III. IMPACTS ON NSF AND THE COMMUNITY

This section seeks to identify where and by how much NSF's ability to fulfill its mission has been impacted by declining funding rates and increasing proposal submissions. In particular, this section examines impacts on:

- NSF's capacity to fund high quality and transformative research
- NSF's review process (reviewer and NSF workload, quality of reviews, etc.)
- Enabling the careers of beginning and new investigators
- Broadening participation of underrepresented groups and institutions
- Different S&E communities

Impact on High Quality and Transformative Research

As NSF's proposal submission rate has increased, the average quality of proposals has not declined. Indeed, the total number of high quality proposal submissions has substantially increased. Each year NSF declines a large number of potentially fundable proposals. However, in recent years the proportion of high quality proposals that are being declined has increased. NSF does not assign numerical scores to its proposals, and does not rank them by percentiles, because the individual review ratings associated with each proposal are not the only measure of the quality of a proposal and do not include the results of the panel evaluation or the assessment of the NSF program director. However, there is a reasonably good correlation between high review ratings and awards.[13] Thus, one way to measure the impact on high quality proposals is to look at the rate at which highly-rated proposals are being funded.

In this analysis, highly-rated proposals were defined as those whose average ratings are equal to or higher than the average rating of the awards in that fiscal year.[14] In FY 1997, 76% of highly-rated proposals were funded; in FY 2006, the funding rate of highly-rated proposals had dropped to 62%. The average rating for awards in FY 1997 and FY 2006 was virtually unchanged. In addition, although the absolute number of highly-rated proposals has grown, the proportion of all proposals that were highly-rated has remained fairly steady (20.6% in FY 1997 vs. 19.2% in FY 2006). Thus, it does not appear that there has been any significant "grade inflation"[15] with respect to proposal ratings between FY 1007 and FY 2006. This outcome is most likely due to an increase in the number of high quality proposal submissions without a corresponding increase in the ability to fund them. In FY 2006, proposals that were highly rated but ultimately declined represent a total of $2B in requested research support.[16]

With respect to impacts on transformative research, a widely-held concern is that as funding rates drop, reviewers become more conservative and less receptive to revolutionary ideas that challenge existing paradigms. This in turn discourages PIs from submitting proposals containing

[13] Shown in Figure 12 in the Report to the National Science Board on the National Science Foundation's Merit Review Process: Fiscal Year 2006 (http://www.nsf.gov/nsb/documents/2007/2006_merit_review.pdf).
[14] The average rating is calculated using the following numerical values: Excellent = 5; Very Good = 4; Good = 3; Fair = 2; and Poor = 1. Note that reviewer ratings are only one component of assessing proposal quality.
[15] "Grade inflation" is a rise in the average grade assigned to students; especially: the assigning of grades higher than previously assigned for given levels of achievement.
[16] Report to the National Science Board on the National Science Foundation's Merit Review Process: Fiscal Year 2006 (http://www.nsf.gov/nsb/documents/2007/2006_merit_review.pdf).

potentially transformative research ideas; as a consequence, support of transformative research decreases. It is difficult to determine if the current funding environment has compromised NSF support of transformative research, in part because it may take years before the transformative nature of a particular avenue of research becomes apparent.

However, IPAMM did attempt to measure the community's attitudes about transformative research and NSF in the 2007 NSF Proposer Survey. The survey results suggested that a significant portion of the community views NSF somewhat favorably in this regard—more than 56% of the respondents believed to a great or moderate extent that NSF welcomes transformative research, although only 42% believed to a great or moderate extent that NSF tended to fund transformative research. When asked where they would submit a transformative research idea, 45% of the respondents chose NSF, far exceeding the number that chose any other of a variety of other potential funding sources. Although the respondents that had served as reviewers tended to believe that transformative research was not prevalent among the proposals that they had reviewed (over 60% indicated that less than 10% of the proposals they had reviewed constituted transformative research), the majority of these reviewers felt that NSF welcomed these proposals (>51%), and that they themselves had recommended transformative research proposals for funding within the past three years (>55%). NSF is currently addressing efforts to enhance support of transformative research, which will be discussed separately with the NSB.

Impact on the Review Process

As shown earlier, the average number of research proposals submitted per PI to obtain an award has increased by 30% since FY 1997 (Figure 4), and the number of PIs submitting proposals has increased by 35% (Figure 7). In the aggregate, this represents a nearly 50% increase in the number of research proposals being submitted to NSF (Figure 3). This increase translates into a 30% increase in PI workload writing proposals, a 50% increase in the number of proposals that have to be processed by NSF, and 50% more review requests and/or panel reviews.

NSF appears to have been able to accommodate the increased workload. Table 2 indicates that from FY 2000 - 2006, during a time of rapidly increasing proposal submissions, NSF increased the percentage of the number of research proposals it processed within six months of receipt. However, there are concerns that NSF staff members and NSF systems are overstressed.

Table 2
Research Proposals Processed within Six Months of Receipt

Fiscal Year	Number of Proposals	% Processed within 6 Months
2006	31,518	78%
2005	31,574	76%
2004	31,553	77%
2003	28,678	77%
2002	25,240	74%
2001	23,096	63%
2000	21,442	54%

NSF has made concerted efforts to expand the number of reviewers in the reviewer pool, both through the actions of the program officers, and by providing information on directorate, division, and program web sites on how to volunteer to be a reviewer. However, the increase in the number of proposals has outpaced the growth in the reviewer pool. Although NSF added new reviewers every year, others dropped out, such that the net change in the number of reviewers used each year increased 15% during the five year period when proposal load increased approximately 50%. The net result is that the increase in proposals outstripped reviewers and therefore the number of proposals each reviewer is evaluating is higher, on average, than in the past.

Concerns have been raised in a number of venues about the increased burden on the reviewer community, and the potential impacts this may have on the reviewers themselves and on the quality of the merit review process. In the 2007 NSF Proposer Survey, nearly 68% of the respondents that had served as NSF reviewers indicated that their overall reviewer workload (including requests to review grant proposals for NSF and other agencies, journal manuscripts, and other types of review) had increased in the last three years. As a consequence, 36% of these respondents said that the time they were able to devote to each proposal review has either greatly decreased or somewhat decreased, while 23% said that the thoroughness of each review had decreased and 16.5% said the quality of their reviews had decreased.

A decade ago, NSF programs relied much more on mail reviews and much less on panels for proposal evaluation.[17] IPAMM believes that the significant increase in the number of proposals contributed to the increasing trend toward panel review only. It is difficult to expect individual mail reviewers to volunteer to do more than a few reviews per year; however panelists are frequently called upon to carry out ten or more reviews for a single panel. Thus, the use of panel reviews is one way to manage an increased proposal review workload. NSF is monitoring the use of the various mechanisms for merit review, to ensure that the quality of the NSF merit review process is maintained.

Impact on Beginning and New Investigators

For the ten years between FY 1997 to FY 2006, new investigators[18] consistently submitted approximately 40% of the proposals received by NSF. During the same period, new investigators comprised between 22 to 24% of all PIs that were submitting proposals. In other words, new investigators are submitting many more proposals per PI than are experienced investigators. As was observed for all other groups, proposal funding rates for new PIs fell in the period between FY 2000 and FY 2005—in FY 2000 proposal funding rates for new PIs were 22%; this rate dropped to 14% in FY 2004-2005, recovering slightly in FY 2006 to 15% (Figure 10).

[17] Report to the National Science Board on the National Science Foundation's Merit Review Process: Fiscal Year 2006 (http://www.nsf.gov/nsb/documents/2007/2006_merit_review.pdf).

[18] New investigators are defined as those that have not previously received an NSF award, and so will include some experienced PIs that are new to NSF as well as PIs that are at the beginning of their careers. However, over 70% of new investigators are within 7 years from their last degree when they receive their first NSF award, thus the "new investigator" cohort predominantly represents early career individuals.

Figure 10
Comparison of Funding Rate Trends for New and Prior PIs

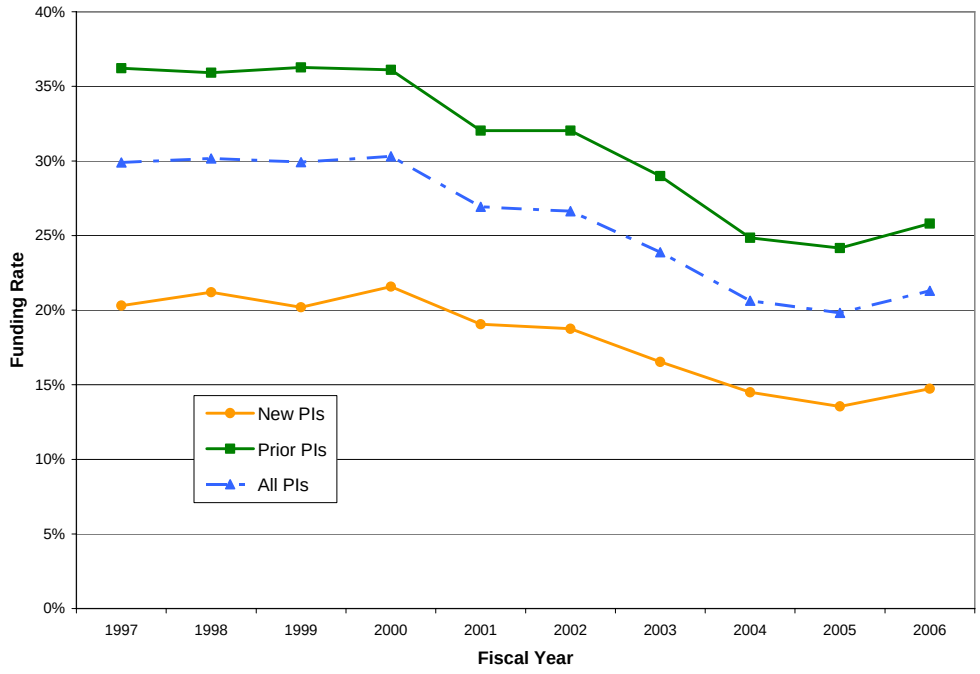

Figure legend: The proposal funding rates for research proposals submitted by new PIs, previously funded (or prior) PIs, and all PIs are shown. The data indicate that proposals submitted by prior PIs tend to be funded at a higher rate than proposals submitted by new PIs; the disparity between these funding rates lessened over time, although both funding rates decreased. Source: NSF's Enterprise Information System

However, there was no evidence that new investigators were disproportionately affected by the low funding rates as compared to the overall population of PIs, nor is it taking longer for new investigators to receive their first NSF award. In fact, as shown in Figure 11, the proportion of research awards belonging to new PIs exceeds their representation in the overall pool of PIs, and has remained constant at 27-28% of the full portfolio of research awards for ten years (between FY 1997 and FY 2006). In addition, the percentage of PIs who received their first award within seven years of getting their degree remained fairly constant from FY 1997 to FY 2006 (Table 3).

Table 3
Cumulative Percentage of PIs Receiving Their First NSF Research Award Within Seven Years of Their Last Degree (Comparing FY 1997 and FY 2006)

	FY 1997	FY 2006
NSF	73%	74%
BIO	65%	70%
CISE	88%	81%
ENG	71%	70%
GEO	76%	77%
MPS	72%	75%
SBE	74%	75%

Table Legend: The number of years from last degree was determined for new PIs receiving their first award in either FY 1997 or FY 2006. The data in the table show the percentage of those new PIs that had received their last degree no more than seven years earlier. The differences between the directorates likely reflect differences in career paths for different disciplines (e.g., the extent to which postdoctoral fellowships are required before moving into faculty positions varies significantly between fields). Source: NSF Budget Division

Figure 11
Comparison of the Presence of New PIs in the Award Portfolio in FY 1997 and FY 2006

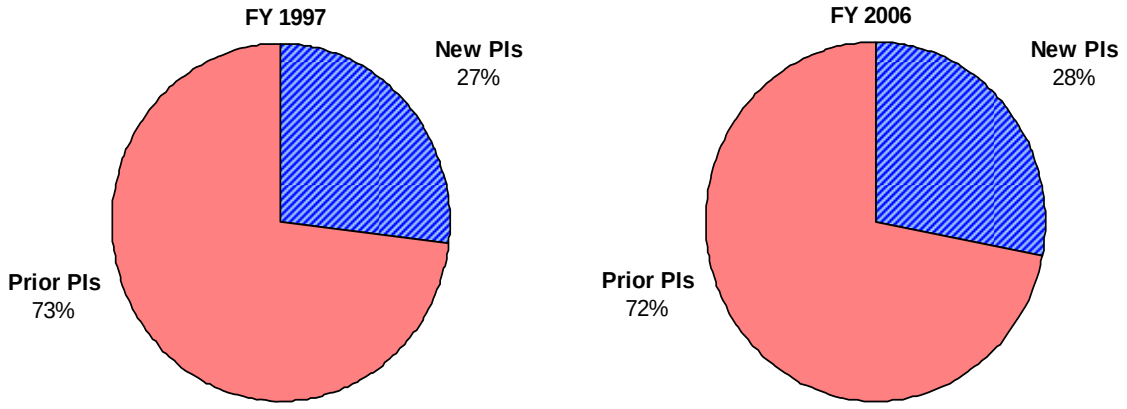

Figure legend: The two pie charts display the proportion of all awards that were given to either new PIs or prior PIs, comparing the distribution in FY 1997 and FY 2006. Source: NSF Budget Division

Another concern related to the potential impact of reduced funding rates on early-career investigators is that their ability to sustain funding may be compromised. To address this question, the funding status of cohorts of PIs who received their first NSF award in either FY 1995 or in FY 2000 was assessed.

Figure 12 shows that, for both cohorts, there is a gradual decline in the number of PIs who sustain funding for the first two years after receiving an award with a significant drop to about 40% after three years, after which the number of PIs with sustained funding declines much more slowly. Given that the average duration of an NSF award is approximately three years, these data suggest that for both the 1995 and 2000 cohorts, between approximately 40% of new PIs are able to secure continued NSF funding (for either the same project or for a new project). The similarity of the profiles of these two cohorts suggests that the ability to maintain funding once

obtained has not changed significantly in recent years. It is not possible to know why some PIs did not sustain NSF funding. It is likely that some tried to renew their NSF funding but were unsuccessful while others left NSF because they secured funding from other sources (these data only reflect NSF funding and will not capture the latter possibility).

Figure 12
Comparison of Trends in Continuation of Funding for New PIs

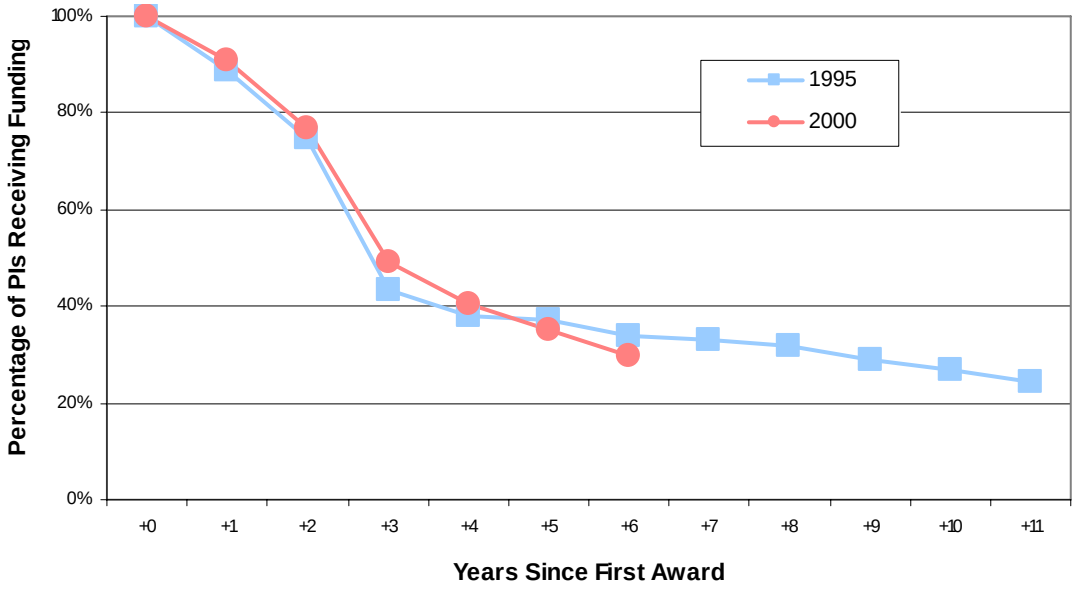

Figure legend: This figure compares the percentage of two cohorts of PIs who maintained funding over several years after receiving their first NSF award—those who received their first award in FY 1995, and those that received their first award in FY 2000. Source: NSF Budget Division

Impact on Underrepresented Groups[19] and Institutions

Women and Minorities

There is no indication that declining funding rates have had, so far, a significant disproportionate impact on support for minorities and women. Figure 13 indicates that during the period between FY 2000 and FY 2006, when the overall funding rate for research proposals dropped from 30% to 21%, the funding rate dropped equivalently for both men (from 30% to 20%) and women (from 31% to 21%).[20] During this same time frame, funding rates for minorities dropped from 26% in FY 1997 to 21% in FY 2006 (recently recovering from a low of 18% in FY 2004).[21] In recent years it appears that the gap between minority groups and non-minority groups has narrowed, a further indication that minority groups have not been disproportionately affected by the decline in funding rate.

[19] For the purpose of this report, the underrepresented groups that were studied included women and racial/ethnic minority groups that are underrepresented in the sciences and engineering (African Americans, Hispanics, Native Americans, Native Alaskans, and Hawaiian/Pacific Islanders). IPAMM was not able to measure the impact on persons with disabilities, as there were insufficient data on this group for a meaningful trends analysis.
[20] During the period FY 1997-2006 the number of proposals with for which the PI did not report their gender increased (growing from 0.2% in FY 1997 to 0.8% in FY 2006), making the interpretation of the data less certain.
[21] During the period FY 1997-2006 the number of proposals for which the PI did not report their race/ethnicity increased (growing from 3.2% in FY 1997 to 7.0% in FY 2006), making the interpretation of the data less certain.

Figure 13
Comparison of Funding Rate Trends for Underrepresented Groups

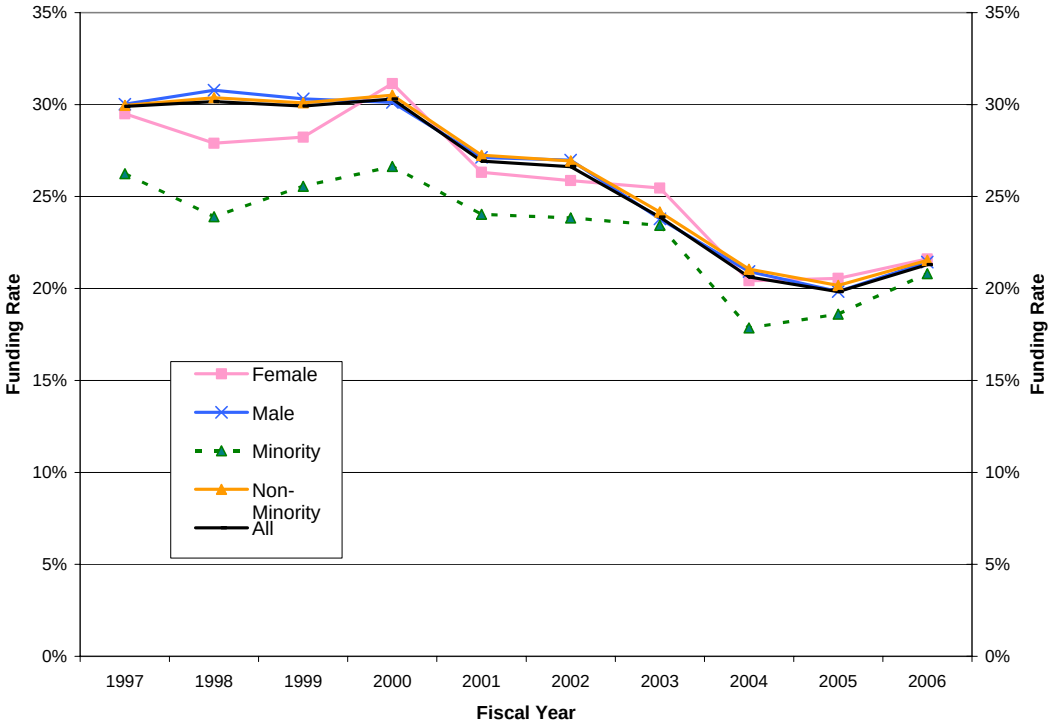

Figure legend: The proposal funding rates for research proposals submitted by all PIs, female PIs, male PIs, minority PIs, and non-minority PIs are shown. All groups experienced reduced funding rates over time. Note that data for PIs of unknown gender (growing from 0.8% to 4.3% of all PIs between FY 1997 and FY 2006) and unknown race/ethnicity (growing from 3.2% to 7.0% of all PIs between FY 1997 and FY 2006) have been excluded from the graph. Source: NSF Enterprise Information System

An additional concern is that, although the overall funding trends do not show evidence of a disproportionate impact on underrepresented groups, there may be hidden impacts on their ability to either get first-time funding, or to get subsequent funding. To address this issue, the funding trends for new and prior female or minority PIs were compared to those for new and prior male or non-minority PIs. As shown in Figure 14, women are slightly more successful at getting their first research award than men or minority PIs, and are equally likely to get subsequent funding as compared to male PIs. Minority PIs lagged slightly behind non-minority PIs in getting their first research award between FY 1999 and FY 2002, but have closed the gap in recent years. Between FY 1997 and FY 2002, minority PIs were less successful as prior PIs than their non-minority counterparts, however in recent years (when the overall funding rate was decreasing) that disparity has disappeared. Thus, these data also support the conclusion that women and minorities have not been disproportionately impacted by the declining funding rates, either as new or prior PIs.

Figure 14
Trends in Proposal Funding Rates for New and Prior PIs within Underrepresented Groups

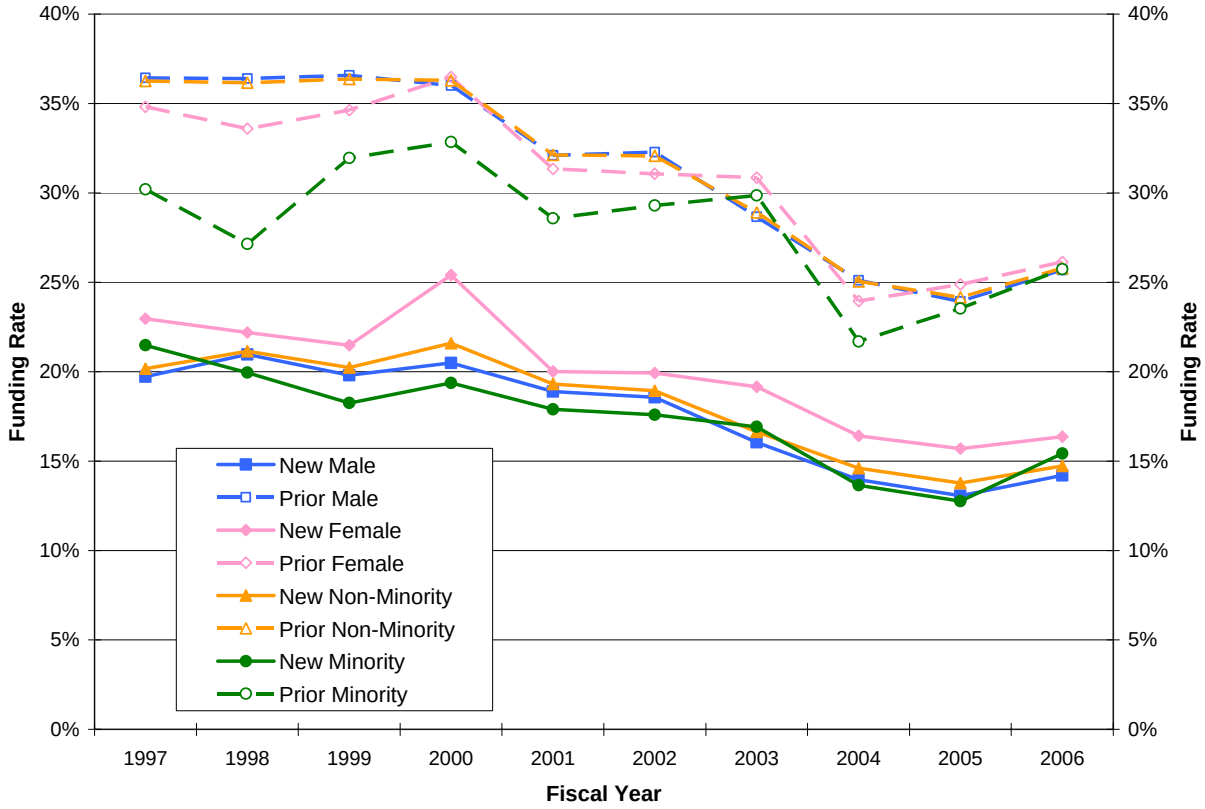

Figure legend: The proposal funding rates for research proposals submitted by new male PIs, prior male PIs, new female PIs, prior female PIs, new minority PIs, prior minority PIs, new non-minority PIs, and prior non-minority PIs are shown. Note that data for PIs of whose gender or race/ethnicity were not reported have been excluded from the graph. Source: NSF Enterprise Information System

Table 4 indicates that the representation of underrepresented groups in both the award and proposal portfolios has remained relatively stable between FY 1997 and FY 2006, and in fact shows some growth in recent years. However, we note that the numbers of proposers not reporting gender and/or race/ethnicity have grown over time. The size of the pool of proposals on which race/ethnicity is not reported is now comparable to the number of proposals known to come from members of minority groups. It is not clear how this may complicate our understanding of these data.

Table 4
Presence of Underrepresented Groups in the Proposal and Award Portfolios from FY 1997 to FY 2006

A.

	PI Race/Ethnicity											
	Minority				Non-Minority				Not Reported			
FY	Proposals		Awards		Proposals		Awards		Proposals		Awards	
1997	922	4.6%	242	4.1%	18,379	92.2%	5507	92.4%	634	3.2%	212	3.6%
1998	912	4.7%	218	3.8%	17,686	92.0%	5372	92.7%	620	3.2%	206	3.6%
1999	943	4.7%	241	4.0%	18,583	92.4%	5594	92.9%	592	2.9%	184	3.1%
2000	1,025	4.8%	273	4.2%	19,813	92.4%	6046	93.0%	604	2.8%	179	2.8%
2001	1,140	4.9%	274	4.4%	21,010	91.0%	5725	92.1%	946	4.1%	219	3.5%
2002	1,229	4.9%	293	4.4%	22,638	89.7%	6097	90.7%	1,373	5.4%	331	4.9%
2003	1,391	4.9%	326	4.8%	25,643	89.4%	6194	90.4%	1,644	5.7%	328	4.8%
2004	1,669	5.3%	298	4.6%	27,871	88.3%	5868	90.2%	2,012	6.4%	342	5.3%
2005	1,720	5.4%	320	5.1%	27,691	87.7%	5584	89.2%	2,163	6.9%	354	5.7%
2006	1,822	5.8%	379	5.6%	27,474	87.2%	5915	88.1%	2,222	7.0%	418	6.2%

B.

	PI Gender											
	Female				Male				Not Reported			
FY	Proposals		Awards		Proposals		Awards		Proposals		Awards	
1997	3,146	15.8%	928	15.6%	16,622	83.4%	4,990	83.7%	167	0.8%	43	0.7%
1998	3,592	18.7%	1,002	17.3%	15,484	80.6%	4,766	82.2%	142	0.7%	28	0.5%
1999	3,613	18.0%	1,020	16.9%	16,364	81.3%	4,961	82.4%	141	0.7%	38	0.6%
2000	3,786	17.7%	1,179	18.1%	17,498	81.6%	5,271	81.1%	158	0.7%	48	0.7%
2001	3,766	16.3%	991	15.9%	19,056	82.5%	5,170	83.1%	274	1.2%	57	0.9%
2002	4,400	17.4%	1,138	16.9%	20,468	81.1%	5,522	82.2%	372	1.5%	61	0.9%
2003	4,867	17.0%	1,239	18.1%	23,207	80.9%	5,521	80.6%	604	2.1%	88	1.3%
2004	5,651	17.9%	1,154	17.7%	24,956	79.1%	5,221	80.2%	945	3.0%	133	2.0%
2005	5,909	18.7%	1,214	19.4%	24,590	77.9%	4,878	77.9%	1,075	3.4%	166	2.7%
2006	5,961	18.9%	1,288	19.2%	24,212	76.8%	5,189	77.3%	1,345	4.3%	235	3.5%

Table Legend: The race/ethnicity (A) and gender (B) demographics of the PIs on all research proposals that were submitted and all awards that were funded between FY 1997 and FY 2006 were determined. These tables display the number of proposals submitted and awards made by PIs in each race/ethnicity category (minority, non-minority, and not reported) as well as in each gender category (male, female, and not reported), and their proportion of the total number of proposals submitted and awards made in each fiscal year. This demographic information is provided to NSF on a voluntary basis, and some PIs choose not to identify their gender and/or their race or ethnicity. Note that there has been an increase in the tendency to not report gender and race/ethnicity information over time; the gender not reported category grew from 0.8% to 4.3% of all PIs between FY 1997 and FY 2006, and the race/ethnicity not reported category grew from 3.2% to 7.0% of all PIs between FY 1997 and FY 2006.

Institution Type

As shown in Figure 15, of the research proposals submitted to NSF in FY 1997, 66% came from the research intensive (RI) institutions[22], compared to 65% in FY 2006. There were no significant percentage shifts in proposal submissions from other institution types. Since NSF

[22] Research intensive (RI) institutions represent the group of one hundred Ph.D. granting institutions that received the most research funding from NSF in that year.

proposals increased by 50% over this period, the numbers of proposal submissions from all groups increased significantly and at similar rates. Figure 15 demonstrates that the profile of institutions receiving NSF awards has not changed much in the past decade. Of the research proposals awarded in FY 1997, 75% went to the research intensive institutions, compared to 74% in FY 2006. There were no significant shifts in support for other institution types.

Figure 15
Comparison of Institution Types in the Proposal and Award Portfolios in FY 1997 and FY 2006

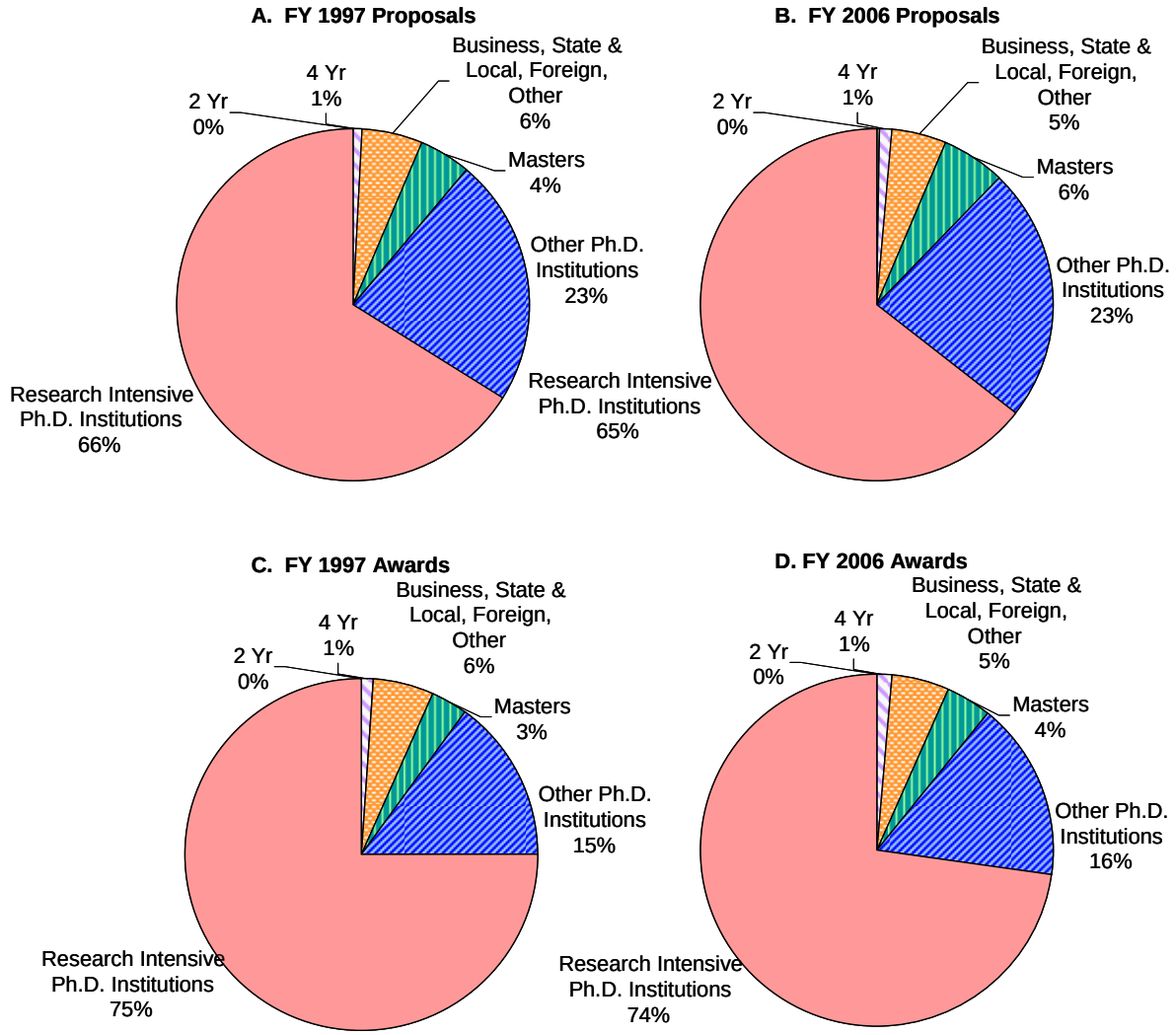

Figure legend: The pie charts display the proportion of all proposals (A and B) and awards (C and D) categorized by institution type, comparing the distribution in FY 1997 (A and C) and FY 2006 (B and D). The percentage of proposals and awards that are associated with 2-year institutions is less than 0.1%, and so does not appear in the charts. Source: NSF Budget Division

A similar analysis was done for institutions in EPSCoR jurisdictions[23] with similar outcomes. In FY 2006, institutions in EPSCoR jurisdictions submitted 16% of the proposals and received 13% of the awards. These percentages are unchanged from FY 1997.

Impact on Different S&E Communities

As noted earlier, NSF currently supports over 50% of the Federal non-medical fundamental research at U.S. colleges and universities. That proportion is even higher for some communities, such as computer science, mathematics, and non-biomedical biology. PIs in S&E communities that are highly dependent on NSF for funds tend to continue to submit proposals to NSF after repeated declines for a much longer period of time than do PIs with alternate funding sources. For example, PIs who submit proposals to the Division of Mathematical Sciences (DMS) represent a community highly dependent on NSF support whereas those that submit proposals to the Division of Chemistry (CHE) are not as dependent on NSF support. To measure the rates at which these two communities leave NSF if unsuccessful at obtaining funding, IPAMM looked at the submission histories for PIs that had submitted proposals to either CHE or DMS between FY 1997 and FY 2006, and identified a population of individuals for each division that had never received an award. The submission histories for these two populations of PIs were compared to determine how many proposals each PI submitted during that ten year period. As shown in Figure 16, over 90% of the never-awarded CHE PIs submitted only one proposal to NSF, with fewer than 10% making multiple attempts. For the never-awarded DMS PIs, 63% submitted only one proposal, with 37% making multiple attempts.

Figure 16
Number of Proposals Submitted by PIs that Never Received an Award

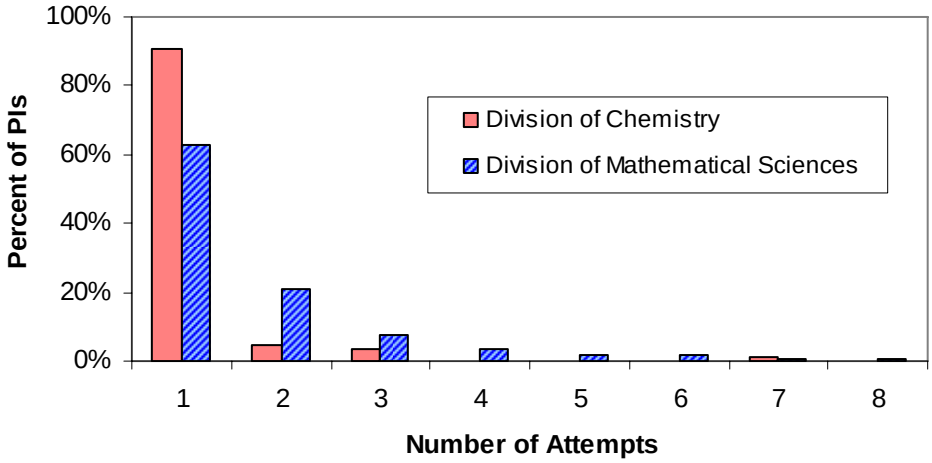

Figure legend: Over the past ten years, 88 PIs submitted proposals to the Division of Chemistry without receiving an award, while 118 PIs submitted proposals to the Division of Mathematical Sciences without receiving an award. The submission histories of these PIs were compared to determine how many proposals each person submitted during that time period. Source: NSF Budget Division.

[23] The mission of the Experimental Program to Stimulate Competitive Research (EPSCoR) is to strengthen research and education in science and engineering throughout the United States and to avoid undue concentration of such research and education. A list of the jurisdictions that are eligible for the EPSCoR program can be found at http://www.nsf.gov/od/oia/programs/epscor/statewebsites.jsp.

In the 2007 NSF Proposer Survey, respondents were asked the degree to which they depended on NSF as the prime source of potential funding. Overall, nearly 47% of the respondents indicated that they relied on NSF for 50% or more of their research funding. This percentage varied widely across the different communities that NSF serves, ranging from only 26% for respondents that usually submitted proposals to ENG to approximately 55% for respondents that usually submitted proposals to OPP, MPS or GEO. Although low funding rates have created stress in all of the communities that NSF serves, the negative impacts may be greater on S&E communities that are highly dependent on NSF support, and on communities with fewer academic positions and more soft-money positions. These groups may be more likely to lose research funding due to a lack of alternative funding options, and be more inclined to continue submitting proposals in the face of declining funding rates.

Conclusions

IPAMM undertook a thorough analysis of the potential impacts of declining funding rates on beginning investigators and underrepresented groups (defined by gender, race/ethnicity, institution type, or EPSCoR status), one of the concerns that motivated this study. The data show no evidence that any of these groups has been disproportionately disadvantaged by declining funding rates. Although all groups experienced lower funding rates, the presence of beginning investigators and underrepresented groups in the NSF portfolio was maintained and, in some cases, even slightly improved.

IPAMM also did not find evidence to substantiate the concern that the increasing proposal submission rate would lead to a deterioration in the overall quality of the proposals submitted, or of the awards that were being made. However, there is evidence that more high quality proposals are being declined. These unfunded proposals represent lost opportunities to advance knowledge, which may ultimately impact the nation's competitive edge. Nonetheless, these analyses indicate that the excellence of NSF's portfolio of awards has been maintained.

The largest impact that was identified was the increased work for all involved – the PI community, the reviewer community, and the NSF staff. The increase in proposal submissions has had an impact on NSF's merit review system; there are several indications that it is overstressed. Reviewers are reviewing more proposals than they were in the past; responses from reviewers to the 2007 NSF Proposer Survey suggest that they are overworked and that their reviews may be diminishing in quality. Although the survey indicated that PI satisfaction with NSF's proposal submission and review processes was reasonably high, many respondents expressed concerns about the quality of the reviews. The survey also reflected the growing anxiety of the community—although NSF has maintained both the percentage of proposals that are processed within six months and the average time to decision since FY 2002, there is growing dissatisfaction with the time to decision, which is likely related to the desire to revise and resubmit declined proposals at the next earliest opportunity. In the long-term, the increasing amount of time that is being spent on efforts associated with obtaining funds will detract from the nation's scientific and engineering enterprise.