
<td>Stem density</td>
<td>Count of stems within 6 randomly placed 0.3x0.3m squares</td>
<td>Possible effects on stem density may lead to changes in sedimentation patterns and alterations to wave attenuation efficacy.</td>
</tr>
<tr>
<td>Flowering</td>
<td>Count of flowers heads within 3, 1mx1m squares</td>
<td>Grazing may lead to reduced flowering and reduction in ability to colonise bare ground.</td>
</tr>
<tr>
<td>Litter biomass</td>
<td>Removal of all plant litter within 1x1m</td>
<td>Removal of AGB likely to lead to reduced litter biomass, with consequences for carbon cycling and detritivores.</td>
</tr>
<tr>
<td>Plant community composition</td>
<td>Percentage cover of each species within plot</td>
<td>Evidence from Dolan (2002) that grazing reduces <em>S. alterniflora</em> cover. Grazing may reduce inter-specific competition and lead to increased species richness.</td>
</tr>
<tr>
<td>Root biomass</td>
<td>3, 15 cm (width) x 30 cm (depth) soil cores per plot</td>
<td>Current conflicting evidence of grazing causing increases or decreases to root biomass.</td>
</tr>
<tr>
<td>Soil carbon</td>
<td>3, 15 cm (width) x 30 cm (depth) soil cores per plot</td>
<td>Removal of AGB, reduction of litter input, alterations to sedimentation patterns and changes to soil composition are likely to impact on carbon cycles.</td>
</tr>
<tr>
<td>Bulk density</td>
<td>33, 15 cm (width) x 30 cm (depth) soil cores per plot NB. Above 3 variables all from same set of 3 cores.</td>
<td>Trampling from animals is likely to compact soil, with consequences for nutrient cycling, water infiltration and marsh accretion rate.</td>
</tr>
<tr>
<td>Water infiltration rate</td>
<td>Timed infiltration of a set volume of water from a cylinder</td>
<td>Compacted soil is likely to absorb water more slowly. A slower water infiltration rate is associated with a flood risk.</td>
</tr>
<tr>
<td>Sediment deposition rate</td>
<td>3 x filter paper traps per plot over 2 tidal cycles (see Nolte et al 2013)</td>
<td>Changes to vegetation height, cover and density may lead to alterations in sediment deposition rate, with consequences for vertical accretion and carbon accumulation.</td>
</tr>
<tr>
<td>Vertical accretion rate</td>
<td>Artificial marker horizon set out over 1x1m (see Nolte et al 2013)</td>
<td>Compaction of soil and changes in AGB and root biomass may lead to a reduced accretion rate, impairing marsh ability to track seal-level rise.</td>
</tr>
<tr>
<td>Invertebrate abundance and diversity</td>
<td>Visual counts of large invertebrates, sweep-netting and pit-trapping for smaller invertebrates. Analyse effects by functional group.</td>
<td>Changes to soil structure, vegetation community composition, and reductions in AGB is likely to impact significantly on invertebrate community.</td>
</tr>
<tr>
<td>Ribbed mussel density</td>
<td>Number of mussel mounds and individual mussels (visible at surface) in each plot.</td>
<td>Mussels affect biodiversity and ecosystem functions (Angelini et al. 2015) and ecosystem resilience.</td>
</tr>
<tr>
<td>Marsh periwinkle density and size distribution</td>
<td>Count all individuals in 6 randomly placed 0.3x0.3m squares. Remove all individuals from 3 of these for length measurement.</td>
<td>Periwinkles (<em>Littoraria irrorata</em>) affect Spartina biomass (Silliman and Ziem 2001) and may compound effects of livestock grazing.</td>
</tr>
</tbody>
</table>
Crab densities | Estimate density of fiddler crabs, omnivorous crabs (Sesarma, Armases) and predacious crabs (Eurytium, Panopeus). | These species are ecosystem engineers and engage in important interactions (e.g., mud crab suppress periwinkle density); they are also likely to be sensitive to livestock grazing.

**Disturbance-recovery experiment**

We will investigate how grazing affects saltmarsh resilience by simulating disturbance to 1x1m subplots within each experimental plot. This experiment would be initiated 1 year after grazers had been excluded, and vegetation recovery assessed 1 year following disturbance. The details of this are yet to be decided, but potential sources of disturbance include wrack deposition, herbivore damage, and hypersalinity. We would welcome input from stakeholders on the most relevant sources of disturbance in the local area.

**References**


Sapelo Research Application Form

Research Application ID: GCE-80-2016 (submitted: 08/10/2016, status: approved)

Provide a brief title for web display

Effects of feral horses on the ecosystem properties of Cumberland Island salt marshes

Investigator Information

**On Island Sponsor:** GCE SINERR UGAMI GADNR

**principal Investigator:**

Steven C. Pennings

**Home Institution:** University of Houston

**Award Information:** Collaborators from England have modest graduate student support for this project.

**Mailing Address:**

Department of Biology and Biochemistry

University of Houston

Houston, Texas 77204-5513

**Phone Number:** (713) 743-2989

**E-mail Address:** scpennin@central.uh.edu

**Co-Investigators:** Elizabeth King (University of Georgia)

Briefly describe the project goals and methodology

We will exclude horses from 8 replicate 4 x 4 m plots in areas dominated by Spartina alterniflora to assess impacts of horse grazing on multiple aspects of salt marsh function and structure. Attached file has experimental details. All work will be done on Cumberland Island.

Where will the project be located?

Cumberland Island, Georgia. Exact location of plots to be determined in consultation with National Park Service personnel.

How will you provide GPS coordinates for study sites?

I will provide a provisional map and arrange with my sponsor to collect and register GPS coordinates.

What are the expected start and end dates of the project?

**Start Date:** 10/18/2016 **End Date:** 10/30/2021

How many people will access the site and at what frequency?

Up to 4 people will visit the site up to three times a year for 1-5 days on each sampling period.

Please check keywords (as many as are appropriate) that describe your project

**Jurisdictional criteria for permitting**

[X] upland habitat

[X] marsh habitat

[X] beach and dune habitat

[X] water column habitat

[X] submerged habitat

[X] Blackbeard Island

[X] observation only

[X] short term deployment (<24 hr)

**Study theme**

[X] testing

[X] Panopeus

[X] Eurytunum

[X] Callinectes

[X] Fundulus

[X] virus

[X] bacteria

[X] archaea

[X] fungi

[X] other

[X] turbidity

[X] water flow

[X] weather

[X] anthropology

[X] atmospheric science

[X] bacterial productivity
<table>
<thead>
<tr>
<th>Organisms</th>
<th>Habitat type</th>
<th>Likely long-term impacts of the study</th>
</tr>
</thead>
<tbody>
<tr>
<td>[X] Spartina</td>
<td>- water column/neritic</td>
<td>- fertilization</td>
</tr>
<tr>
<td>[ ] Juncus</td>
<td>- mud flat</td>
<td>- genotype introduction</td>
</tr>
<tr>
<td>[ ] Iva</td>
<td>- oyster reef</td>
<td>- chemical application</td>
</tr>
<tr>
<td>[ ] Salicornia</td>
<td>- marsh</td>
<td>- major soil modification</td>
</tr>
<tr>
<td>[ ] Borrichia</td>
<td>- beach</td>
<td>- altered hydrology</td>
</tr>
<tr>
<td>[ ] Zizanopsis</td>
<td>- forest</td>
<td>- permanent structure installation</td>
</tr>
<tr>
<td>[X] Littoraria</td>
<td>- freshwater wetlands</td>
<td>- tree removal</td>
</tr>
<tr>
<td>[X] Geukensia</td>
<td>- atmosphere</td>
<td>- [X] no long-term impacts</td>
</tr>
<tr>
<td>[X] Melampus</td>
<td>- subterranean</td>
<td></td>
</tr>
<tr>
<td>[X] Uca</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**What equipment will be deployed in the field?**

Horses will be deployed with barbed wire fences in consultation with NPS personnel at Cumberland Island. See attached file for details.

**Will plants or animals be collected as part of this study?**

Plants and invertebrates will be collected from plots under the UGAMI collecting permit covering Steven Pennings and collaborators.

**What are the likely impacts of the project on the site?**

During the experiment, we expect plants to grow better due to reduced grazing. After the experiment, the plots will return to conditions typical of the site.

**Will the project design include boardwalks? If not, explain why not.**

No. These will not be needed because we will visit the site only a few days per year.

**How long will impacts persist after the research is concluded?**

We expect that horses will rapidly graze the plots once fencing is removed. We expect that any trails that we make will recover within one year.

**What GCE-LTER research objective will this study address?**

Not specified

**Files attached to this application**

GCE-06-2016_Documents_Mammal_experiment_proposal_KD_XG_SP.docx (MS Word file, 861.08 kb, submitted 08/10/2016)

**Attach additional files to this application**

Approved Permits (e.g. DNR Letter of Permission file, FWS Permit)

GPS location data (e.g. uncorrected GPS data files for post-processing)

Maps or other files (e.g. Google Earth files, ESRI shapefiles, study description, photos, reports)