THE PLANETARY SCIENCE WORKFORCE: GOALS THROUGH 2050. J. A.. Rathbun[1], B. A. Cohen[2], E. P. Turtle[3], J. A.. Vertesi[4], A. S. Rivkin[3], S. M. Hörst[5], M. S. Tiscareno[6], F. Marchis[6], M. Milazzo[7], S. Diniega[8], E. S. Lakdawalla[9], N. Zellner[10], [1]Planetary Science Institute (1700 East Fort Lowell, Suite 106, Tucson, AZ 85719-2395, rathbun@psi.edu), [2]NASA Marshall Space Flight Center, [3]Johns Hopkins Applied Physics Lab, [4]Princeton University, [5]Johns Hopkins University, [6]SETI Institute, [6]USGS, [8]JPL, [9]The Planetary Society, [9]Albion College.

Introduction: The planetary science workforce is not nearly as diverse as the society from which its membership is drawn and from which the majority of our funding comes. The most recent survey (2011) of the planetary science workforce [1], showed that only 25% of responding planetary scientists were women; while by ethnicity, while 87% were white, 7% were Asian, and 1% each Black and Hispanic. The US population in 2010 was 51% women and 64% white, 13% Black, 16% Hispanic, and 5% Asian [2]. The curent planetary science workforce has an overrepresentation of men, particularly white and Asian men.

Diversity and inclusiveness along gender, ethnicity, ability, sexual orientation, generational, and other axes is a business as well as a social imperative. Organizations that embrace diversity as a vehicle for approaching complex tasks and processes succeed in increasing creativity and innovation, and diversity in leadership positions encourages recruitment and retention of top talent [3-5].

By 2050, demographics in the US will shift further, resulting in 47% whites, 29% Hispanic, 13% Black, and 9% Asian [6]. Hence, if no action is taken there will be a growing discrepancy between the representation of the US diverse communities in the planetary science workforce.

Why diversity: *Innovation:* Diverse workforces are proven sites of innovative and interdisciplinary thinking. Places where invididuals come together from different backgrounds offer new solutions to intractable problems, leading to both technological and scientific breakthroughs [7]. By contrast, places with high levels of homogeneity in their workforce are subject to groupthink and risk [8,9]. Investment towards evening the playing field for female scientists and scientists of color is an investment in NASA's innovation.

*Funding***:** The planetary science workforce survey showed that 72% of planetary science research is supported by US public research funds (NASA and NSF) [1]. Since funds are from the public, ensuring public support of our scientific endeavors is particularly important for planetary science. As our workforce threatens to become increasingly less diverse than the US population, it will become difficult for the US public to see themselves engaged in planetary science, and public support will likely wane.

Barriers to entry: In industries that pride themselves on meritocratic advancement, one might suggest that the best junior participants will rise like cream to the top. But the notion that well-qualified minorities fail to make it in science because they are not good candidates has been disproved by a barrage of sociological studies of the sciences and technical domains.

The role of culture: Being reminded of minority status negatively affects people's performance [10]. Also, minorities who attempt to take leadership roles acquire negative reputations because they are perceived as deviant [11]. Experimental studies that change the name on a resume have shown the tremendous effects of implicit bias at play in evaluation of female and minority candidates for promotion, support, or hiring [e.g. 12], more so during economic hard times [13]. Meanwhile, women who are judged "competent" are typically held back in their careers instead of offered opportunities to advance [14] – or hold themselves back so as to remain in-line with gendered expectations [15].

Masculine work cultures can create self-fulfilling prophecies, where the right person for the technical or scientific job can only be white and male [16]. Peer networks and mentor relationships are also essential for the advancement of young scientists [17]; these relationships may arise naturally for certain young men with their senior colleagues but are unavailable to women and minorities.

The role of demographics: In addition to cultural barriers, studies of organizations demonstrate that environments with fewer than 30% minorities are subject to devastating interpersonal dynamics that punish those same minority individuals for their participation. 15% or fewer minorities invokes a tokenist environment, where individuals are negatively impacted by their heightened visibility [18].

Demographics and measures of success: Insufficient data exists to evaluate the impact of the situations described above in planetary science. Considering involvement in a spacecraft mission as one possible measure of success as a planetary scientist, Rathbun et al. [19,20] determined the percentage of women participating in the original science teams of 26 NASA robotic missions over a 41-year period. They found that since 2001 the participation of women has remained constant at about 15%, substantially less than the overall percentage of women planetary scientists, dramatically different from the US population, and more likely to trigger poor outcomes. Rathbun et al. were unable

to quantitatively study the number of scientists of color on spacecraft teams, but concluded that the number remains very low.

Suggestions for equity: The above data suggest that there are barriers in place within planetary science which prevent equal participation from certain groups.

Step 1: Determine who is currently affected by the barriers. The demographic data indicate that white women and people of color are not only finding barriers to entering planetary science, but, once participating, they are finding barriers to funding success and inclusion on teams. We do not know which structural factors are at play, nor which determine how other groups are affected, i.e. those with minority statuses such as sexual orientation and disability.

NASA has recently begun to collect data on demographics information for people submitting research applications through the NSPIRES system. This is a welcome change, but data collection is only the first step to understanding the problem. NASA must fund analysis of these data and distribution of the results. Studies to address this issue must start immediately to enable positive impacts through 2050.

Step 2: Determine the nature of the barriers. The AAS Committee on the Status of Women in Astronomy conducted a survey on workplace climate and found that 8% of respondents had been harassed because of their race, 5% for sexual orientation, and 32% because of their gender [21], indicating that harassment is one barrier to success in planetary science.

Step 3: Invoke policies to remove barriers. Data will help to establish which issues are at play. But policy changes can yield immediate effects. For instance, the AAS recently released a statement encouraging universities to limit the use of Physics GRE scores in graduate admissions in the astronomical sciences after studies demonstrated that the GRE scores were not correlated with success but were correlated with demographic information [22]. Such policy change is expected to have an important effect on their community.

An implementable policy that could be enacted immediately would be to use more participating scientist programs on spacecraft missions, since those programs have a greater participation of women than the originally selected teams [20]. Mentorship networks, specialist conferences, and scholarships have also been implemented in other fields such as physics [23] and computer science [24]. NASA should also consider implementation of implicit bias training for all review panels. Since NASA is currectly collecting demographic information, we hope to find data on whether the demographics of funded proposals match that of the submitted proposals and whether implicit bias training changes the outcome.

We require more data than are currently available to have sufficient guidance on how to remove the barriers that prevent minority groups success in planetary science. However, current policies are not reversing the trend. Therefore, fearing and delaying changes to current practices will continue the disadvantages to minority groups, and the advantages of majority groups. We encourage NASA to make bold, straightforward, visible policy changes now and to collect the data necessary to determine whether implemented changes have the desired effect on our community. Development and and implementation of a concrete long-term strategy will show that NASA leadership are committed to improving the situation for underrepresented minorities, and making Planetary Science inclusive of the society whom we serve.

References: [1] White, et. al. 2011 (http://lasp.colorado.edu/home/mop/files/2015/08/Report.pdf). [2] 2010 US Census Brief (http://www.census.gov/prod/cen2010/briefs/c2010br-02.pdf). [3] Jayne, et al. (2004) Human Resource Management 43, doi:10.1002/hrm.20033. [4] Richard (2000) *Academy of Management Journal* 43, 164-177, doi:10.2307/1556374. [5] Robinson, et al. (1997) *Academy of Management Journal* 11, 21-31, doi: 10.5465/AME.1997.9709231661 [6] Passel, J. S. and Cohn D. (2008) *US Population Projections: 2005-2050,* (http://assets.pewresearch.org/wp-content/uploads/sites/3/2010/10/85.pdf). [7] Phillips, K. 2014. *Scientific American, 311*(4):42–7. [8] Neff, G. 2012 *Venture labor* (MIT Press). [9] Vaughan, D. 1997. *The Challenger Launch Decision* (University Of Chicago Press). [10] Steele C. and J. Aronson (1995) *J Pers Soc Psychol 69*(5):797–811 [11] Rudman, L. A., & Glick, P. 2001, *Journal of Social Issues*, *57*(4), 743–762. [12] Foschi, M., L. et al. 1994. *Social Psychological Quarterly* 57(4):326–339 [13] Thébaud, S. and Sharkey, A.J. 2016. *Sociological Science* 3: 1-31. [14] Ridgeway, C. L. 2011. *Framed by gender: how gender inequality persists in the modern world*. Oxford University Press. [15] Correll, S. J. (2004). *American Sociological Review*, *69*(1):93–113. [16] Ensmenger, N. (2015). *Osiris*, *30*(1):38–65. [17] Fox, M. F. (2001). *Gender & Society*, *15*(5), 654–666. [18] Kanter, R. M. (1993). *Men and women of the corporation*. New York, NY: Basic Books. [19] Rathbun, J. A., et al. (2015) DPS, 312.01 [20] Rathbun, J. A. (2016) DPS, 332.01 [21] Richey, C. (2015) DPS, 406.01 [22] https://aas.org/governance/council-resolutions#GRE (resolution adopted 4 January 2016). [23] www.nsbp.org [24] http://anitaborg.org/