Satellite Remote Sensing for Conservation Action

Case Studies from Aquatic and Terrestrial Ecosystems

Satellite remote sensing presents an amazing opportunity to inform biodiversity conservation by inexpensively gathering repeated monitoring information for vast areas of the Earth. However, these observations first need processing and interpretation if they are to inform conservation action.

Through a series of case studies, this book presents detailed examples of the application of satellite remote sensing, covering both aquatic and terrestrial ecosystems, to conservation. The authors describe how collaboration between the remote sensing and conservation communities makes satellite data functional for operational conservation, and provide concrete examples of the lessons learned in addition to the scientific details.

The editors, one at the National Aeronautics and Space Administration (NASA) and the other at a conservation non-governmental organisation, have brought together leading researchers in conservation remote sensing to share their experiences from project development through to application, and emphasise the human side of these projects.

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Preface

The view of Earth from space has provided us with powerful imagery, from the inspiring 'blue marble' image taken by the astronauts of Apollo 17 to disquieting images of progressive deforestation. Images of night-time lights illustrate better than words how much of the terrestrial surface is influenced by humans, while lights from fishing fleets convey the human impact on the ocean. Animations of these features provide a clear visualisation of how rapidly Earth is changing. Beyond the visual impact, the images of the globe that have been collected over decades have scientific applications that enable researchers to examine environmental patterns and processes on land, in the oceans, and in the atmosphere. Through imagery, we can map in space and over time how land cover or sea conditions are changing. This in turn allows us to assess changes in habitats, and determine how the species that rely on these habitats are being impacted. Importantly, research and monitoring enables us to understand and quantify the impact of conservation and restoration actions, allowing modification of activities as needed. We can evaluate if certain actions succeed or fail, in turn creating opportunities for applying such knowledge to other conservation challenges. Images captured from space are making a major contribution to biodiversity conservation. And it comes at a time when we need it more than ever, as Earth's biodiversity is under huge pressure from a multitude of threats.

Conservation problems abound but so do solutions, and satellite remote sensing is contributing to conservation success. A revolution in the number and accessibility of satellite remote sensing observations, combined with advances in computing power and the knowledge that has been gained over the past two decades, has led to increased use and recognition of the technology. There are many examples of how remote sensing data collected from space have

helped inform conservation actions, leading to improved outcomes for species or ecosystems. However, the use of satellite remote sensing in conservation is still not generally considered routine or embedded in decision-making protocols. The application of remote sensing to identify conservation problems and solutions, a growing field, aptly named 'conservation remote sensing', is not as straightforward as it sounds. As is the case of any interdisciplinary field, it requires those with different expertise, academic training, and professional backgrounds to learn about and work together on a new topic. For example, conservation scientists themselves have diverse backgrounds that span the dictionary from anthropology through to zoology. They work in distinct ecological and cultural settings, and have had varying training in physical sciences and statistics. Few conservationists have taken remote sensing classes, let alone have an academic background in the field. As a consequence, they are often unfamiliar with key concepts in remote sensing such as trade-offs in spatial, spectral and temporal resolution, or basics such as how satellites 'see' the Earth. Those with a satellite remote sensing background have the knowledge base to exploit satellite instruments with different spatial, spectral, and temporal resolutions, but may have a limited understanding of conservation issues, or what parameters might be of greatest biological importance.

Yet while remote sensing has been applied to conservation research for decades, operational systems and tools for practitioners are still relatively uncommon. This book contains six case studies from around the world, detailing the use of satellite remote sensing for conservation action, followed by a study of the evolution of the use of remotely sensed observations by a conservation non-governmental organisation. Together, they provide examples of how satellite remote sensing has been successfully incorporated into operational conservation. They by no means provide a comprehensive review of studies that are using satellite remote sensing for conservation, but they are all linked in that they demonstrate how Earth observations (a phrase

used synonymously with satellite remote sensing) are being used on an ongoing, operational basis. Consequently, they represent a leap from many previous instances where remote sensing played a key, although one-off, role in informing management. Furthermore, the case studies identify how people with diverse backgrounds worked together to advance conservation. Crucially, each project explains how the conditions to bring the groups together came about, discusses the challenges associated with their endeavour, and identifies lessons learned. By providing this developmental insight, we hope to catalyse further uses of remote sensing for conservation.

Our objective is to stimulate collaborations that result in the development and implementation of operational systems through which satellite remote sensing informs conservation. We hope this book will reach both the conservation and remote sensing communities. Both editors come from the ecological side of conservation science. They have worked in conservation research, non-governmental organisations, and space agencies with around 35 years' combined experience in conservation science. Allison started her conservation career studying butterflies in the Rocky Mountains, and only came to remote sensing through an AAAS Science & Technology Policy Fellowship, where she worked at NASA Headquarters in the Earth Science Division. In working with the biodiversity program, she was exposed to the amazing ways that remote sensing advanced biodiversity research and how these observations could be used for conservation applications. Staying on as a contractor after her 2-year fellowship, she increasingly saw the gap between the conservation and remote sensing communities. Graeme started off researching birds in the Scottish uplands and, after time in the Seychelles, Mauritius, and Poland, he returned to his native Edinburgh and upland birds, where he began exploring the potential of satellite remote sensing for mapping upland vegetation. As with Allison, Graeme was exposed to the potential remote sensing in conservation action. His research with The Royal Society for the

Protection of Birds soon took an international direction. We met through a series of workshops aimed to bridge gaps between the conservation and remote sensing communities. We were then inspired to run a session at the 2015 International Congress for Conservation Biology on examples of where satellite remote sensing was being applied to conservation, and were subsequently asked by Cambridge University Press to turn the symposium into a book. As we first set about developing the book, we sharpened our focus to case studies where satellite remote sensing was being used for operational conservation. We also concentrated on conveying the story of how a project came about and lessons learned, in addition to presenting the scientific details.

We developed this book with the goal of reaching those in the conservation and remote sensing communities who are not already working at the boundary of conservation and remote sensing. The conservation community will be familiar with many of the issues presented in each of the six case-study chapters, but may have had less exposure to applications of remote sensing. These same stories will also be valuable to those who have a good practical or academic background in remote sensing, but have less familiarity with how this technology contributes to conservation. Recognising that each of the communities may have variable backgrounds in the other, we included brief primers on conservation and remote sensing. Chapter 1 starts with a short background on biodiversity conservation. Those familiar with conservation need not dwell on the first part of the chapter, but we then provide an overview of conservation remote sensing, followed by an outline of the contributed chapters. For those who need a remote sensing overview or refresher, Brink *et al.*, in Chapter 2, highlight key concepts of satellite remote sensing as it applies to conservation. After the six case-study chapters and a chapter written from the perspective of those working at a conservation non-governmental organisation, we conclude with a chapter that briefly synthesises themes from the preceding chapters and identifies next steps for the field.

We certainly recognise that satellite remote sensing is not a panacea for conservation monitoring, but do firmly believe that there are many more opportunities to apply space-based observations to conservation on the land and in the sea. We hope that the promotion of successful examples, together with the lessons learnt by these studies, will spur new applications of satellite remote sensing to conservation.

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