The value of Surtsey for ecological research

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ABSTRACT

Ecological research on Surtsey spans over 40 years of measurements, including monitoring of individual plants early on and later establishment of permanent plots with estimates of vegetation cover. In this paper we discuss the value of these studies for primary succession and the importance of strict control of access to the island. The long-term data set from Surtsey contains detailed demographic data, and they provide the opportunity to address aspects of species interactions, island biogeography, and nutrient dynamics. We conclude that Surtsey is unique for primary succession because the study provides a thorough census of an entire island since it was created, combined with minimal human influence because of the restricted access to the island.

INTRODUCTION

Ecological research on Surtsey has provided an unusual record of plant and animal colonization. Vascular plants, bryophytes, lichens, fungi, birds and invertebrates have been monitored on the island (Baldursson & Ingadóttir 2006). These data are unusual because they span over 40 years of measurements, they include several decades of monitoring individual plants, they allow one to distinguish between arrival and establishment of a species, they highlight how the interactions of birds, nutrients and plants impact primary succession and they provide a thorough census of an entire island. These are all very important aspects of this data set. However, what truly makes Surtsey unique is the minimal human influence. Set aside as a Nature Reserve in 1965 (category Ia according to the IUCN classification), Surtsey is accessible only by a limited number of people, mostly biologists and geologists and a crew that maintains the hut. Each of these teams limits its stay so people are on the island less than two weeks each year. The Surtsey Research Society manages the island on behalf of the Environment Agency of Iceland. Surtsey was added to the World Heritage List of UNESCO in July 2008. Natural remoteness of some studies of succession make human visits to study areas unlikely (e.g., landslides in the mountains of western New Zealand, glacial moraines in Alaska and Canada, uninhabitable volcanic islands in the Pacific) but we know of no other study of primary succession in the world where human visitation is so restricted. Such restricted access is extremely valuable to the study of primary succession.

We were both privileged to be guests of the biological research team that visited Surtsey for five days in July 2003. Our comments that follow come from our impression during that visit and lifelong interests in primary succession in general, research on Surtsey in particular and the interactions of science and society. The aim of this paper is to address the value of on-going research on primary succession in Surtsey.

RESEARCH VALUE

Long-term data

Primary succession involves the development of plant and animal communities and soil formation following such severe disturbance that little or no biological legacy remains. Typically this process takes decades or centuries before well-developed soils appear, so long-term studies are essential. Surtsey is one of only several studies of primary succession with such long-term data. Others include volcanic surfaces on Krakatau, Indonesia (since 1908), glacial moraines at Glacier Bay, Alaska, USA (since 1923) and dunes in Cooloola, Australia (since 1962). See Walker and del Moral (2003) for details. On Surtsey, we expect stable communities to take several hundred to several thousand years to develop, based on similar histories on the nearby Westman Islands. Minimal human interference allows us to examine this process of succession in its natural state.

Detailed demographic data

Marking individual plants as they colonize Surtsey has provided a remarkable record of natural invasion processes and species dynamics (Fridriksson 1978, 1982, 1992). Although data collection has now logically gone to plot-based sampling as the number of individuals has grown, such demographic data could be explored further. A potential use of the mapped plants around the entire island is to explore secondary dispersal from species already on the island. How individual species impact primary succession is best examined in such a field laboratory where details exist on the populations of individuals and individual species.

Species interactions

Surtsey is also an excellent setting in which to explore how species interact. One of the most important lessons from Surtsey is that gull colonies introduce nutrients and plants, and locally change successional change in dramatic ways (Magnússon & Magnússon 2000). This study has highlighted the importance of annual data collection in determining the pattern and rate of such changes. The sharp contrast between the lush, species-rich plant communities at the bird-impacted sites and the nearly barren sites outside that influence (Fig. 1 and 2) has been better documented on Surtsey than at any other primary succession site in the world. Insect diversity has also increased due to the fertilization effect of the birds (Erling Ólafsson, *pers. comm*). There is an urgent need to understand how fertilization (whether from birds or anthropogenic sources of pollution) impacts biological communities – particularly in the context of rehabilitating damaged lands. One suggestion

Fig. 1 The bird nesting area in Surtsey is clearly seen from a distance due to the impact of the birds on the vegetation.

(Walker & del Moral 2003) is that fertilization inhibits successional development and rehabilitation by favoring dense swards of vegetation. Surtsey is an ideal place to pursue such studies that will have important practical applications.

Island biogeography

Rarely are the flora and fauna of an entire, intact and undisturbed island recorded as they accumulate. Surtsey provides an excellent opportunity to understand colonization, extinction and carrying capacity of one island ecosystem. Additionally, as the island erodes in size, species numbers may decline. Such direct tests of the classic island biogeography concept (MacArthur & Wilson 1967) are invaluable and rare.

Additional opportunities

There are many other, non-destructive measurements that could be made on Surtsey that would

Fig. 2 The vegetation within the nesting area in Surtsey is lush and species rich compared with the area outside seen in the background.

further our understanding of primary succession. These include studying nutrient dynamics (particularly of nitrogen and phosphorus) and how these cycle through the increasingly complex yet still relatively simple ecosystems; linking nutrient fluxes to changes in both vascular plant and belowground invertebrate populations; measurements of carbon accumulation by species and location (above and below ground); the roles of herbivory and mycorrhizae in succession and consequences of escape from mainland herbivores; closer examination of microhabitats where plants colonize and how these are partitioned among functional groups; and the role of spatial aggregation of plants in succession. Finally, we want to emphasize that understanding scientific principles about primary succession has direct value to society, particularly in terms of improving our ability to restore severely damaged ecosystems.

VULNERABILITY AND HUMAN VISITATION

The new biota on Surtsey is vulnerable and at risk to disturbances, both natural and anthropogenic. The main natural disturbance on the island is the erosion of its coast that has occurred since it was created (Jakobsson *et al.* 2000, Jakobsson & Gudmundsson 2003). Any visit to Surtsey causes some disturbances to the island, including trampling and possible introduction of species. However, with the current strict control of access to the island that risk should be kept minimal.

There has been some debate, mainly amongst the local people from the Westman Islands, about releasing the strict closure of Surtsey and allowing some controlled tourism on the island. This has been seen as a possible way to promote the tourist industry in the area and counteract some of the decrease in employment and economic deprivation on the islands. In spring 2005, a local representative to Parliament formally asked the Minister of Environment whether there were any plans to allow tourists to enter Surtsey. On that occasion and again at a workshop held in Heimaey, Westman Islands in September 2005 on Surtsey and its management, the Minister said that there were no plans to change the management and strict control of access to Surtsey. We welcome this statement and emphasize the importance of it for future studies on primary succession on the island. Apart from the risk of increased anthropogenic disturbance with tourism on Surtsey, more frequent visits would jeopardize the continuing study of primary succession. In harsh climates such as exist on Surtsey, human impacts can have large and long-lasting impacts on the environment (Komárková & Wiegolaski 1999).

CONCLUSION

Ecological research on Surtsey is unusual and valuable to science for many reasons enumerated above but it is unique in its restricted access. We strongly urge the Environment Agency of Iceland to continue its current policy of limited access. Such a policy best advances our understanding of the development of biotic communities and leads to better land management and restoration practices.

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References

Baldursson, S. & Á. Ingadóttir, (eds.) 2006. Nomination of Surtsey for the UNESCO World Heritage List. Icelandic Institute of Natural History, Reykjavík.

Fridriksson, S. 1978. Vascular plants on Surtsey 1971–1976. Surtsey Res. Progr. Rep. VIII: 9–24.

Fridriksson, S. 1982. Vascular plants on Surtsey 1977–1980. Surtsey Res. Progr. Rep. IX: 46–58.

Fridriksson, S. 1992. Vascular plants on Surtsey 1981–1990. Surtsey Res. Progr. Rep. X: 17–30.

Jakobsson, S.P., G. Gudmundsson & J.G. Moore 2000. Geological monitoring of Surtsey, Iceland, 1967–1998. Surtsey Research 11: 99–108.

Jakobsson, S.P. & G. Gudmundsson 2003. Rof Surtseyjar: Maelingar 1967–2002 og framtídarspá. Náttúrufraedingurinn 71: 138–144.

Komárková, V. & F.E. Wiegolaski 1999. Stress and disturbance in cold region ecosystems. *In* L.R. Walker (ed.), Ecosystems of disturbed ground. Elsevier, New York, pp. 39–122.

MacArthur, R. & E.O. Wilson 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey.

Magnússon, B. & S.H. Magnússon 2000. Vegetation succession on Surtsey, Iceland, during 1990–1998 under the influence of breeding gulls. Surtsey Research 11: 9–20.

Walker, L.R. & R. del Moral 2003. Primary succession and ecosystem rehabilitation. Cambridge University Press, Cambridge.