Normalizing non-academic career paths in planetary science

Galvanizing a qualified workforce for the next decade of planetary science and exploration

White Paper Submission for the 2023-2032 Planetary Science and Astrobiology Decadal Survey

Authors

Elizabeth A. Frank, First Mode & American Astronomical Society Employment Committee (elizabeth@firstmode.com)
Paul K. Byrne, North Carolina State University
Shoshana Z. Weider, Arctic Slope Technical Services
Lindy Elkins-Tanton, Arizona State University

Co-signers

Rachel Klima, JHUAPL
Ryan Watkins, Planetary Science Institute
J. Paul Knightly, University of Arkansas
Paul V. Regensburger, University of Oregon
Joseph O'Rourke, Arizona State University
Cynthia Phillips, JPL / Caltech
Melissa G. Trainer, NASA Goddard Space Flight Center
Patricio Becerra, University of Bern
James T. Keane, Jet Propulsion Laboratory
Christian Klimczak, University of Georgia
Svetlana Shkolyar, USRA / NASA GSFC
Brendan Anzures, Brown University
Claire McLeod, Miami University, Ohio
Tanya Harrison, Planet Labs
Emilie Royer, Planetary Science Institute
Marshall Eubanks, Space Initiatives Inc
Jemma Davidson, Arizona State University
Jayashree Sridhar, National Aerospace Laboratories
Dara Laczniak, Purdue University
Shawn Brueshaber, Jet Propulsion Laboratory
Jessica L. Noviello, Arizona State University
Marshall J. Styczinski, University of Washington
Trudi Hoogenboom, Ad Astra School
Justin Garland, Hampton University
Delia Santiago-Materese, NASA Ames Research Center
Gordon Osinski, University of Western Ontario
Monica Vidaurri, Howard University / NASA GSFC
Larry Nittler, Carnegie Institution of Washington
Patrick J. McGovern, Lunar and Planetary Institute
Soumya Ray, Arizona State University
Margaret E. Landis, University of Colorado/LASP

The Problem

The fields of planetary science and astrobiology (hereafter just "planetary science") have an immense power to inspire, yet it is clear that the number of full-time academic planetary science jobs and available resources in the US is insufficient to sustain the current rate of new graduates entering the field. Presently, NASA Planetary Science Division Research and Analysis program selection rates rarely rise above 20%. However, despite the limited funds and scarcity of jobs within planetary science—and academia as a whole—a 2019 *Nature* survey of ~6,300 early-career researchers worldwide showed that, for 56% of respondents, academia was still their first career choice.[1]

The recent COVID pandemic and the resulting economic fallout has brought many of these problems to the fore. For instance, it has already brought hiring freezes to many academic institutions and highlighted the precarious employment status of early-career scientists in our community. The potential loss of a significant proportion of this demographic from planetary science endeavors could cause major detriments to the nation's long-term solar system exploration capabilities.[2]

Without a substantial increase in funding opportunities for research in planetary science, students and early-career researchers must seriously consider the prospects of careers outside academia. The heterogeneous and multidisciplinary nature of planetary science means that scientists trained within the field are naturally equipped with an array of skills that can be applied to a range of industries and positions. Furthermore, not every planetary scientist may derive professional satisfaction from a career centered on research and/or education. For examples, see the two Case Studies on page 7 of this white paper.

Yet despite the opportunities available outside academia and research, planetary science training (undergraduate, graduate, and postdoctoral) programs generally fail to appropriately inform students on "alternative" careers outside academia. For instance, **Figure 1** shows the results of a 2011 Planetary Science Workforce Survey, in which fewer than 20% of planetary scientists with a Ph.D. thought they received "Good" or "Very Good" training on non-academic careers; ~22% received no such training at all. Of course, professors who have followed (and been successful on) a "traditional" career path (i.e., college–grad school–postdoc–tenure-track position) are unlikely to be able to advise students on alternative paths based on their own experiences. There are ways, however, to change the academic culture and to improve the job prospects of students graduating from planetary science programs. **In this paper, we outline a vision for the planetary science community in the next decade and suggest a set of recommendations for the Decadal Survey in order to better equip students and researchers for planetary science-adjacent careers.**

The Vision

Over the next decade, we envision a transformation within the current planetary science community into one in which the following statements are true:

Goal 1. Planetary science graduate students are educated on career paths outside the traditional academic track (i.e., government, non-profit, industry sectors) and receive training on how to prepare for, find, and apply to those jobs.

Why This Matters: As described in the "Problem" section, there simply are not enough jobs or funding to support the number of Ph.D.s graduated yearly by universities. The resulting

[1] Woolston, C. (2019) PhDs: The Tortuous Truth. *Nature*.
[2] Glaze, L. (2020) Letter to the Planetary Science Community.

pressure on proposal selection rates and economic instability has a disproportionate impact on early-career scientists trying to establish themselves. Beyond the limited jobs and resources, not everyone actually wants to stay in an academic setting. Ironically, people who want to stay in academia are being pushed out, and those who want to pursue other career paths have to claw their way into non-academic careers because of the dearth of information on how to successfully navigate such changes successfully.

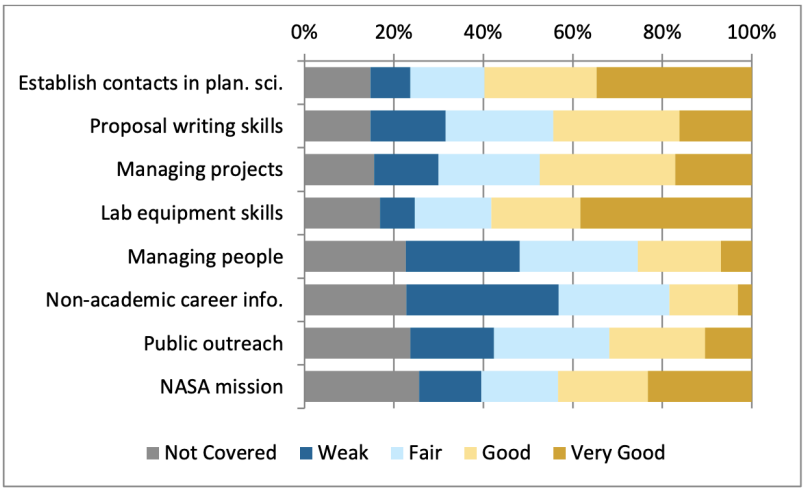

Figure 1. Respondent ratings from a 2011 Workforce Survey[3] on how well their doctoral program prepared them for critical career skills. Only ~18% of respondents believed that they received "Good" or "Very Good" information on non-academic careers; ~22% received no information at all on the topic.

Goal 2. A cultural shift has occurred such that early career scientists do not internalize a stigma that leaving academia is failure.

Why This Matters: Many sectors, including government and industry, can greatly benefit from those in leadership positions possessing the critical-thinking, problem-solving, and information-assessment skills that a Ph.D. training provides. Yet a stigma exists in the science community towards career paths that deviate from academia. Internalizing this message starts early in graduate school. The term "mastering out" is commonly used to describe students who entered a Ph.D. program but left with a Master's degree. The judgement conveyed in that phrase suggests that a Master's degree is a consolation prize for an unsuccessful venture down the academic path and, by implication, that other paths are not worthy. In reality, leaving graduate school with a Master's degree, in many cases, may be sufficient to fulfill an individual's career goals and should be encouraged in those cases.

Further anecdotes illustrate the problem. In 2019, first author Frank organized a Lunar and Planetary Science Conference (LPSC) panel featuring five planetary scientists who pursued non-academic careers. After the panel, multiple people approached Frank to thank her for organizing the panel. One individual told her that after Frank stated that "leaving academia does not make you a failure," she nearly started crying. Another attendee approached her in tears thanking her for the validation. To this day, Frank is contacted ~monthly by students seeking advice on how to pursue careers outside the academy—because they are not receiving this support within their departments.

How is the message of failure for pursuing non-academic careers being communicated implicitly and explicitly to early-career scientists? Why is this lack of training in such conflict

with the realities of the academic job market? Which demographics of our community are being disproportionately impacted by this mentality? Answering these questions warrants community-wide reflection.

Goal 3. There is a centralized, community-wide location for career resources specific to planetary science.

Why This Matters: In general, planetary scientists have physics/astronomy- or geoscience-focused undergraduate educations.[3] Accordingly, planetary astronomers tend to attend the LPSC and the Division of Planetary Science (DPS) meetings, and planetary geologists tend to go to LPSC and American Geophysical Union (AGU) meetings. (We acknowledge that this is an oversimplification of the community, but this breakdown is nonetheless illustrative.) Although the professional societies that host the AGU Fall Meeting and DPS annual meeting (the American Geophysical Union and American Astronomical Society, respectively) have robust resources for supporting astronomers and geologists, neither is fully tailored to the unique interdisciplinary nature of a planetary science education.

LPSC, although more traditionally geoscience-focused, is the largest meeting where these sub-disciplines converge. Unlike DPS and AGU, however, LPSC is a conference that is not linked to a professional organization that serves a membership. Since LPSC is run by the Lunar and Planetary Institute rather than a professional society, LPSC panels and events on career-related topics are typically grassroots-led rather than initiated by the conference organizers. As a result, available career resources are fractured and dispersed across the community.

Another consequence of the lack of a centralized professional planetary science organization is that there is insufficient data on career outcomes for planetary scientists. In 2020, DPS distributed a survey to address this need[3]; we look forward to the final report. Despite the authors' attempts at broad distribution, a potential shortcoming is that this survey is biased towards planetary astronomers and insufficiently surveys other planetary science sub-disciplines. Furthermore, those who leave planetary science entirely (e.g., to become data scientists) rather than moving to adjacent fields (e.g., aerospace) are unlikely to have received this survey, resulting in an undersampling of those who find professional success and satisfaction outside the traditional paths.

Actions

To transform the planetary science field into the community described in the previous section, we recommend the following actions.

Actions by NASA

1. NASA expands the scope of its training programs (e.g., FINESST and NPP) to encompass and engage industry partners.

Expanding NASA-funded programs that enable students and postdoctoral researchers to develop as independent researchers would be a powerful way to empower those who are looking to transition from a purely academic track. For example, the Future Investigators in NASA Earth and Space Science and Technology (FINESST) program offers funding for graduate students to carry out compelling science projects and features an explicit requirement for a mentoring plan. The FINESST award is one example of a NASA program that could be expanded in scope to enable graduate students to pursue research and

[3] Hendrix, A. et al. (2020) The State of the Planetary Science Community. LPSC 2020.

training opportunities with industry, either via co-mentorship by an academic advisor and industry partner or entirely with an industry partner as an intern. Similarly, the NASA Postdoctoral Program (NPP) could be modified to further encourage postdoctoral fellows to engage with, and even be advised by, NASA-based engineers, program managers, policy experts, etc. Although the current NASA NPP has a management arm (the NASA Postdoctoral Management Program), this element could be expanded and the usual requirement for such Fellows to have at least one year of experience as a NASA Postdoctoral Research Program Fellow could be lifted. Pairing future planetary space scientists with industry and administrative partners, particularly with a clearly articulated mentoring plan, would represent a highly effective approach for preparing those scientists for industry, management, and policy careers as well as those in the academy.

2. NASA encourages a greater focus on cross-sector partnerships within its programs.

NASA is uniquely positioned to facilitate greater collaboration and networking among academic, research, non-profit and commercial organizations to enable students to pursue non-academic opportunities after graduation. Tools such as Cooperative Agreement Notices (e.g., for the Lunar and Planetary Institute, Solar System Exploration Research Virtual Institute, and Minority University Research and Education Project), mission Announcements of Opportunity (e.g., for Discovery and New Frontiers), and statements of task for studies (such as those performed by the National Academies) represent avenues by which NASA can facilitate and help foster increased numbers of research partnerships that offer pathways for young researchers to move into industry. For example, NASA-sponsored conferences could, where appropriate and useful, host events in which routes to non-academic space-related careers are discussed. Mission AOs could include opportunities to partner early-career scientists with industry and/or engineering mentors from the mission team at particular points during phases B–D of a selected mission. These actions would not detract or endanger NASA's exploration and research objectives, but rather, would offer valuable opportunities to diversify the professional expertise of the planetary community.

Actions outside of NASA

3. University departments/research institutions provide training for non-academic careers.

Planetary science departments could collaborate with other science and engineering departments, as well as departments and schools of business, communications, government and public policy, economics, and humanities, to provide a well-rounded education for the students and make them ideally positioned for a wide range of future careers. Co-author Byrne has successfully instituted a senior undergraduate course that partners students in his Marine, Earth, and Atmospheric Sciences department with an equal number from the Department of Mechanical and Aerospace Engineering, with a view to helping each cohort learn to effectively work, and communicate, with the other. Students work in teams to develop a spacecraft mission concept, with the science students first identifying and then articulating their science objectives to the engineering students. The latter group thus learns why a given mission objective is formulated. In turn, the engineering students outline the physical, budgetary, etc., limitations that challenge these objectives, requiring that the science students iterate their science objectives in light of those limitations. Student response to this course is overwhelmingly positive, and equips the students with collaborative skills they might not otherwise have when faced with such partnerships later in their careers. But courses such as these are simply a first step: they do not themselves equip undergraduate or graduate students with the skills needed to network, identify prospective career opportunities, and pursue them.

An example at the postdoctoral-training level can be found at the Carnegie Institution of Science's Earth and Planets Laboratory (previously the Geophysical Laboratory and the Department of Terrestrial Magnetism), which has implemented a successful training program for their postdoctoral fellows, created by co-author Elkins-Tanton. As well as including sessions focused on improving research tools and skills, the fellows also regularly have the chance to interact with professionals from a range of science organizations and roles, including those outside of traditional academic and research paths (e.g., those working for science journals, federal funding agencies, as well as defense, and gaming companies). Co-authors Frank, Weider, and Byrne all benefited from this program as postdocs.

Another approach to improve the breadth of student/early-career researcher training is to provide practical and translational experience (outside of direct research) during the program. An easy example is inviting non-academic colloquium speakers to show to students—and faculty!—the breadth of possible career paths. Another approach could be to encourage undergraduate and graduate students to conduct internships or co-ops in a sector outside of academia (e.g., government, non-profit, private). Such an experience would serve multiple purposes: (1) future career options if they want to work outside of academia, since in 2019, 70.4% of interns received an entry-level job offer from their employer;[4] (2) career resilience and having a backup plan if an academic or research path does not work out; (3) network strengthening, no matter what career path they follow; and (4) a broadened perspective if they stay in academia and advise students on their career options.

4. A planetary science professional society inclusive of all sub-disciplines is created or expanded from an existing organization.

Though a non-trivial task, establishing a planetary science professional society—analogous to the AGU for geologists and the AAS for astronomers—inclusive of *all* relevant sub-disciplines would serve multiple purposes. Namely, such a society would allow: planetary science career resources to be centralized; a multidisciplinary, multisector network of planetary scientists (no matter their ultimate career path) to be maintained; the data collection and tracking of career outcomes; and senior generations of planetary scientists to easily connect with their peers, early-career researchers, and students for career development.

This organization could follow the AAS, which has a discounted "Alumni" membership rate to incentivize those not performing astronomy research to retain their membership at a cheaper rate, allowing them to stay connected to their academic community—to the benefit of all. The creation of a planetary science professional society could also help to facilitate specific aspects of the vision and actions we have laid out in this paper. Moreover, the society would provide the community with a centralized voice—with which to communicate to NASA, other government agencies, and beyond—but which is currently fragmented, e.g., between the geoscience-focused AGU or planetary astronomy-focused DPS as well as across the numerous planetary-body-focused Assessment/Analysis Groups.

Creating a new professional society would require substantial effort, capital, and community support; an approach to minimize the effort might be to splinter off from an existing organization within the planetary science community, such as the Planetary Society or Universities Space Research Association. Another option is to expand the scope of the DPS to welcome planetary scientists with a geoscience background (or another expertise that is not astronomy-related). Most geoscientists do not attend DPS or are aware of its resources. Thus, expanding its scope would leverage the existing resources and frameworks from the DPS as well as an existing—though incomplete—network of planetary scientists.

[4] National Association of Colleges and Employers. (2019) Converting Interns, Co-Ops into Full-time Hires on the Rise.

Conclusions

We believe that the set of actions outlined above will create a culture that normalizes non-academic career paths and in so doing would (1) relieve some pressure on NASA's R&A program to support the growing planetary science community and (2) provide a better-equipped planetary science workforce for any direction an individual may wish to take their career. Having advocates for planetary science distributed across all workforce sectors—academia, non-profit, government, industry—can only serve to benefit our community and its goals of unraveling the mysteries of our solar system.

Case Study 1: Academia → NASA Mission → Aerospace Sector

Name	Elizabeth Frank
Undergraduate Education	Interdisciplinary Science with Geology Concentration & Astrobiology Minor, Rensselaer Polytechnic Institute (2009)
Graduate Education	Planetary Geochemistry, University of Colorado at Boulder (2014)
Postdoctoral Experience	MESSENGER Postdoctoral Fellow, Carnegie Institution for Science (2014–2016)
Professional Experience	Geospatial Analyst, Planetary Resource, Inc. (2016) Director of Data Products, Planetary Resources, Inc. (2017–2018) Applied Planetary Scientist, First Mode (2018–present)

Experience

Early in graduate school, I realized a professorship wasn't for me, but the idea of relying heavily on grant money as a research scientist, the most probable alternative, for the rest of my career was not appealing either. An internship at JPL confirmed my love of missions and space exploration, so I was thrilled to join the Carnegie Institution for Science as a MESSENGER postdoc. Although I was living my dream as a NASA team member, I still wasn't enamored with the realities of being a research scientist and decided I needed to try a different direction. I spent much of my free time during my postdoc researching career options, studying the industry job search process, and networking. This preparation set me up for success when I applied to an open position at Planetary Resources, the asteroid mining company. That experience led to my current role as an Applied Planetary Scientist at start-up First Mode, where I continue to enjoy applying my skills to interdisciplinary projects in and beyond aerospace.

Take-away Message

Loving a subject is not the same as loving a job. There is a mentality in academia that if you are "good enough," you'll put up with any negative aspects of the career path. Deciding to take a different direction can lead to feeling of inadequacy, when really the issue is job fit. The trick in finding the right job for you is to strike the balance between pros and cons, which are different for everyone. I still love planetary science, but I would not enjoy the day-to-day

realities of being a professor or a research scientist. Industry is a far better fit for my preference to work in a fast-paced environment with diverse projects.

Case Study 2: Academia → Science Writing → NASA HQ

Name	Shoshana Weider
Undergraduate Education	Earth Sciences, University of Oxford (2007)
Graduate Education	Lunar Science, Birkbeck College (2010)
Postdoctoral Experience	MESSENGER Postdoctoral Fellow, Carnegie Institution for Science (2011–2014)
Professional Experience	Freelance science editing and writing (2012–2018) NASA PSD Program Officer (2018–present)

Experience

I decided to leave academia and full-time research after my postdoctoral fellowship for two main reasons: (1) I did not have an overarching science question (or set of questions) that would define and sustain my career; and (2) I did not want to face the constant need to write proposals to fund my research and my role. I decided to move into science communication because writing is an inherent skill I've always had and enjoyed cultivating. While still a postdoc, I began working as a freelance editor—working on a range of science and engineering publications aimed at a variety of audiences. After finishing my postdoc, I increased my freelance activity, and worked for a variety of major STEM organizations in the UK and Europe (including the European Space Agency, Imperial College London, Diamond Light Source, and the Science Media Centre, and wrote a children's book for DK). An opportunity to become a Program Officer in the Planetary Science Division at NASA Headquarters drew me back to the planetary science community in a full-time capacity. In this role, I get to use my scientific training, my project management and communication skills, expand my understanding of the policy side of science research, and continue to engage with, and serve, the planetary science community of which I am part.

Take-away Message

Communication and project management are key parts of the scientific process. As just a few examples, the skills researchers develop in designing and running research projects, in writing and reviewing papers and proposals, and in giving lectures and presentations are highly valuable transferable skills that can be applied in a host of industries.