

■ NSF Support of Research at Primarily Undergraduate Institutions (PUIs)

The importance of undergraduate research for student learning, personal development, and professional advancement is regularly reported in *CUR Quarterly* articles and highlighted through a variety of activities supported by the Council on Undergraduate Research (CUR). The significant impact of undergraduate research programs in producing graduates who obtain doctoral degrees in science, technology, engineering and mathematics (STEM) fields or who ultimately serve in national scientific leadership positions is well documented (Burrelli, Rapoport, and Lehming 2008). Rowlett *et al.* recently summarized the characteristics of institutions and programs that sustain high-quality undergraduate research. The characteristics include a committed faculty, supportive administration, and appropriate resources, including both institutional and external funding. Extramural support of undergraduate research initiatives is particularly critical in this period of limited resources.

Over the past 30 years, CUR leadership in advocating for federal support of undergraduate research has led to the establishment of many current National Science Foundation (NSF) programs that directly or indirectly support STEM research and education, largely at so-called “primarily undergraduate institutions” (PUIs). During a recent rotation as a program director, author Slocum worked with NSF administrators and staff to assemble statistics relating to overall NSF support of research at PUIs over the past decade. Other goals were to understand how well PUI faculty competed for research funding and the depth and breadth of PUI research support within the NSF’s Directorate for Biological Sciences (BIO).

Major support for undergraduate research at PUIs has been provided by NSF’s Research in Undergraduate Institutions (RUI) program. In 1982 the Council on Undergraduate Research (CUR) originally proposed to the National Science Board, the NSF’s governing body, the establishment of a Research at Undergraduate Institutions (RUI) program (Doyle, Andreen and Mohrig 1982). CUR acted consistent with its mission “... to support and promote high-quality undergraduate student-faculty collaborative research and scholarship.” The NSF implemented the RUI program in 1983. The current RUI materials recognize undergraduate research as “... the ultimate in inquiry-based learning” and note the critical role that PUIs play in STEM education (NSF 2000). Indeed, the RUI program and myriad other programs supporting research and education at PUIs are essential to one of the NSF’s core missions, to initiate and support science and engineering education programs (NSF 1995).

In order to gather data relating to NSF’s support of research at PUIs, it was necessary to identify them in the NSF databases. It soon became clear that neither the NSF nor any other agencies or professional organizations, including CUR, maintained an updated list of PUIs. Therefore, the first step in our investigation was to develop a current list of PUIs, a major undertaking that required approximately six months.

What is a Primarily Undergraduate Institution?

A PUI is defined by the NSF as meeting the following eligibility criteria, allowing the institution to submit a grant proposal to the RUI program:

- Grants baccalaureate degrees in NSF-supported fields (or provides programs of instruction for students pursuing such degrees after transfer to four-year institutions),
- Has greater undergraduate enrollment than graduate enrollment, and
- Awards fewer than 10 doctoral or doctor of science degrees per year in all NSF-supportable disciplines, averaged over two to five years preceding submission of the proposal (NSF 2000).

It is important to note that the NSF does not maintain a PUI list, and eligibility is determined by the institution submitting a grant proposal to the Research in Undergraduate Institutions (RUI) program.

How Was the PUI List Developed?

An initial search of the NSF Reporting Databases Server identified 8,377 institutions. Manual culling of this list and use of standardized institutional names included in the Carnegie Classification 2010 (Carnegie Foundation 2010; see below), produced a list of 2,707 individual institutions. Of these, 2,153 had previously submitted RUI proposals (self-certifying their PUI status), and 554 institutions had not submitted RUI proposals, but were considered as potential PUIs (Figure 1).

“Undergraduate Instructional Program” and “Graduate Instructional Program” data were downloaded from the Carnegie Classifications website (Carnegie Foundation). The lists were then combined, and duplicate institutions were removed by filtering, using the unique IPEDS “Unitid” number for each institution. The list of 3,688 institutions (1,637 two-year institutions and 2,051 four-year institutions) was then further filtered to remove special-focus

Figure 1. Producing an NSF List of PUIs.

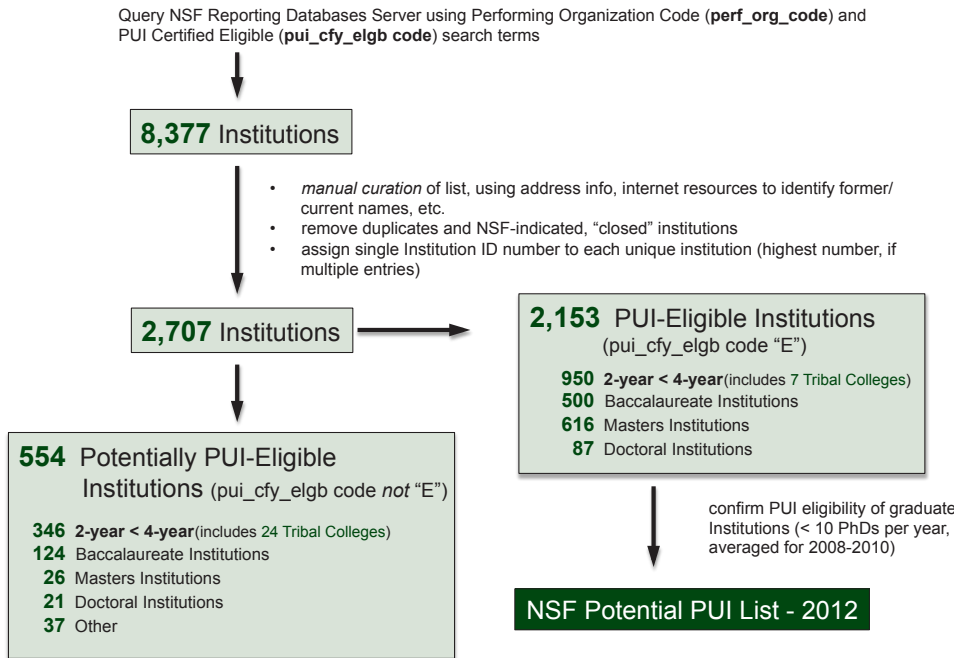
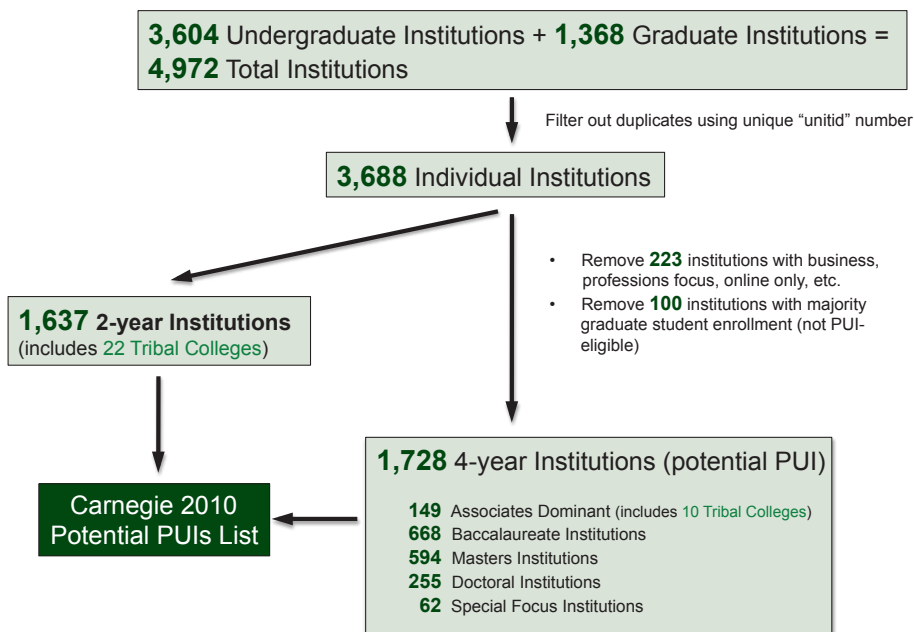


Figure 2. Producing a Carnegie Classification 2010 List of Potential PUIs.



four-year institutions, except for those with an engineering or technology focus (Basic 2010 Carnegie variables "Spec/Engg" and "Spec/Tech"). The list was further culled to remove 100 four-year institutions with a majority graduate/professional student enrollment (Carnegie Enrollment Profile Classification variables "MGP" or ExGP"). By definition, those institutions are not primarily undergraduate institutions.

An additional 266 four-year institutions with an undergraduate business/professions focus (Carnegie Undergraduate Program Classification variables "Prof-F/NGC," Prof-F/SGC," Prof-F/HGC") were further evaluated. Of those, 43 institutions with post-baccalaureate A&S (arts and sciences) or STEM programs (Carnegie Graduate Program Classification variables "Doc-STEM," "Postbac:A&S," "Postbac:A&S/Ed," "Postbac:A&S/Bus," or "Postbac:A&S/Other") were retained in the list of 1,728 potential PUIs; the rest were eliminated (Figure 2).

The lists of potential PUIs identified in the NSF databases and in the Carnegie 2010 data were then compared (Figure 3). Institutions certified as PUIs in the NSF list, which also occurred in the Carnegie list, made up the initial working list of PUIs. Institutions listed as PUI-certified in the NSF databases, but which no longer met one or more eligibility criteria, 115 institutions, were moved to a separate list (Table 1, see *CURQ on the Web*). Most institutions on this separate list awarded an average of more than 10 PhD degrees annually in NSF-supported disciplines (Table 2, see *CURQ on the Web*). A separate cohort of 876 institutions that met PUI selection criteria in the Carnegie 2010 data, but were

not present in NSF databases were also removed. Of these, 750 were two-year institutions for which the Carnegie 2010 data are not useful in assigning potential eligibility as PUIs. Future evaluation of the list of community colleges (and four Tribal Colleges) may result in the addition of many of these institutions to the list of potential PUIs. The remaining 126 four-year institutions are listed in Table 3 (*CURQ on the Web*).

It should be noted that institutions in NSF databases are limited to those that have submitted proposals, and it is likely that many of the institutions that occur only in the Carnegie list are PUIs and would be eligible to submit RUI proposals to the NSF in the future. In addition, 37 potential PUIs that were in both the NSF and Carnegie 2010 lists, but were not certified as PUIs in the NSF databases, were removed (Table 4, *CURQ on the Web*). Most of these institutions appear to be PUIs but have not previously submitted RUI proposals. A final group of four institutions that were listed in NSF databases, but are not included in the Carnegie 2010 list, were removed (Table 5, *CURQ on the Web*), resulting in a final list of 2,104 PUIs (Table 6, *CURQ on the Web*).

Institutional Profiles of PUIs

As is seen in Table 7, about 45 percent of PUIs are two-year or four-year associate-degree dominant institutions, nearly all of which are public institutions. Baccalaureate institutions make up 27 percent of PUIs and are largely private. Twenty-eight percent of masters institutions are PUIs, with 330 privates and 251 publics in this category. As might be expected, only 17 doctoral institutions (0.8 percent) meet the current PUI eligibility criterion of awarding fewer than 10 PhD degrees annually in STEM disciplines. An additional 31 masters and doctoral institutions awarding more than 10 but fewer than 20 PhD degrees annually in STEM disciplines are included in Table 1 (*CURQ on the Web*) and likely would be added to the PUI list if the NSF revises this PUI eligibility criterion to fewer than 20 PhDs annually in STEM disciplines, a move currently under consideration. Only seven institutions with an engineering/technology focus are included as PUIs in the NSF databases, to date.

Demographic data in the Carnegie Classifications Data File were further analyzed (Carnegie Foundation 2011). PUIs accounted for 58 percent of the 3,599 non-special focus institutions (including non-PUIs and those with an engineering/technology focus) and 63 percent of total enrollments (Table 8, *CURQ on the Web*). PUIs that are minority-serving institutions (MSIs), Hispanic-serving institutions (HSIs), Historically Black Colleges and Universities (HBCUs), women's colleges, and tribal colleges represent only a small percentage of all U.S. institutions and total enrollments (fewer than 10 percent). However, these PUIs constituted 80 to 100 percent of institutions and enrollments in their individual cohorts, indicating an important role for PUIs in educating underrepresented minorities.

As is shown in Table 9 (*CURQ on the Web*), PUIs awarded 74 percent of associate's degrees, 47 percent of bachelor's degrees, and 43 percent of master's degrees, but only 5 percent of doctoral degrees, which are awarded primarily by research-intensive institutions. STEM degrees awarded by U.S. institutions are shown in Table 10. Baccalaureate and master's institutions awarded 41 percent of the bachelor's degrees and 27 percent of the master's degrees. Baccalaureate colleges awarded only 12 percent of those bachelor's degrees, but, when adjusted by the number of bachelor's degrees awarded in all fields, they

Figure 3. Producing a Final List of PUIs, 2012.

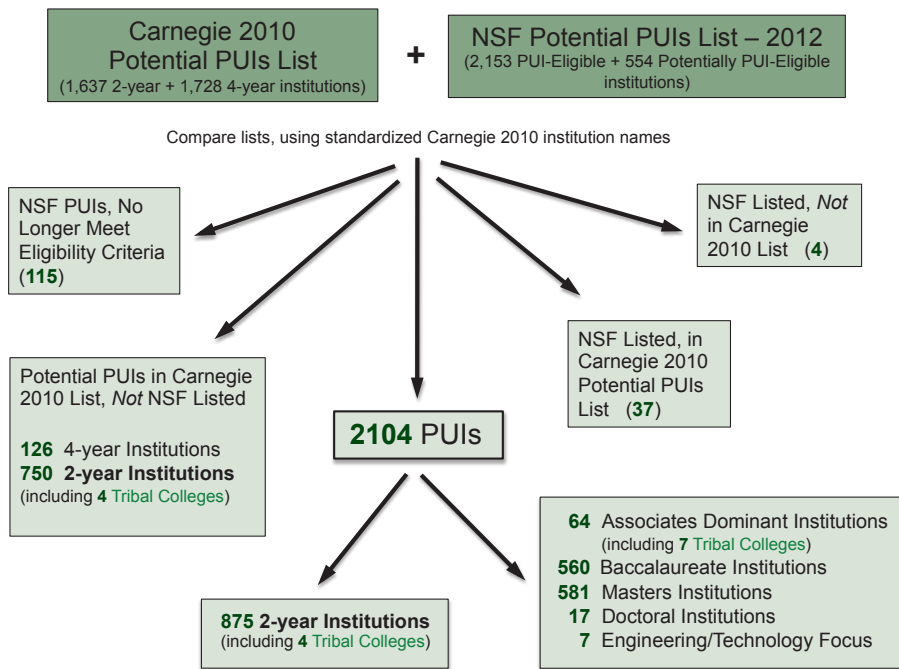


Table 7. Profile of Institutional Types of Primarily Undergraduate Institutions (PUIs) in the U.S.

Institution Type	Private Institutions	Percent	Public Institutions	Percent	Private + Public Institutions	Percent
2-Year	22	2.7%	853	66.2%	875	41.6%
4-Year Associates	9	1.1%	55	4.3%	64	3.0%
Baccalaureate	434	53.2%	126	9.8%	560	26.6%
Masters	330	40.4%	251	19.5%	581	27.6%
Doctoral	15	1.8%	2	0.2%	17	0.8%
Eng/Technol Focus	6	0.7%	1	0.1%	7	0.3%
Totals:	816		1288		2104	

NOTES: Data from Carnegie Classification 2010, NSF Enterprise Information Systems (EIS) database queries and published sources, such as the NSF/NIH/USED/USDA/NEH/NASA, 2008, 2009 and 2010 Surveys of Earned Doctorates. 2-Year institutions included here were self-identified as PUI "Eligible" (NSF 00-144). Other potential PUIs in this category may be identified. An additional 126 institutions that appear to be PUIs, according to Carnegie Classifications, but are not represented in NSF databases, are not included. An additional 37 institutions that are in NSF databases but not certified as PUIs, and are potential PUIs in Carnegie Classifications, are not included. An additional 115 institutions, currently included as PUIs in NSF databases, but which no longer appear to meet PUIs eligibility criteria, also are not included.

Table 10. U.S. Science & Engineering (STEM) Degrees Awarded in 2009, by Degree Level and Carnegie Institution Type

INSTITUTION TYPE	DEGREE TYPE							
	Associate's	Percent	Bachelor's	Percent	Master's	Percent	Doctorate	Percent
Doctoral-Granting Universities (very high research activity)	89	0.2%	192,853	38.6%	56,074	43.1%	24,802	78.2%
Doctoral-Granting Universities (high research activity)	181	0.4%	72,243	14.5%	25,593	19.7%	4,954	15.6%
Doctoral/Research Universities	4,186	8.3%	28,503	5.7%	12,722	9.8%	1,522	4.8%
Master's Colleges & Universities	2,459	4.9%	144,265	28.9%	34,755	26.7%	394	1.2%
Baccalaureate Colleges	3,155	6.3%	61,207	12.3%	1,077	0.8%	35	0.1%
Associates Colleges	40,184	80.0%	201	0.0%	22	0.0%	3	0.0%
TOTALS:	50,254	100.0%	499,272	100.0%	130,243	100.0%	31,710	100.0%

Total S&E degrees: 711,479

Source: National Science Board (2012), Appendix Table 2-1
www.nsf.gov/statistics/seind12/appendix.htm

yielded more future science and engineering doctoral recipients, per hundred bachelor's degrees, than any other type of institution except research universities (Burrelli *et al.* 2008). Further analysis of these data are required to determine the numbers of STEM degrees awarded by PUI versus non-PUI institutions, but data in Table 9 (*CURQ on the Web*) suggest that baccalaureate and master's institutions make significant contributions to overall STEM education in the U.S.

NSF Support of Research at PUIs

The NSF supports research and education in STEM disciplines at both PUIs and non-PUIs through a variety of programs. Major resources for STEM education are provided by programs within the Directorate for Education and Human Resources, dedicated to undergraduate curricular transformation and laboratory instrumentation improvements (NSF 2010) or graduate student training (NSF 2011a; 2011b). Faculty Early Development (CAREER) awards (NSF 2011c) support junior faculty who are interested in integration of STEM research and education at their institutions. Research Experiences for Undergraduates (REU) Site programs (NSF 2013a; Benninson, Koski, Villa, Faram and O'Connor 2011) and REU supplements support active research participation by undergraduates in any areas funded by the NSF. The RUI (Research at Undergraduate Institutions) program supports individual or collaborative research projects, including shared use of instrumentation, but is available only to investigators at PUIs (NSF 2000).

NSF resources directly supporting undergraduate research over the past decade are summarized in Table 11. Some \$1.24 billion was invested, foundation-wide, between 2002 and 2012, with \$385 million in support provided by the BIO Directorate via several programs. The BIO Directorate's commitment to undergraduate research is particularly noteworthy. By comparison, support from the National Institutes of Health's Academic Research Enhancement Awards (AREA) program, which supports student research training in the biomedical and behavioral sciences, largely at PUIs, totaled \$481 million during this period (NIH), while overall NIH support of research in science and engineering disciplines was more than four-fold higher than that of the NSF in 2009 (National Science Board).

Demographic Profile of BIO Awardees at PUIs and Non-PUIs

Principal Investigators (PIs) from 234 PUIs and 431 non-PUIs received a total of 8,675 awards from the BIO Directorate between 2002 and 2012 (Table 12, *CURQ on the Web*). Female PIs received 29 percent of all awards, but they received a

Table 11. NSF Direct Support of Undergraduate Research, 2002-2012

		Totals*
REU Site Awards (9250)*		
NSF		\$505,726,867
BIO Directorate		\$83,096,843
BIO % Total		16.4%
REU Supplements (9251)		
NSF		\$229,609,541
BIO Directorate		\$72,149,991
BIO % Total		31.4%
Research Undergraduate Inst (RUI) (9229)		
NSF		\$400,105,374
BIO Directorate		\$177,870,718
BIO % Total		44.5%
Research Undergraduate Inst - Equipment (9141)		
NSF		\$88,619,306
BIO Directorate		\$39,575,533
BIO % Total		44.7%
Research Opportunity Award (ROA) Supplements (9232)		
NSF		\$16,798,602
BIO Directorate		\$11,871,852
BIO % Total		70.7%
NSF Totals:		\$1,240,859,690
BIO Totals:		\$384,564,937

Data provided by Donald Leiss (NSF, BFA) March 14, 2012; NSF Reference Code for each initiative in parentheses

* Data for FY 2012 through 2-29-2012 only

slightly higher percentage of PUI awards (36 percent). There were no significant differences in gender ratios among PUI cohorts receiving RUI awards versus non-RUI awards.

Minority PIs received only 7 percent of all awards, but 13 percent of PUI awards (Table 12). Minority PIs at PUIs received 24 percent of non-RUI awards, while submitting only 14 percent of the proposals in this cohort. Only 5 percent of RUI awards to PUIs had minority PI's, proportional to the 6 percent of proposals submitted by this group.

Beginning Investigators submitted between 45 and 50 percent of the total proposals BIO received. PUI investigators in this cohort who submitted non-RUI proposals received

62 percent of the awards, indicating that this group was somewhat more successful than non-PUI applicants or PUI investigators submitting RUI proposals (Table 12). New Investigators submitted 62 percent of proposals but received only 30 percent of awards. Prior Investigators submitted 38 percent of proposals but received 70 percent of BIO awards, indicating that this more experienced group of investigators was more successful in obtaining funding, overall. Within the PUI cohort, a higher percentage of both non-RUI proposals and RUI proposals were submitted by new investigators (74 percent and 62 percent, respectively), compared with prior investigators. Interestingly, nearly equal numbers of non-RUI awards went to new investigators and prior investigators at PUIs, while 64 percent of RUI awards went to prior investigators in the PUI cohort, despite the fact that they submitted only 38 percent of proposals. This suggests that PIs' experience may contribute to the approximately two-fold higher success rate in winning awards in this group, compared with PUI faculty submitting non-RUI proposals, as is noted below.

Between 31 and 39 percent of BIO proposals were from institutions in EPSCoR states, which receive relatively low levels of federal research funding (NSF 2013b; Table 12). The program, the Experimental Program to Stimulate Competitive Research, was designed to help institutions that historically had received lesser amounts of federal research and development funding. There were no significant differences in the percentage of awards received by these institutions (16-18 percent) across all PUI and non-PUI cohorts.

Ten PUIs that award STEM doctoral degrees received 37 RUI awards from BIO in the past decade (Table 2 *CURQ on the Web*). An additional 11 "PUI-like" institutions, which produce between 10 and 20 STEM doctoral degrees annually, received 25 RUI awards. These institutions may have met PUI eligibility criteria at the time of proposal submission but currently do not. The remaining 46 RUI awards were made to non-PUIs, including several large research universities, suggesting that self-certification of PUI eligibility is allowing at least some non-PUIs to submit RUI proposals.

Table 14. Award Numbers, Average Size and Duration and Total Award Dollars for Research at PUIs, NSF BIO Directorate 2002-2012

	All Awds	PUI Only	Non-PUI Only	All RUI*	RUI, PUI	RUI, Non-PUI
Total Number of Awards	8,675	695	7,980	487	409	78
Percent Total Number of Awards	100.0%	8.0%	92.0%	100.0%	84.0%	16.0%
Average Award Size	\$632,484	\$386,168	\$653,936	\$369,425	\$365,532	\$389,791
Average Award Duration (Months)	3.75	3.65	3.76	3.74	3.72	3.8
Average Annual Award Size	\$167,721	\$109,367	\$172,803	\$103,849	\$103,573	\$105,293
Percent Average Annual Award Size	100.0%	65.2%	103.0%	100.0%	99.7%	101.4%
Total Awards Amount	\$5,486,795,558	\$268,773,035	\$5,219,062,627	\$179,540,640	\$149,502,509	\$30,403,663
Percent Total Awards Amount	100.0%	4.9%	95.1%	3.3%	2.7%	0.6%

	All CAREER	CAREER, PUI	CAREER, Non-PUI	Collab. Res., All	Collab. Res., PUI	Collab. Res., Non-PUI
Total Number of Awards	462	34	428	1022	82	940
Percent Total Number of Awards	100.0%	7.4%	92.6%	100.0%	8.0%	92.0%
Average Award Size	\$715,717	\$682,126	\$718,385	\$799,257	\$550,464	\$820,672
Average Award Duration (Months)	5.21	5.26	5.21	3.78	3.80	3.80
Average Annual Award Size	\$147,837	\$141,513	\$148,339	\$219,582	\$153,437	\$225,275
Percent Average Annual Award Size	100.0%	95.7%	100.3%	100.0%	69.9%	102.6%
Total Awards Amount	\$331,376,886	\$23,874,414	\$308,187,266	\$816,840,213	\$44,587,589	\$773,073,296
Percent Total Awards Amount	6.0%	0.4%	5.6%	14.9%	0.8%	14.1%

* includes RUI awards made to non-PUI

Award Size, Duration, and Success Rates for PUIs versus Non-PUIs

Data were analyzed for 55,093 competitive research proposals submitted to the BIO directorate between FY 2002 and 2012, excluding proposals for conferences, symposia, or workshops, facilities renovations, REU sites, and graduate student or postdoctoral awards (Table 13, *CURQ on the Web*). PUIs submitted 4,575 of the total proposals (8.3 percent). Of the 8,675 awards, 7,980 (92 percent) were made to non-PUIs, for a total of \$5.2 billion (Tables 13 and 14). PUIs received 695 awards (8 percent), for a total of about \$269 million. Of the PUI awards, 409 were RUI awards, representing 59 percent of the total. The average duration for PUI and non-PUI awards was similar, although average annual award sizes for PUIs were only 65 percent of the average awards made to non-PUIs. Award size and duration were not significantly different for non-RUI awards to PUIs, compared with RUI awards made to these institutions. The size and duration of CAREER awards to PUIs versus non-PUIs were also similar,

but the average Collaborative Research awards made to PUIs were only 70 percent of the size of the average awards made to non-PUIs.

As is seen in Table 13, the overall award success rates for PUIs (15.2 percent) and non-PUI (15.8 percent) were not significantly different. In contrast, for proposals submitted by PUIs only, the award success rate for RUI proposals was 20.7 percent, versus 11 percent for non-RUI proposals (Table 15). Further analysis of these data by institutional type and proposal type is revealing. Masters institutions submitted 63.7 percent of all PUI proposals and had an overall award success rate of 13 percent, while RUI proposals were funded at a slightly higher rate (16.2 percent) than non-RUI proposals (11.1 percent) in this cohort. Baccalaureate institutions submitted 31.7 percent of PUI proposals, with a 20.2 percent award success rate. In this cohort, the award success rate for RUI proposals (26.6 percent) was more than twice that for non-RUI proposals (11.5 percent).

Table 15. Award Success Rates For PUIs, by Institution Type, Non-RUI vs. RUI Proposals, NSF BIO Directorate, 2002-2012

Institution Type	Awards		Declines		Total Actions		Percent Total Actions		Award Success Rate			
	Non-RUI	RUI	Non-RUI	RUI	Non-RUI	RUI	Non-RUI	RUI	Non-RUI	RUI	Non-RUI	RUI
2-Year	0	0	11	4	11	4	0.4%	0.2%	0.0%	0.0%		
4-Year Associates	0	1	5	3	5	4	0.2%	0.2%	0.0%	25.0%		
Baccalaureate	70	224	541	618	611	842	23.5%	42.6%	11.5%	26.6%		
Masters	199	181	1,597	937	1,796	1,118	69.0%	56.6%	11.1%	16.2%		
Doctoral	15	3	156	4	171	7	6.6%	0.4%	8.8%	42.9%		
Tribal	2	0	8	2	10	2	0.4%	0.1%	20.0%	0.0%		
Totals:	286	409	2,318	1,568	2,604	1,977			11.0%	20.7%		
											% Total Actions, Inst. Type	
											Non-RUI	RUI
OBERLIN GROUP												
Baccalaureate	48	176	278	441	326	617	12.5%	31.2%	14.7%	28.5%	53.4%	73.3%
Masters	0	2	2	11	2	13	0.1%	0.7%	0.0%	15.4%	0.1%	1.2%
Subtotals:	48	178	280	452	328	630			14.6%	28.3%		
NON-OBERLIN GROUP												
Baccalaureate	22	48	263	177	285	225	10.9%	11.4%	7.7%	21.3%	46.6%	26.7%
Masters	199	179	1,595	926	1,794	1,105	68.9%	55.9%	11.1%	16.2%	99.9%	98.8%
Subtotals:	221	227	1,858	1,103	2,079	1,330			10.6%	17.1%		

To a large extent, the higher award success rate among baccalaureate institutions is driven by an elite group of 80 liberal arts colleges that make up the so-called Oberlin Group (The Oberlin Group 2012), which submitted about 65 percent of all proposals from this cohort (Table 15). This group, representing only 3.8 percent of all PUIs, submitted 23.5 percent of total PUI proposals and received 35.2 percent of all PUI awards and 43 percent of RUI awards in the past decade (Table 15).

An analysis of endowment size in 2010 (NCES 2013) and total NSF support for science and engineering at the Oberlin Group institutions between 1999-2008 (NSF 2013c) showed little correlation between institutional resources and award success rates among member institutions (Table 16, *CURQ on the Web*), although these institutions do enjoy substantially greater resources than most PUIs. The higher number of funded proposals for Oberlin Group institutions did not result from more frequent applications, as they submitted an average of only 13.4 proposals per institution during the past decade while other PUIs submitted an average of 22.8 proposals (data not shown). Given the higher success rates for RUI proposals, it is not surprising that overall award success rates for baccalaureate and masters institutions were proportional to the numbers of RUI versus non-RUI proposals submitted. Doctoral institutions in the PUI cohort submitted very few RUI proposals (0.4% of total actions) and had an overall award success rate of only 9 percent, much lower than for other PUIs or for non-PUIs. Conversely, Oberlin Group institutions submitted nearly 75 percent of all RUI proposals in the baccalaureate cohort.

It should also be noted in Table 15 that two-year and four-year associates institutions submit relatively few research proposals and are not competing successfully for research funding. Out of a total of 24 RUI and non-RUI proposals submitted, these institutions received only one RUI award. It seems likely that most of these institutions, which make up about 40 percent of the current PUI list, are included in NSF databases because they have submitted proposals to the Transforming Undergraduate Education in Science, Technology, Engineering and Mathematics (TUES) program, or similar programs with a science education focus within NSF's Directorate for Education and Human Resources (NSF 2010).

The reasons for the approximately two-fold higher award success rate for RUI proposals from PUIs (Table 15) are unknown. While all NSF proposals are evaluated on the basis of the intellectual merit and broader impacts of the proposals under the foundation's merit review criteria (NSF, 2013d), it is possible that *ad hoc* reviewers and review panels more carefully consider the "context" for research conducted

at a PUI, as is provided for in the RUI Impact Statement of RUI proposals (NSF, 2000), than for non-RUI proposals. In a standard proposal, the PI has a more limited opportunity to provide such context in the body of the proposal. The previously noted higher success rate for prior versus new PUI investigators suggests that PI experience may also be an important contributor to success in this group.

PUI Reviewers for NSF

As is shown in Table 17 (*CURQ on the Web*) more than 94,000 individuals served as panelists or *ad hoc* reviewers of proposals submitted to the BIO Directorate between 2002 and 2012. Of these, only 7 percent were affiliated with two-year institutions, four-year associates institutions, baccalaureate institutions or masters institutions. Although PUI-specific data for these reviewers are not available, PUIs make up nearly 60 percent of all institutions (Table 8), so roughly 4 percent of reviewers in Table 17 can be assumed to be from PUIs, indicating a relatively low level of engagement with the foundation. NSF program directors recognize that PUI faculty members are an under-utilized resource in peer review of grant proposals and make an effort to identify them and recruit them for service. PUI faculty, who are broadly trained and were educated primarily at research universities, can make valuable contributions to this process. Increased involvement of PUI investigators in proposal review would expose them to leading-edge science and would provide opportunities for them to interact with program staff and learn NSF "culture." This experience would also help them to identify competitive proposals, providing valuable guidance for preparation of their own applications.

Conclusions

This study produced a comprehensive list of PUIs in the U.S. The list of PUIs will be hosted by CUR (Table 6, *CURQ on the Web*). This resource should be valuable to a variety of educational institutions, professional organizations, and funding agencies with an interest in developing sustainable programs that support undergraduate research. Future updates to this list will be required, as RUI program goals or institutional characteristics evolve. Revisions might be considered when new Carnegie Classifications are completed, approximately every five years, and as data from the Surveys of Earned Doctorates (www.nsf.gov/statistics/doctorates/) are updated by the NSF National Center for Science and Engineering Statistics (NCSES).

The original CUR proposal to the National Science Board in 1982 requested a modest \$3 million annual budget for the RUI program (Doyle et al.), which has since increased to

about \$40 million a year over the past decade. During this period overall NSF investments in undergraduate research totaled \$1.2 billion. Much of this funding was directed to non-PUI programs that support undergraduate research, and 95 percent of the \$5.5 billion in competitive award dollars from NSF's Directorate of Biological Sciences (BIO) went to non-PUI investigators during the same period. In view of the fact that PUIs enroll 63 percent of students at U.S. institutions, including about 80 percent of underrepresented minorities, and that they make significant contributions to STEM research training in this group, obvious questions arise concerning whether PUIs are receiving appropriate levels of research funding from the NSF.

An analysis of BIO funding data clearly shows that award success rates for PUIs versus non-PUIs are not different, although success rates are significantly higher for women and minority PIs in the PUI cohort. PUI proposals are competitive but average annual award sizes for PUIs are only about two-thirds the size of awards to non-PUIs. The data further show that for the 43 percent of PUI investigators who submitted RUI proposals, the funding success rate was twice as high as for non-RUI applicants. This finding suggests that PUI investigators should consider submitting more RUI proposals.

If PUIs' proposals are competitive, then how can the relatively small amount of NSF funding for PUI science be explained? The 4,581 PUI proposals considered for funding by BIO in the past decade represented only 8.3 percent of the 55,099 proposals reviewed (Table 13). The relatively low number (234) of PUIs represented by these applicants represent approximately 10 percent of the PUIs identified in the present study (Table 6), including the additional 200 potential PUIs (Tables 1, 3, 4, and 5). This means that approximately 90 percent of PUIs are not applying for undergraduate research support from the NSF (although 875 two-year institutions and 54 four-year associates institutions (Figure 3), which submitted only 0.5% of BIO proposals as shown in Table 13, are included here). The simple message in this, given the nearly identical PUI and non-PUI award success rates, is that submission of proposals should be a priority for PUIs that are interested in undergraduate research.

One group of PUIs, the Oberlin Group, maintains a strong science education tradition and has been extraordinarily successful in securing extramural support for undergraduate research from the NSF. A better understanding of the factors contributing to this success would guide efforts of non-Oberlin Group institutions to enhance support of their own undergraduate research and education programs.

Investigators from PUIs who have previously received NSF grants were funded at a significantly higher rate than new

investigators, suggesting that experience is an important factor in funding success. Previously funded investigators at PUIs would be excellent mentors for other PUI scientists who are preparing their own applications. Relatively few PUI scientists serve on NSF review panels or as *ad hoc* reviewers of proposals. This is another way that they could gain practical experience that would help them to develop more competitive proposals. Such service is also critical for effective peer review of PUI science and provides an opportunity to raise the visibility of high-quality PUI research programs at the NSF.

Finally, it should be noted that nearly all of the analyses in this article were limited to data for programs in NSF's Directorate for Biological Sciences (BIO) because these data were accessible to the authors. BIO programs support a significant portion of undergraduate research funded by the NSF, and it is assumed that the funding and demographics statistics presented here would be typical of programs in other directorates.

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