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**Title:** The Need for a Rational Framework for Coordinated Management of Future Exploration, Uses and Exploitation of Outer Space Environments and Resources

**Authors:** [Race, Margaret](#); [Kramer, William](#)

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### Abstract

Although there is an acknowledged need to manage the environments of extraterrestrial bodies like the Moon, Mars, or even asteroids, there are currently no international policies for guiding space-based activities including exploration, resource use, and exploitation that could impact planetary environments (e.g., mining, energy production, and general construction of infrastructure required for landing areas, extended human habitation, large telescopes, or facilities away from bases, etc.). There is an obvious need to develop a clear, justifiable and implementable framework in anticipation of proposals for diverse activities and uses beyond Earth, whether by governments, non-governmental, commercial, or private entities. In recent years, a variety of suggestions have been published on how to manage space environments based on adaptations of various Earth based analogues (e.g., industry codes of conduct and best management practices; establishment of reserves; mitigation for or control of unavoidable impacts; monitoring claims; developing review processes similar to environmental impact assessments, etc.). Clearly, standards or approaches to avoid harmful contamination or irreversible damage to extraterrestrial environments are warranted. Yet the path forward to achieving such policies is uncertain at best. What project planners and proponents need are clear guidelines and policies that include more than vague notions of responsible activities. The development of such policies will take considerable time as evidenced by the nearly two-decade long process for considering COSPAR's Planetary Protection policy for human missions beyond Earth orbit. Already, COSPAR's Panel on Planetary Exploration (PEX) has begun to consider issues of space environmental management beyond planetary protection concerns, but it will undoubtedly take many more years to provide necessary details. In addition, while other groups are focusing on regulatory approaches and policies for exploration and uses beyond Earth orbit, they are a long way from dealing with the implementation details needed to guide space activities for different bodies. In the meantime, there is no cross-sector plan or standardized framework for assessing how and to what extent human or directed robotic activities might affect surface environments during either general science exploration, commercial/private activities or resource exploitation. In addition, there are no criteria on which to gauge the direct, indirect or cumulative impacts on space environments or their sustainability over time. This is particularly problematic for areas of bodies that might be affected by inadvertent transfer of Earth associated microbes and materials - which might contaminate subsurface ices or other areas considered for

resource utilization (different from planetary protection concerns per se). Looking ahead, it is certain that many considerations will need research attention. How might an effective and practical process be developed to assess the extent to which human or robotic activities may affect extraterrestrial environments? Would such a process include opportunities for public review and comment? Might a uniform protocol or set of voluntary guidelines be developed to encourage project proponents to fully describe their proposals, identify how they may affect extraterrestrial environments and describe measures that will be taken to mitigate or reduce adverse effects? Just as the development of planetary protection requirements for human exploration missions have required step-wise, cross-cutting, collaborative efforts involving both science and technology communities from many countries, so too will the development of guidelines and requirements for future exploitation and use of resources-and their sustainability. This presentation will discuss the diversity of science, protection, exploitation, use, management, stakeholder and societal concerns that will need to be included in project planning, review and approval to ensure responsible exploration and use of space resources and planetary surfaces for the benefit of all humankind. Considering that international missions to the Moon, Mars and asteroids involving multiple stakeholders and objectives are possible in the coming decade, it is important to begin the stepwise consideration of framing and analyzing environmental sustainability criteria soon.