UNIVERSITY OF WYOMING

College of Arts and Sciences
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29 July 2016

MEMO

TO: Kate Miller
Provost/VPAA

FROM: Paula M. Lutz
Dean, Arts and Sciences

RE: Program Review for the B.S. in Statistics—Dean's recommendation

The B.S. in Statistics has produced eight graduates in the past five years. Currently there are twenty majors, perhaps representing an increase in interest in this degree nationwide.

There is no doubt that the undergraduate introductory courses are important to A&S and UW. Seventy different majors are served by these courses with >4000 SCH's of service teaching. Their Outreach teaching serves 250-300 students. The department comments that their curriculum aligns with ASA guidelines for undergraduate statistics programs and requires only one additional undergraduate course offering for majors.

That said, the nationwide increase in interest has been in degree programs such as 'Data Science' and 'Computational Science' or a 'Data Analytics' track within a more mainstream B.S. degree. The 'Data Science' and 'Computational Science' degrees represents an interdisciplinary path (perhaps joint with Computer Science in CEAS).

It is the Dean's recommendation that this degree be "re-vamped" with a 'Data Analytics' track added, and that serious consideration be given to an interdisciplinary degree as well. The department's Ph.D. accepted no new students this academic year; that degree should be considered for closure so that emphasis may be placed on the M.S., the B.S. (in new form), and minors. The small number of faculty (six) is also a concern. A merger with another department such as Mathematics is being discussed.

Program Review of the Undergraduate Statistics Major at UW

Department of Statistics, College of Arts and Sciences

Head: Ken Gerow; gerow@uwyo.edu, 766-6600.

Program Productivity

We have graduated 8 undergrad majors from AY 2010-2011 through AY 2014-2015. Table 1 shows the numbers of enrolled undergraduate majors and minors over the past five years.

Table 1. Increase in Numbers of Enrolled Undergraduate Majors and Minors (recorded for Spring Semester of noted year)

	2011	2016	% Increase	Average yearly increase
Majors	8	20	250 %	20%
Minors	13	27	208%	16%
Total	21	46	219%	17%

Program Quality

(a) Program accreditation. Not applicable.

(b) Credentials of faculty (currently active full-time: 6, including Head). Of the six, four are white males, one is a white female, and one is an Asian-American female.

Professors

1. Richard Anderson-Sprecher, Ph. D. Statistics, University of Iowa.
2. Ken Gerow, Ph. D. Biometry, Cornell University; Head of Department.

Timothy Robinson, Ph.D. Statistics, Virginia Tech (seconded into Directorship of WWAMI since summer 2014).

Stephen Bieber, Ph.D. Quantitative Psychology, University of California-Berkeley (seconded into Directorship of WYSAC since summer 2015).

Associate Professors

3. Snehalata Huzurbazar, Ph.D. Statistics, Colorado State University.
4. Shaun Wulff, Ph.D. Statistics, Oregon State University.

Assistant Professor

5. Annalisa Piccorelli, Ph.D. Epidemiology and Biostatistics, Case Western Reserve University.

Assistant APL
6. Scott Crawford, Ph.D. Statistics, Texas A & M University.

Grants Awarded to Tenured and Tenure-track faculty during AYs 2011 through 2016
Details are in Appendix A; a summary follows.

Over academic years 2011-2012 through 2015-2016, department colleagues have been involved (as PI or Co-PI) on a total of $6,792,720 in funded research. The vast majority of that is in a single grant in which Shaun Wulff is a Co-PI; that award is worth $5,247,094.

Graduate Student Committees. Another aspect of our research/teaching activities is our role on graduate committees outside of our department. In the period encompassing calendar years 2011 through 2015, we collectively served on well over 100 such committees, supporting research across virtually all of the science departments on campus.

(c) Program Reputation

Our undergraduate major is small. Our current enrollment of 20 majors is at a historical peak and is also part of a trend showing promising growth. Like other programs across the country, our positive trend in enrollment indicates increasing interest in the field of statistics.

From 2010 through 2013 the number undergraduate statistics degrees across the country grew by 95%[1]; this increase amounts to an annual rate of 25%, and ours in the past five years has been 20% (Table 1). In another report[2], the American Statistical Association recorded the number of degrees for undergraduate statistics majors from 2003 – 2013. Taking 2011 – 2013 (the three years that overlap with the five year period being documented in this review of our program), the largest five programs grew (in total) at an annualized 22%, while the middle 10 in the list of 130 schools grew at about 17%.

To address the question of program demand, I will address the demand for the curriculum on which rests our program, namely our undergraduate service courses. Our undergraduate introductory courses (2050, 2070, 4220) collectively serve about 70 different majors, estimated using data from AY 2015-2016 (Appendix A; Tables A1 – A4). STAT 2050 and 2070 combined to serve over 950 students (3,800 student credit hours), while STAT 4220 added another 87 students (261 credit hours). None of these

[1] http://magazine.amstat.org/blog/2015/03/01/statistics-fastest-growing-undergraduate-stem-degree/

[2] http://www.amstat.org/misc/StatsBachelors2003-2013.pdf

courses are part of the USP curriculum (it requires only one quantitative course, and the college algebra prerequisite to these courses (Figure 1) fulfills that requirement. I note that less than 1% of the enrollment in these classes is composed of our undergraduate majors. Hence the vast majority of students who take these do so based on the merits of the courses are taken for their own merits rather than their enrollments benefitting from institutional requirements.

Our upper level service courses (offered as STAT 4XXX and STAT 5XXX; details of numbers and names are in Table 2) collectively served over 34 majors in AY 2015-2016, teaching 226 non-statistics students (many of which have taken more than one class); almost 680 credit hours (Appendix A; Table A1). Regression (STAT 4015/5015) is in greatest demand; in AY 2011, 19 students enrolled in this course (29 in AY 2012). In the current year, 53 students registered for this course, necessitating multiple offerings (two sections in Fall 2015; one in Spring 2016). Design and Analysis of Experiments (STAT 4025/5025) and Applied Multivariate Analysis (STAT 4300/5300) routinely serve close to two dozen students. Other courses are smaller in number but serve real needs for a variety of scientific disciplines (Appendix A; Table A1). These upper level courses are required by our own majors, who compose only a very small minority of the enrollment in them. For those students outside of the statistics department, these courses serve as electives or requirements for our popular graduate minor in statistics The fundamental importance of these courses is their role as service teaching; our undergraduate majors benefit from their being offered.

(d) Curriculum of major. The only course that is dedicated to our undergraduate major is STAT 4870 (Senior Thesis). This course is taught as an independent study and taught as a course overload by faculty, representing no financial encumbrance. Beyond that course, the entire curriculum for the Statistics BS consists of either USP service courses (STAT 2050, 2070) or applied service courses (STAT 3050 and all the 4XXX (which also appear as 5XXX for graduate students) courses, which are available to all of the undergraduate and graduate degree programs at UW (Figure 1 and Table 2).

Figure 1. Flow chart of the curriculum of our undergraduate major

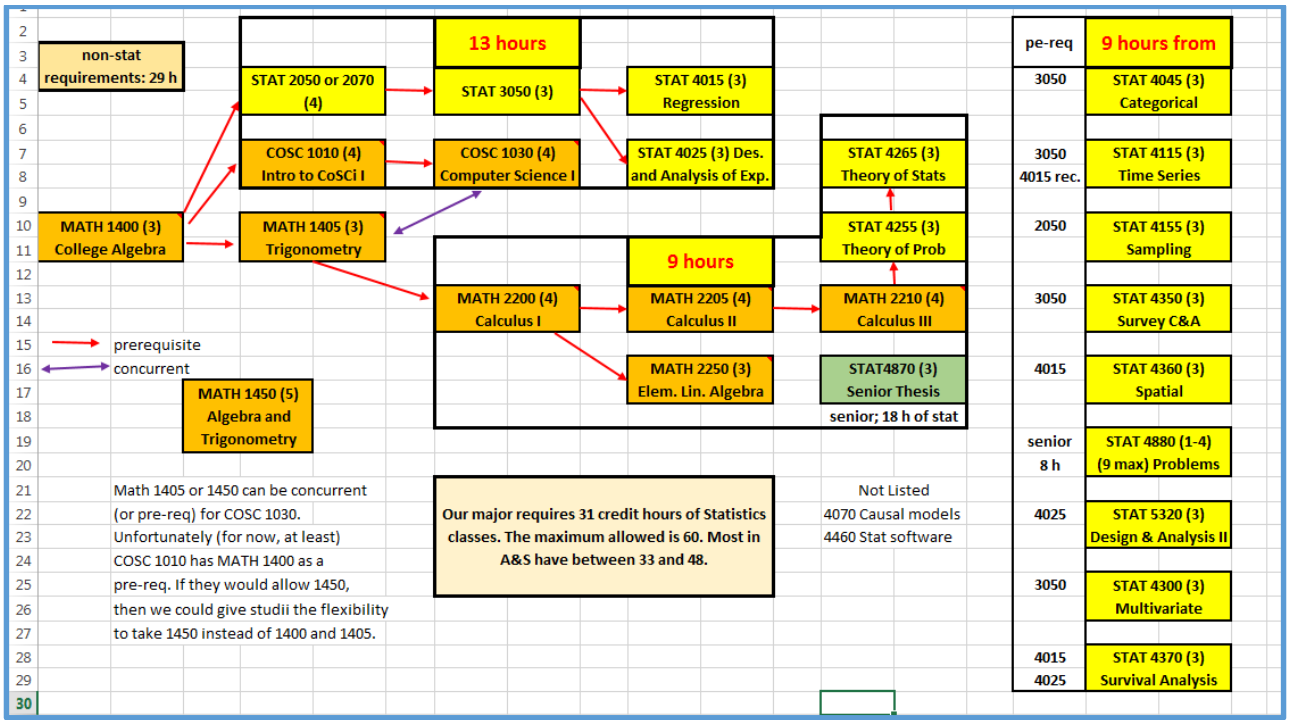


Table 2. Detailed course titles.

MATH 1400	College Algebra	**MATH 1405**	Trigonometry
COSC 1010	Intro to Computer Science I	**COSC 1030**	Intro to Computer Science II
MATH 2200	Calculus I	**MATH 2205**	Calculus II
MATH 2250	Elementary Linear Algebra	**MATH 2210**	Calculus III
STAT 2050	Fundamentals of Statistics	**STAT 2070**	Introductory Statistics for the Social Sciences
STAT 3050	Statistical Methods – General		
STAT 4015	Regression Analysis	**STAT 4025**	Design and Analysis of Experiments
STAT 4255	Mathematical Theory of Probability		
STAT 4265	Intro. to the Theory of Statistics	**STAT 4045**	Categorical Data Analysis
STAT 4115	Time Series Analysis & Forecasting	**STAT 4155**	Fundamentals of Sampling
STAT 4350	Survey Construction and Analysis	**STAT 4360**	Spatial Statistics
STAT 4370	Survival Analysis	**STAT 4880**	Problems in Statistics
STAT 5320	Design and Analysis of Experiments II		
STAT 4300	Applied Multivariate Analysis	**STAT 4870**	Senior Thesis

(e) Distance Delivery. Currently the program is not offered via distance delivery, except for our introductory pair of classes (STAT 2050 and STAT 2070). These classes are offered online with enrollments currently between 250 and 300 students each semester. Further, Scott Crawford is developing an online version of STAT 3050; he has developed materials and beta-tested them with a single student, who enrolled in an independent study with him.

(f) Program Assessment. We currently have not assessed this program, per se, only the intro statistics classes (STAT 2050 and STAT 2070) via a pre- and post-test approach. We have had only 8 undergraduate majors receive degrees over the span from Fall 2010 through Spring 2015, and my training as a statistician tells me that credible inference to qualities of the program using exclusively quantitative assessment will be limited with such a small sample. Implementation of the program as a whole is not the same now as it was a decade ago, despite the same curriculum structure. Part of these changes have resulted from personnel changes, and part of it has resulted from better meeting the needs of our students. For example, a number of courses are more computational in nature. We have incorporated the open source program R throughout our undergraduate curricula due to its popularity and wide-spread use.

That said, we have developed an assessment rubric to apply to our undergraduate senior theses; it can measure the degree to which our students have demonstrated, through their writing in that capstone experience, have attained the communication skills and statistical maturity we expect for them as undergraduates. That assessment process is still underway for our assessment report for AY 2016 (work on which had to be set aside while this report was being written. Look for details in that report.

In addition, I offer the following additional comments.

In 2014, the American Statistical Association released the most recent guidelines for undergraduate programs[3]. Our program aligns with it very well. The central theoretical foundations involve STAT 4255 and STAT 4265, which require Calculus I, II, and III, as prerequisites. Also included is an abundance of "tools" courses which are applied classes featuring commonly used statistical methods. with a modest abundance of "tools" courses: applied classes featuring commonly used statistical methods. The most common academic applied statistical courses are STAT 4015 and STAT 4025, but STAT 4045, STAT 4115, STAT 4155, STAT 4350, STAT 4360 are also prominent and ones in which we have faculty expertise.

We enjoy a high rate of success in placing our undergraduate majors into the next step of a statistical career upon graduation; a fine thing for a major that is an essentially free add-on to our service courses. We have had nine students graduate during the period from 2010 to present. Of them, four have gone on to Ph.D. programs (Michelle Londe (2016), heading to University of Idaho; Kayla Williamson (2015), attending Colorado State University; and Milo Page (2014), presently at North Carolina State University), and one to a Master's Program (Brandon Smart (2012), Montana State University). Heather Welch (2011) went to graduate school at MSU Bozeman, and is currently employed as an

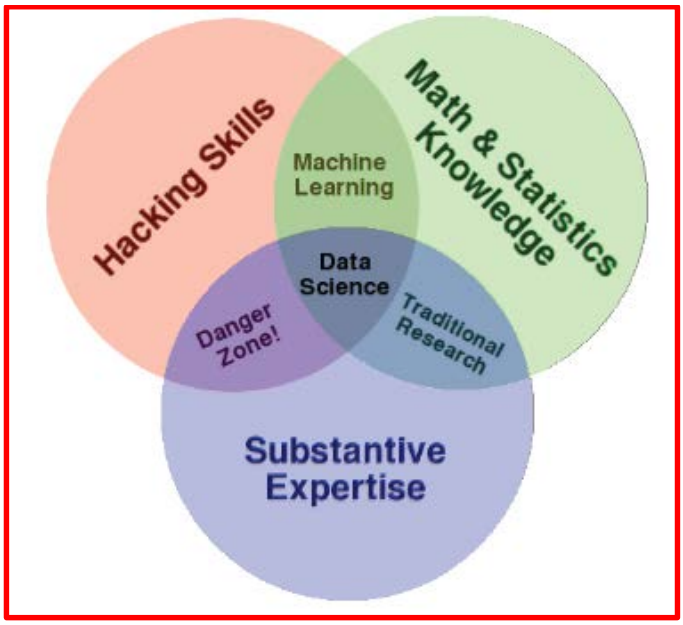
[3] American Statistical Association Undergraduate Guidelines Workgroup: Curriculum Guidelines for Undergraduate Programs in Statistical Science. http://www.amstat.org/education/pdfs/guidelines2014-11-15.pdf

analyst with Sierra Trading Post. Megan Meckel (2014) is employed by the State of Wyoming Department of Audit (Minerals Division).

(g) Strategic Plan. There are, across the country, a multitude of "Data Science" programs being developed as undergraduate majors[4]. A "data science" (DS) major is attractive from the perspective of employability of graduates. There are some challenges, in particular the fact that a good portion of the training of a data scientist is not statistical, but is computer science related (Figure 2)[5].

Indeed, a modern data scientist requires a core competency in statistics, including some skills not in the usual curriculum, but also competence with a substantial toolkit of programming and other skills (Figure 3)[6]. A classically educated statistician would be trained in many, but not all, of these skills.

Figure 2. Venn diagram of certain skill sets, at the intersection of which is data science.

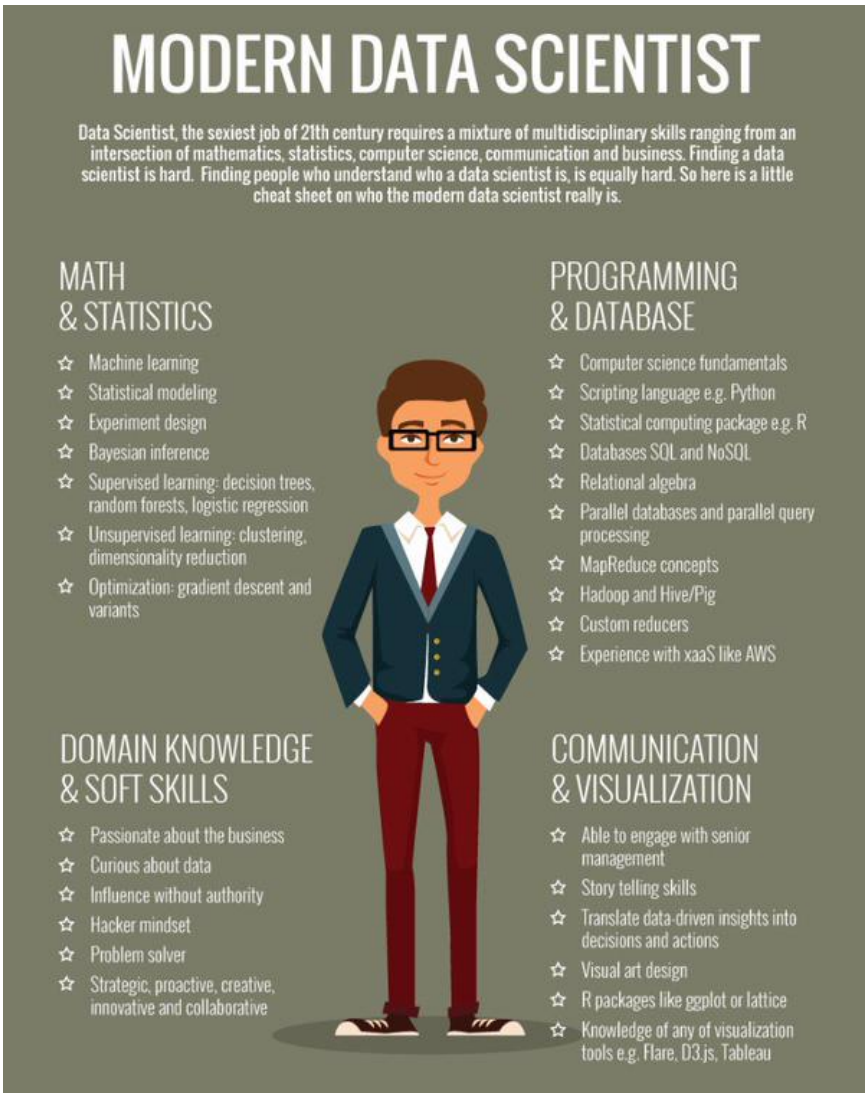


[4]"New Undergraduate Data Science Programs", Amstat News, July 2015: http://magazine.amstat.org/wp-content/uploads/2015an/AmstatJuly2015.pdf and Amstat News, August 2015: http://magazine.amstat.org/wp-content/uploads/2015an/AMSTAT_Augfinal.pdf

[5] Figure compliments of Simon Alexander, data scientist with UW-IT.

[6] Figure compliments of Simon Alexander, data scientist with UW-IT.

Figure 3. Data Scientists are necessarily multidisciplinary, requiring skills in four domains (statistics, database management, domain knowledge and communication).



We would like to move towards a data science major. There is support for the idea beyond our department. Computer Science already has a data science concentration, which curriculum includes several statistics courses. Robert Aylward, UW Vice President for IT, believes that such a major would be quite beneficial in educating undergraduates for the modern job market. Some of the coursework will necessarily be from outside our department (computer science courses in particular), so we would need to work with the Department of Computer Science.

In order to assess its viability at UW (as regards both interest and demand), we propose to offer a "data analytics" track as an option within our undergraduate major. In it, we would remove some of the current requirements and replace them with (first thoughts):

(1) A course on programming in Python, aimed at data management skills; this course could be called "Data Visualization" with the goal of training students to extract from and clean up messy databases in order to manipulate the data into compelling and useful graphical and numerical summaries.
(2) A course on statistical programming (building on (1)) in R.
(3) A capstone applied "data analytics" or "data science" course.

Our existing courses/curriculum can easily be adapted to accommodate two of these three courses: STAT 4880 (Problems in Statistics) for (1), STAT 4460 (Statistical Software) for (2), and STAT 4870 (Senior Thesis) for (3). As such, a pilot version of a data analytics track could be added with no additional cost to the college.

As it happens, we have at UW a data scientist (Simon Alexander) on staff with IT. Initial conversations with Simon and Robert Aylward indicate enthusiasm for our partnering to have Simon get involved in teaching such courses. These conversations are very preliminary just now, but encouraging; it is quite possible to move forward quickly on this idea, and to have something in place for next academic year, on a trial basis. Our Outreach income could provide support for buying, say, 25% of Simon's time.

Mission Centrality

The fact that our undergraduate statistics curriculum is central to the teaching and research mission of the University of Wyoming is made manifest by the very large number of majors (and of students in them) who take our service courses (Appendix A). In particular, none of our 4XXX/5XXX classes are required for other majors, although several programs have requirements along the lines of "some number of credits from the following list". Those students taking those courses shows the value of them.

Cost: Is the program financially viable?

I used AY 2015-2016 to compute the ratio of student credit hours per FTE. The group one classes we taught this year that are part of our undergraduate major include STAT 2050, STAT 2070, STAT 3050, STAT 4025, STAT 4045, STAT 4115, STAT 4155, STAT 4255, STAT 4300, and STAT 4350. In sum, these courses generated 4274 credit hours. Our current roster of teachers adds up to five FTEs (six counting me). Thus the ratio is 4274/6 = 712. In a certain sense this ratio is a slight underestimate as all of the STAT 4XXX classes are dual-listed as graduate courses. I counted only the undergraduate enrollment for these classes. None of these classes fall under UW minimums for enrollment.

The only course we teach that is available *only* to our undergraduate majors is STAT 4870 (Senior Thesis). This is done as an independent study, with each student working with a chosen mentor, and such teaching is done as an overload to the usual teaching duties, and so incurs no direct costs. So another perspective on the cost of the program suggests that it is entirely free, as it piggybacks on our service teaching. What a deal!

Appendix A: Non-Statistics Majors served by our Service courses.

Table A1. Numbers of Majors taking Upper Level Service courses (each is also offered as 5XXX); data are from AY 2011-2012 through 2015-2016.

Course	4015	4300	4255	4025	4155	4045	4350	4265	4115
Statistics	14	12	23	6	6	6	6	12	6
Civil Engineering	24	5	1	6	1	4	3		
Zoology and Physiology	14	4	1	3	3	1	1		
Mathematics	5	5	2	3	4	1	2	1	1
Psychology	2	6		1	2	2			2
Economics		4	2	2	1			1	1
Petroleum Engineering	3	2		1		2			1
Agronomy	2	3		2					
Geology	1		1	1	2	1	1		
ngeland Ecol and Watershed Mgmt	3	2			1		1		
Accounting	1	1		1		2	1		
Animal and Vet Science	4	1		1					
Botany	1	1		1			1		
Chemical Engineering	3		1						
Communication	1	1		1		1			
Ecology	2			1	1				
Geography	3	1							
Kinesiology	1	2		1					
Management and Marketing	1	1					2		
Criminal Justice	1			1	1				
Geophysics			2					1	
Mechanical Engineering	1	1		1					
Microbiology	1	1		1					
Soil Science	1	1		1					
Undeclared	1		1	1					
Computer Science			2						
Curriculum and Instruction		1	1						
Education		1							1
Electrical Engineering	1							1	
Secondary Educ/Math	1				1				
Sociology	2								
Ag and Applied Econ		1							
A&S Undeclared	1								
History	1								
Hydrologic Science	1								
Religious Studies									1
Number of non-majors served:	83	45	14	30	17	14	12	4	7

Table A2. Majors taking STAT 2050 (in class and online) during AY 2015-2016

Majors with 20 or more students enrolled (7): Psychology, Zoology, Physiology, Management, Kinesiology & Health Promotion, Pre-Nursing, Animal & Veterinary Science, (63 Undeclared included here also).

Majors with 10 – 19 students enrolled (16): Biology, Energy Resource Management/Development, Criminal Justice, Finance, Undeclared – Business, Accounting, Agricultural Business, Marketing, Pre-Pharmacy, Rangeland Ecology & Watershed Management, Wildlife & Fish Biology & Management, Computer Science, Agroecology, Speech Language & Hearing Science, Molecular Biology

Majors with only 1 – 9 students enrolled (45): Business Administration, Nursing - RN/BSN Track, Communication, Family and Consumer Sciences, Health Science Undeclared, Microbiology, Anthropology, Architectural Engineering, Physical Education Teaching, Secondary Education/Biological Science, Social Work, Statistics, Civil Engineering, Agricultural Communications, Business Economics, Chemical Engineering, Economics, Medical Laboratory Science, Political Science, Social Science, Education – Undecided, Geology, Mathematics, Mathematics/Science, Pre-Nursing - RN/BSN Track, Secondary Education/Math, Theatre and Dance, Art, Botany, Chemistry (ACS Approved), English, Natural Science, Petroleum Engineering, Pre-Nursing - BRAND Track, Secondary Education/Chemistry, Agricultural Education, Agriculture Undeclared, Arts & Sciences Undeclared, Astronomy and Astrophysics, Computer Engineering, Dental Hygiene, Earth Systems Science, Electrical Engineering, Engineering – Undeclared, Geography, History, International Studies, Mechanical Engineering, Music

Table A3. Majors taking STAT 2070 (in class and online) during AY 2015-2016

Majors with 20 or more students enrolled: Rangeland Ecology & Watershed Management, Undeclared – Business, Dental Hygiene, Management, Computer Engineering, Marketing, Social Work, Pre-Nursing - RN/BSN Track

Majors with 10 – 19 students enrolled: Mathematics, Agricultural Business, Pre-Nursing, Architectural Engineering, Criminal Justice, Kinesiology & Health Promotion, Political Science, Social Work – MSW

Majors with only 1 – 9 students enrolled: Business Economics, French, Spanish, Wildlife & Fish Biology & Management, Business Administration, Speech-Language Pathology, Agroecology, Agricultural Communications, Electrical Engineering, Organizational Leadership, History, International Studies, Journalism, Pre-Pharmacy, Secondary Education/Undecided, Speech Lang & Hearing Science, Anthropology, Chemical Engineering, Communication, English, Environ Geology & Geohydrology, Psychology, Undeclared, Zoology, American Studies, Biology, Civil Engineering, Computer Science, Economics, Family and Consumer Sciences, Finance, Gender and Women's Studies, Geography, German, Health Science

Undeclared, Industrial Tech Education, International Studies, Mechanical Engineering, Microbiology, Molecular Biology, Music Education, Philosophy, Physiology, Religious Studies, Secondary Education/Biological Science, Secondary Education/Math, Secondary Education/Social Studies, Statistics

Table A4. Majors (20) taking STAT 4220 during AY 2015-2016.

Accounting, Architectural Engineering, Atmospheric Science, Chemical Engineering, Chemistry, Civil Engineering, Communication, Computer Engineering, Computer Science, Electrical Engineering, Energy Resources Management/Development, Environmental Engineering, Hydrologic Science, Mathematics, Mechanical Engineering, Music, Petroleum Engineering, Physics, Statistics.

Appendix B: Grants and Contracts Awarded as PI or Co-PI to Tenured and Tenure-track faculty during AYs 2011 through 2016

Scott Crawford:

2014.	$500	Planning and Creation of First Year Seminar UW-ECTL

Ken Gerow

2011-present	$22,000	Biostatistics Support, NPS Fire Ecologists National Park Service

Burke Grandjean

2006-2012	$294,000	Comprehensive Survey of the American Public National Park Service
2011-2012	$10,200	Arrest-related Deaths in Wyoming US Bureau of Justice Statistics
2011-2012	$6,100	Statistical Consulting for Environmental Monitoring National Park Service
2011-2014	$35,000	Building Science Capacity While Addressing Climate Change, U.S. Fish and Wildlife Service
2011-2014	$50,000	Modeling Support for Species Recovery National Park Service
2012	$13,000	International Symposium on National Parks and Climate Change, University of Wyoming
2012-2013	$12,800	Statistical Consulting for Environmental Monitoring National Park Service

Snehalata Huzurbazar

2011-2016	$750,761	Modelling and Analysis of Gene Duplication National Science Foundation
2012-2014	$6,800	Establishing the Feasibility of FDA for Determining the Health Consequences of Body Weight Changes Among Older Adults, Institute of Translational Health Sciences, University of Washington
2013-2018	$140,375	Clinical Translation Research Infrastructure Network National Institute of Health
2014-2015	$25,875	SAMSI Bioinformatics Program Research Participation National Science Foundation
2015	$22,000	Visualizing and Modeling vaginal microbiome data for improved understanding of BV, National Institute of Health
2015	$10,000	Collecting baseline data and documenting best practices for improving recruitment and retention of diverse STEM

		faculty at the University of Wyoming UW Office of Research and Economic Development
Tim Robinson		
2011-2012	$6,100	Statistical Consulting for Environmental Monitoring National Park Service
2011-2012	$22,500	Developing graphical presentations of high dimension design applications in energy research School of Energy Resources, UW
2011-2014	$35,000	Building Science Capacity While Addressing Climate Change, U.S. Fish and Wildlife Service
2011-2014	$15,000	Building Science Capacity to Implement Strategic Habitat Conservation While Addressing Climate Change U.S. Fish and Wildlife Service
2013-2016	$16,700	Statistical Consulting for Environmental Monitoring National Park Service
2015-2018	$95,114	Statistical Support for Inventory and Monitoring U.S. Fish and Wildlife Service
Shaun Wulff		
2014	$3000	Statistical Modeling of Resilient Modulus Wyoming Department of Transportation
2014	$10,533	Improvement to Intraoperative Hearing Assessment and Prevention of Inner-Ear Damage in Humans Oticon Research Grants
2014-2016	$5,224,094	Atmosphere to Grid: Advanced Modeling to Enhance Energy Conversion and Delivery Department of Energy Experimental Program to Stimulate Competitive Research

Academic Program Review: **Statistics BS**

Section 8 – Cost

a) Ratio of student credit hours per FTE (AY 2014/15): **789.5**

b) Direct instructional expenditures (FY 2015): **$1,118,035**

i) Per student FTE: **$4,402**

ii) Per total degrees awarded: **$223,607**

iii) Non-personnel expenditures / total academic FTE: **$4,566**

c) Course enrollment (AY 2014/15)

i) Classes falling under university minimums: **6**

ii) Lower-division courses falling under university minimums: **0**

e) Research expenditure per tenure-track FTE (FY 2015): **$46,783**