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Economic value of ecosystem services, minerals and oil in a melting Arctic: A preliminary assessment

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ABSTRACT

The Arctic region is composed of unique marine and terrestrial ecosystems that provide a range of services to local and global populations. However, Arctic sea-ice is melting at an unprecedented rate, threatening many of these ecosystems and the services they provide. This short communication provides a preliminary assessment of the quantity, distribution and economic value of key ecosystem services as well as geological resources such as oil and minerals provided by Arctic ecosystems to beneficiaries in the Arctic region and globally. Using biophysical and economic data from existing studies, preliminary estimates indicate that the Arctic currently provides about $281 billion per year (in 2016 US$) in terms of food, mineral extraction, oil production, tourism, hunting, existence values and climate regulation. However, given predictions of ice-free summers by 2037, many of the ecosystem services may be lost. We hope that this communication stimulates discussion among policy-makers regarding the value of ecosystem services and such geological resources as minerals and oil provided by the Arctic region, and the potential ecosystem losses resulting from Arctic melt, so as to motivate decisions vis a vis climate change mitigation before Arctic ice disappears completely.

1. Introduction

Although often perceived as barren and devoid of life, the Arctic region (Fig. 1) is composed of unique marine and terrestrial ecosystems and abiotic natural resources, such as minerals and oil, that provide a range of services to both local and global populations (Barros et al., 2014; CAFF, 2013). Local communities benefit from access to subsistence goods, such as fish, birds and marine mammals, and obtain significant cultural benefits from collectively engaging in subsistence hunting and interacting with their landscapes (CAFF, 2013). Non-Arctic communities around the world benefit indirectly from aesthetic services provided by the Arctic environment (e.g. documentary and photography) and knowledge generated by research in the region; they also benefit directly from recreational opportunities in the Arctic. And the well-being of the entire global community is dependent on climate regulation services provided by Arctic sea-ice and land-based permafrost (Goodstein et al., 2010).

However, the Arctic region is experiencing rapid climate change. Permafrost (permanently frozen subsoil) on Arctic land areas is melting, sea temperatures are rising, and the Arctic sea is predicted to be completely ice-free in summer before mid-century (Fig. 2) (Program, 2014; IPCC, 2013; Wang and Overland, 2009).

Declining sea-ice, warmer temperatures, and longer summer periods have serious implications for the health of Arctic ecosystems and the well-being of local and global communities. Sea-ice decline will result in decreasing availability of sea-ice algae, which contributes about 57 percent of Arctic marine primary production (Gosselin et al., 1997). Sea-ice dependent species, such as polar bears, are already experiencing declines as their usual hunting grounds disappear (Durner et al., 2009). Warmer sea-temperatures may lead to declines in marine species that depend on cooler Arctic waters for survival (e.g. Arctic cod) (Vilhjálmsson and Hoel, 2013). These ecosystem impacts directly affect local communities that depend on their surrounding environment for subsistence, income generation and cultural identity. The loss of unique ecosystems and species may also represent a loss to people around the world who value them for their own sake independent of use; moreover, some would argue that these ecosystems have intrinsic value independent of human preferences (Turner, 2001).

Climate change impacts on the Arctic will also have physical consequences at a global scale. As permafrost melts, methane is released from the newly exposed soil thereby increasing the concentration of greenhouse gases in the atmosphere (Goodstein

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Fig. 1. The Arctic Circle.

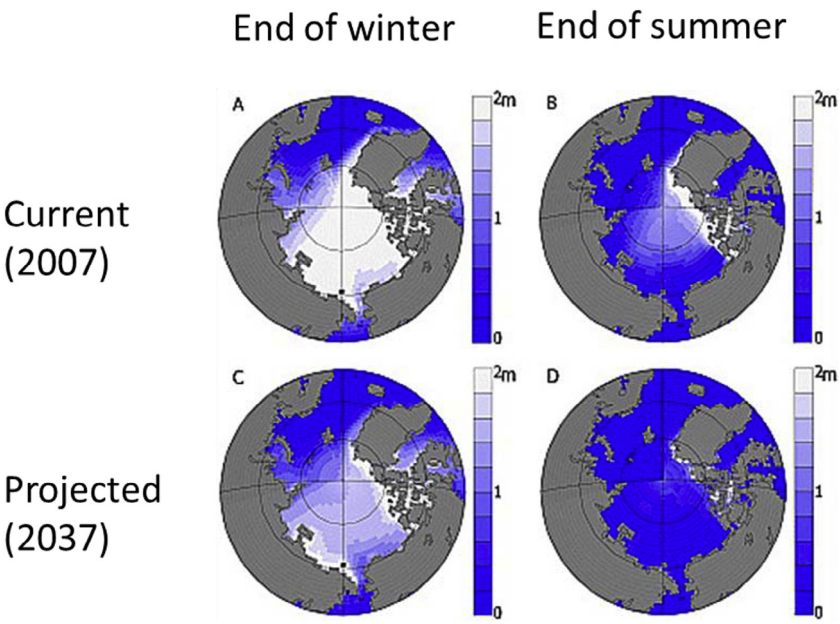

Fig. 2. Current and projected Arctic sea ice extent.

et al., 2010). In addition, the ice-albedo effect is diminishing as retreating sea-ice means less sunlight is being reflected back into space. Both these effects imply the loss of important climate regulation services provided by the Arctic, which will lead to even greater warming of the atmosphere (Goodstein et al., 2010).

Given the rapid changes that are taking place in the Arctic, it is critical to account for the value of the services provided to society by Arctic ecosystems and the potential costs resulting from their loss (de Groot et al., 2012). This will allow for more informed decision-making regarding protection and conservation efforts, and estimation of compensation for local communities suffering the brunt of these losses. This study provides a preliminary assessment of the quantity, distribution and economic value of key goods and services currently provided by Arctic ecosystems. Benefits will