Presidential Faculty/Student Collaboration and Publication Grant
Deadline Monday, February 24th

Please use this checklist and budget. Include with your completed application. For more information about Presidential Faculty/Student Collaboration and Publication grants, please see https://gustavus.edu/kendallcenter/grant-opportunities/presidential-grant.php.

FACULTY INFORMATION

Name: Jon Grinnell
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Department: Biology
Rank: Associate Professor

STUDENT INFORMATION

Name: Anthony Massaro
Email: amassaro@gac.edu

Major(s): Biology
Graduation Year: 2016

CHECKLIST

Project Details

- ✓ Brief description of the proposed project including its collaborative nature
- ✓ Clear statement of anticipated outcomes
- ✓ Likely placement for publication or performances
- ✓ Anticipated research completion date

Participant Details

- ✓ Names and brief biographies of all participants
- ✓ Explanation of how this project fits into the career of the faculty member
  Note: Applications from faculty at all career stages are encouraged
- ✓ Explanation of how this project fits into the educational trajectory of the student
  Note: Statement should be written by the student; include year of graduation; student eligibility is limited to full-time returning students

- ✓ **Presidential Budget Proposal Form**

- ✓ If successful, my proposal can be used as an example to assist future applications. Check to give permission. This decision will not influence the application evaluation.

Submit electronically as a PDF to cblaukat@gustavus.edu at the John S. Kendall Center for Engaged Learning.

Using behavior and DNA to keep bison wild
Jon Grinnell, Biology
Tony Massaro (Biology, 2016)

Brief description of proposed project

The Problem

Bison almost went extinct in the late 1800s as hunting drove their numbers from the tens of millions to less than 1000 (Gates et al. 2010). Happily, there are now lots of bison in North America again (400-500,000) but (unhappily) the vast majority of them exist in small private herds of less than 400 adults on relatively small acreage (Sanderson et al. 2008). Thus, these populations need to be managed to avoid a) overpopulation (bison are prolific breeders), and b) inbreeding (they can no longer move themselves from one herd to another). Owners recognize that they must manage populations and have proposed guidelines to keep bison "wild" (Lammers et al. 2013) but have rarely tracked the behavior of individuals in the herd to be managed (Berger & Cunningham 1994; Lott 1991; Wolff 1998) and never combined knowledge of individuals' behaviors with their known success at reproducing. If not done thoughtfully and informed by data, bison management can lead to the loss of wild behaviors and genes from a bison herd. For example, managers often sell bulls once they reach 7 years (Ungerer et al. 2013), in part because the natural competitive behaviors of these older bulls make them harder to work with. This artificial selection could eventually result in a "pacification" of bison, and is one step towards domestication (Lott 2002). Another reason older bulls are sold is out of concern that they could mate with their grown daughters. However, bison owners typically know very little about what goes on in their herd, and this concern has never been tested. We have two ways of gathering relevant data on who mates with whom: 1) use DNA microsatellite differences to assign parentage, and 2) use behaviors during the breeding season to assign parentage. This study, for the first time, aims to do both, and to use this information to provide evidence-based recommendations on how to manage these small isolated herds to maximize the behavioral and genetic "wildness" of bison.

The Solution

My students and I have collected behavioral data for 10 summers (2004-2013) at the Nature Conservancy's Samuel H. Ordway Prairie Reserve in South Dakota. During this time period we manipulated the ratio of bulls to cows as a way of testing ideas about the age at which to replace bulls and the influence of large numbers of older bulls on breeding in a herd. We also have collected DNA samples for each of these years (in the form of tail hairs), and for one year (2006) had DNA analysis done to assign parentage. This one year's worth of DNA work suggested that our behavioral estimates of parentage (based on which bulls guarded which cows and on observed matings) were very good (Fig. 1). The year 2006 was a year in which bull numbers were low. We would like to compare that year with one now in which bull numbers in our herd are high. With two years of DNA results to compare against our behavioral estimates we can proceed with confidence with the analysis of what will be 11 years' worth of data.

These results will allow us to address important outstanding questions in bison management, including:

1. how manipulating bull numbers and ages changes the value of competitive behaviors of bulls and influences who and how many bulls contribute genes to the next generation
2. characterizing the success of different bull behavioral strategies for getting matings
3. the potential for mating with daughters when bulls get older

These are important unknowns, recognized as being necessary for a complete management strategy for bison in the small herds in which they're mostly found (Amato et al. 2011; Dratch & Gogan 2010; Lammers et al. 2013). With our years of behavioral data, my students and I are in a unique position to provide some of these answers.

The Proposal

We propose to use these funds to support Tony Massaro in field work this summer at the Ordway Prairie in South Dakota, and to finance (in part) DNA analysis through Texas A&M's bovid genetics center. Tony will be part of a team of 4 field workers organized by the Nature Conservancy to gather bison behavior and ecological data for my research, and to contribute to reserve management activities (e.g. fix fences, survey butterflies and wildflowers, kill weeds). In this time, Tony will coordinate the other seasonal workers to ensure the bison data are high quality and consistent. After the summer, Tony will work with me on the analysis of the field and the DNA results to put together the long-term behavioral data with the two snapshots of DNA parentage.

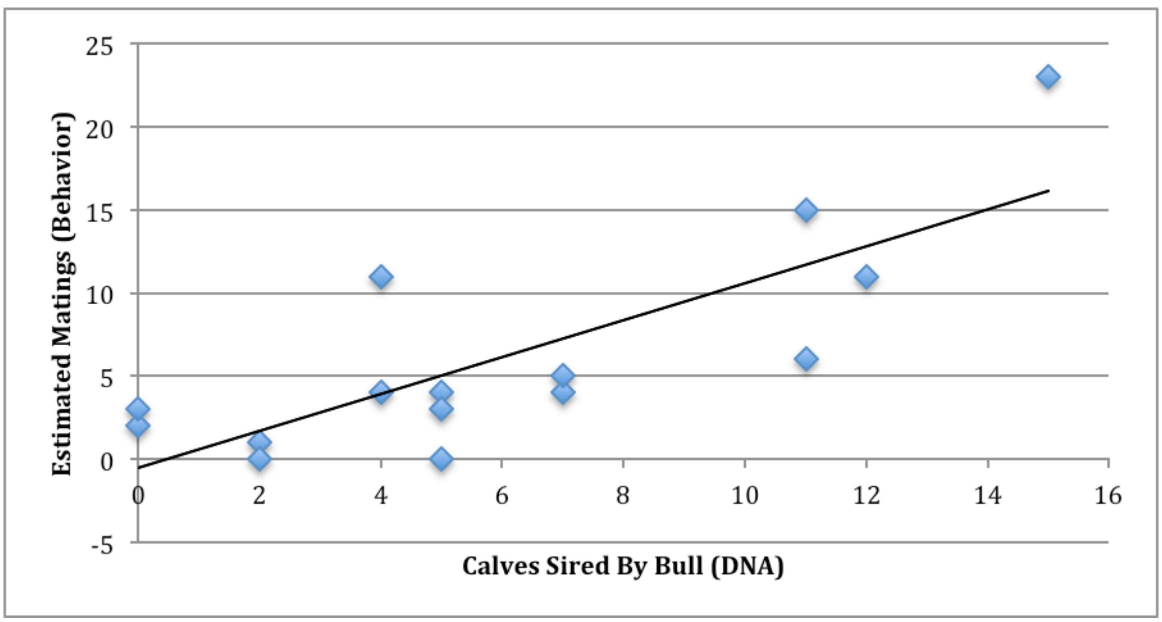

Figure 1. Estimates of bull mating success by DNA (x-axis) and behavioral (y-axis) measures agree (2006 data, Linear regression: $F_{1,13} = 21.5$, $p<0.001$; $y=1.1x-0.54$, $R^2 = 0.62$).

The Questions

The combination of behavioral and DNA parentage estimates will give us good information on the mating success of each bull in the herd over the period in which we manipulated bull numbers. These data, combined with other behavioral measures from the field such as dominance interactions between bulls, fights, timing of matings, and the age and sex of calves produced, will allow us to answer many of the remaining questions in bison ecology and management. It is an unusual opportunity to contribute to the recovery of this iconic American species. Questions that we will focus on first include:

1. How does the presence of greater numbers of mature bulls influence genetic contribution to the next generation?

   Many managers sell bulls once they reach 7 years of age (Ungerer et al. 2013) as a way of limiting inbreeding. But by doing so they may also be limiting the competition between bulls for access to cows, changing the value of dominance and competitive behaviors by the bulls, and altering who gets to mate with the cows and pass on their genes. Thus, they may also be reducing the "quality" of the genes that get passed on by allowing younger bulls to breed that would otherwise have been dominated by the older bulls. Studies among elephants have shown that without old bulls in the herd, younger males will adopt behavioral patterns not normally seen (Slotow 2000).

   Greater number of mature bulls may also increase the number of bulls breeding by increasing the costs of competition, thereby limiting how long a particular bull can remain dominant to others. Early analyses of ours suggest this is the case (Fig. 2). Thus, by keeping older bulls, managers may increase both the genetic and behavioral diversity in the herd.

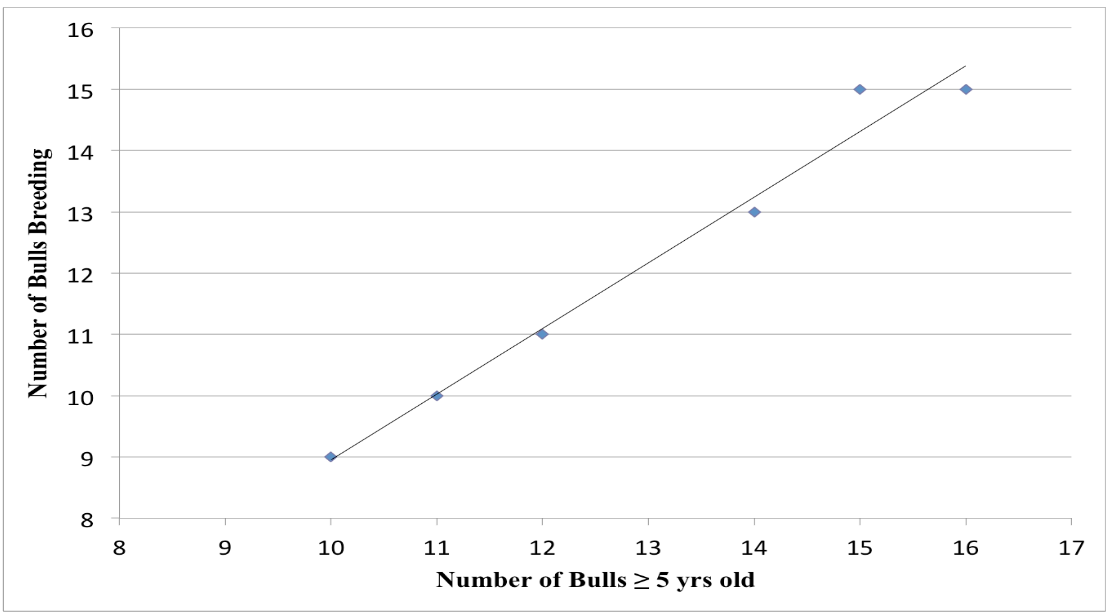

   Figure 2. As the number of mature bulls (≥5 yrs) increases, so does the number of bulls breeding (and thus passing on their genes).

2. How likely is it for older bulls to mate with their daughters?

   As the number of mature bulls increases, so should the competition between them, resulting in shorter periods in which any particular bull is the most dominant (and thus has easiest breeding access to cows). Preliminary analyses suggest that this is the case, and that 6 and 7 year old bulls are the most competitive, followed by progressively older age groups. If the window of opportunity to be a successful breeder is limited to a few years (e.g. ages 6-9), the chance of mating with a daughter may in fact be small. We have yet to do the analyses necessary to test this rigorously.

3. How do bull breeding strategies and age influence how many offspring a bull sires?
   Another possible detriment to selling bulls once they reach prime competitive years is the potential that these bulls won't have passed on their genes yet. Six and seven year old bulls seem to be the most capable of dominating, but older bulls (8-10 yrs) make up the second and third tiers of dominance (Table 1). Once the bull that dominates the herd earliest in the breeding season exhausts himself, it is usually an older bull that takes over. If that older bull hadn't managed to breed while 6 or 7, this may be his first chance to pass on his genes. If sold at 7, this chance wouldn't exist. Thus, keeping older bulls may increase the genetic diversity of the herd, which is opposite the assumption made by advocates of selling older bulls. This is another analysis we will do that will make use of our parentage estimates.

Table 1. Name, age, and estimated proportion of matings of bulls for the period 2005-2011.

Year	First Dominant	Age	Matings	Second Dominant	Age	Matings	Third Dominant	Age	Matings
2005	OGlo	6	0.27	D8R	7	0.31	none		
2006	Legslash	7	0.13	Hipspot	9	0.17	D8R	8	0.12
2007	Red E	6	0.15	OGlo	8	0.04	Hipspot	10	0.10
2008	Junior	6	0.15	Red E	7	0.17	D8R	10	0.14
2009	Junior	7	0.19	O94	8	0.15	none		
2011	Bootleg	7	0.06	Deuce	9	0.28	O94	10	0.10

The Location

The laboratory phase of this project will take place on the Gustavus campus, utilizing my research lab for data analysis. The summer field work will be conducted at the SH Ordway Prairie Reserve outside of Leola, South Dakota, owned and managed by The Nature Conservancy. I have worked with the manager there, Mary Miller, since 2004 on a cooperative bison behavior, ecology, and management project that has employed one to two Gustavus students per summer. Ordway has a herd of about 300 adult bison, providing good sample sizes while still a manageable number on which to maintain detailed interactions records. This is an exceptional arrangement for me and Gustavus students, as Mary allows us to stay in her research facilities and use her trucks and fuel free of charge. Besides Tony, there will also be an intern (possibly two) and two management technicians working at Ordway this summer, so there will be a community of 4-5 young people (counting Tony) that will contribute in various degrees to the bison work. Tony would be the lead researcher in the field for much of the summer. I will spend the first two weeks of the bison season training these participants and trouble-shooting the techniques and equipment, then will return at the end of the season (late August) for a week to wrap it up.

Anticipated Outcomes

1) <u>behavioral data on breeding success, bull-bull interactions, and cow-calf birthdates and sex for 2014.</u> These are outcomes from the summer's field work, coordinated by Tony at Ordway Prairie.

2) DNA estimates of parentage for bulls and cows for a high-bull year. Although our behavioral estimates of paternity seem to be good (Fig. 1), a second round of DNA testing for a year with a different level of bull-bull competition will tell us how generally believable these methods are.

3) publishable results. The questions asked by our research group are timely and in many cases uniquely able to be answered by us. No other bison study has the ability to combine detailed behavioral observation with DNA results. Tony has expressed interest in continuing the analyses begun this year after the summer field season. His junior year (2014-15) will give us time to finish the analyses and write manuscripts for submission to appropriate journals.

4) a great learning experience for Tony. This will be accomplished from each phase of the project.

Publication

We will target *Conservation Biology*, one of the top conservation journals, for the aspects of this project that are generalizable (e.g. the intersection of bull mating strategy with herd genetics). We will also target a management journal (such as *Rangeland Management and Ecology*) to publish how our results can be directly applied to the management of bison (e.g. the consequences of keeping or selling older bulls).

Completion Date

We anticipate completing the field work by August 24, 2014 and the analysis and writing by May 2015.

Participants

1. **Jon Grinnell**. I have worked with large mammals since 1986, and with bison since 2003. This study builds on prior work on the social organization and vocal behavior of African lions (1986-2003), and on the past bison work by my students and me (2003-present). It's a logical continuation of my career as a behavioral ecologist with interests in conservation.

2. **Tony Massaro** (2016). Tony has proven himself a capable and responsible researcher this year as the lead researcher on a rabbit spatial ecology project that he and 3 other students have conducted with me this fall and winter. This spring semester he has also begun work on the analysis of past years' field data for the bison project. We have worked closely together for the past 6 months. He adds "I have had a life-long interest in biology, specifically ecology and zoology. "

3. **Mary Miller & Assistants**. Mary is the Reserve Manager at Ordway Prairie. Her generosity in providing support for this project has been key to its success. She recently arranged for me to talk to the regional Nature Conservancy office (and outlying offices via phone link) about our work with the bison at Ordway and its management implications. Mary also arranges for interns and other management assistants that will help with the bison behavioral data collection.

How this project fits into our careers

Jon Grinnell. I switched to American bison as my primary study organism in 2003. Since that time I have presented bison-related results at two national conferences (Animal Behavior Society 2003, 2012) but have not yet published anything on them. (I have continued publishing African lion related work in this time.) This year (2014) will conclude our long-term bull number manipulation experiment, and with a second bout of DNA parentage data we will be in great shape for putting all the pieces together into a series of papers that address the behavioral and genetic ramifications of herd management strategies.

Tony Massaro. I believe that this research opportunity will enrich my education greatly. While I have had experience in biological fields, I have yet to explore opportunities in the field of research and conservation. This work also fits in perfectly with my career goals; I would love to participate in biological research professionally and I am eager to explore the field of behavioral ecology. Ever since my Presidential Scholarship interview with Dr. Grinnell, I have been interested in working with him on his personal research. After Gustavus, I hope to attend graduate school, and research is essential for admission into these programs as well as fostering a complete biological education.

Budget Justification

Materials: lab work for DNA analysis

The Texas A&M College of Veterinary Medicine Bovid Testing Service (run by Drs. James Derr and Natalie Halbert) is one of a few labs in the US that is equipped to do parentage analysis on bison (Halbert et al. 2005). They did the analysis for me in 2006 and charge a relatively modest $20 per bison sample for a complete parentage analysis of the herd. (This is less than we could do it for, assuming we had the expertise: J. Dahlseid, pers. comm.) Given 304 animals currently in the herd, this would cost (304 x $20) $6080.

Materials: field supplies

Rechargeable batteries for our audio recorder. *Printer ink* and *Photo Paper* are used to print identification photos of the different bison bulls.

Travel

Both Tony and I will travel to Ordway Prairie in South Dakota (700 miles round trip). Both of us will go out at the start of the season. I will stay for the first two weeks as I train him and the other Ordway volunteers on bison field techniques. I will then leave Tony in charge of the bison work until I come back near the end of the breeding season to wrap it up, staying in contact with him and the others there via phone and internet. Thus, one round trip for Tony, two for me.

Stipends

I will spend a total of 3 weeks in the field with Tony and the TNC crew, but don't anticipate asking for a stipend (given other expenses). Tony will spend from approximately June 8 – August 24 (11 weeks). If contracting out the DNA work is not an expense that the Presidential

Collaboration grant would support, I will happily claim a stipend and contribute that money towards it.

Total funding

The budget total for this project comes out to be $11,366. With the Francis Uhler funds I have in place ($3300), the total I am requesting from the Presidential grant is ($11,366 – 3300) $8066.

Presidential Faculty/Student Collaboration Grant

Budget Information

Faculty Stipend ($300 per week, up to $3,000 for a maximum of 10 weeks)
Student Summer Stipend ($400 per week, up to $4,000 for a maximum of 10 weeks)
Student Summer Campus Housing ($60 per week, for a maximum of 10 weeks)
Budget Maximum ($8,100 for all categories)

Item		**Amount**
Equipment (e.g., transcription machine, camera, cassette recorder – but not to include computer hardware)		**$ 0**
1:	Cost:	
2:	Cost:	
3:	Cost:	
Materials (e.g., books, printing, software, lab supplies)		**$6190**
1: Parentage lab expenses	Cost: $20 x 304 samples	$6080
2: Photo Paper (4x6)	Cost: $20 (100 sheets)	20
3: Ink Cartridge Set	Cost: $50	50
4: Rechargeable batteries	Cost: $40 (20 AA batteries)	40
Travel Costs (cannot include conference travel, see http://gustavus.edu/finance/travel.php for allowable travel expenses)		**$ 1176**
Airfare:		
Mileage: Number of miles 2100 @ $0.56/mile		1176
Lodging:		
Meals:		
Stipends & Housing		**$4900**
Faculty Stipend	$300 per week, up to $3,000 for a maximum of 10 weeks	$0
Student Summer Stipend	$400 per week, up to $4,000 for a maximum of 10 weeks	$4000
Student Summer Campus Housing	$60 per week, up to 10 weeks	$0
Total Expenses		**$11,366**
Less other funding (below)		$3300
Amount Requested (Total Expenses + Requested Stipends + Housing)		**$8,066**

Have you applied for, or received funding from, another source to help support this project? (If no, skip a, b, and c below.)

✓ Yes ☐ No

a. Funding Source: Francis M Uhler Fund
b. Amount: $3300
c. Please explain how the Presidential grant will be used in addition to the other funding, and (if relevant), how the Presidential grant project would be impacted if external funding is not approved.

The Uhler funding is confirmed and would be sufficient by itself to fund Tony for the summer field work (though at less generous pay than the Presidential grant would give). This Presidential grant will enable us to get DNA testing done and thus combine our behavioral with genetic results, making the project much stronger and more compelling (and publishable).

Literature Cited

Amato, G., Aune, K., Jung, T., Craine, J., Fuhlendorf, S. D. & Gogan, P. J. 2011. Recommendations from the American Bison Society Meeting on Bison Ecological Restoration. In: *American Bison Society Meeting on Bison Ecological Restoration*. Tulsa, OK: American Bison Society.

Berger, J. & Cunningham, C. 1994. *Bison: mating and conservation in small populations*. New York: Columbia University Press.

Dratch, P. A. & Gogan, P. J. 2010. Bison conservation initiative: Bison conservation genetics workshop: Report and recommendations. In: *Natural Resources Report NPS/NRPC*. Ft. Collins, CO.

Gates, C. C., Freese, C. H., Gogan, P. J. & Kotzman, M. 2010. *American bison: Status survey and conservation guidelines 2010*. Gland, Switzerland: IUCN.

Halbert, N. D., Ward, T. J., Schnabel, R. D., Taylor, J. F. & Derr, J. N. 2005. Conservation genomics: disequilibrium mapping of domestic cattle chromosomal segments in North American bison populations. *Molecular Ecology*, 14, 2343-2362.

Lammers, D., Ogorzalek, K., Olson, T., Flocchini, J., Forrest, S., Anderson, B., Grajal, A., Jorgensen, D., Kremer, C., LeFaive, T., Majerus, J., Mintanye, D., O'Brien, D., Sarver, S. & Stone, J. 2013. Bison conservation management: Guidelines for herd managers. (Ed. by B. C. W. Group): World Wildlife Fund.

Lott, D. F. 1991. American bison socioecology. *Applied Animal Behavior Science*, 29, 1-4.

Lott, D. F. 2002. *American bison: a natural history*. Berkeley: University of California Press.

Sanderson, E. W., Redford, K. H., Weber, B., Aune, K., Baldes, D., Berger, J., Carter, D., Curtin, C., Derr, J., Dobrott, S., Fearn, E. V. A., Fleener, C., Forrest, S., Gerlach, C., Cormack Gates, C., Gross, J. E., Gogan, P., Grassel, S., Hilty, J. A., Jensen, M., Kunkel, K., Lammers, D., List, R., Minkowski, K., Olson, T. O. M., Pague, C., Robertson, P. B. & Stephenson, B. O. B. 2008. The Ecological Future of the North American Bison: Conceiving Long-Term, Large-Scale Conservation of Wildlife. *Conservation Biology*, 22, 252-266.

Slotow, R., van Dyk, Gus, Poole, Joyce, Page, Bruce, Klocke, Andre. 2000. Older bull elephants control young males. *Nature*, 408, 425-426.

Ungerer, M. C., Weitekamp, C. A., Joern, A., Towne, G. & Briggs, J. M. 2013. Genetic variation and mating success in managed american plains bison. *J Hered*, 104, 182-191.

Wolff, J. O. 1998. Breeding strategies, mate choice, and reproductive success in American bison. *Oikos*, 83, 529-544.