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Short Communication

Climate variability induced shifts in nitrogen loading from terrestrial to aquatic ecosystems

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Abstract :

Nitrogen is a critical nutrient linked to degradation of freshwater and marine ecosystems. The nitrogen inputs to terrestrial ecosystems and subsequent loadings to aquatic ecosystems have been doubled and changed the nitrogen cycle as population and human activities increased over the past century. One of the consequences of human alter- nation of the nitrogen cycle is the eutrophication of marine and freshwater ecosystems.

We tested if climate variability can change nitrogen loading from terrestrial to aquatic ecosystems. We used stream nitrogen concentrations from 2,125 sites and climate data from 301 stations from 30 eco-regions across British Columbia, Canada, to test our objective and to compare it with anthropogenic loading of nitrogen in the same regions. We show that elevated air temperature and associated precipitation resulted in increase in nitrogen loading from terrestrial to aquatic ecosystems. Furthermore, inorganic nitrogen (IN) loading increased more rapidly than organic nitrogen (ON) with increasing air temperature. Each oC increment annual air temperature caused a 24% increase in nitrogen loading to aquatic ecosystems and a 22% increase in ratio of IN: ON concentrations in stream water. We also show that the coastal mountains ecosystems seem to be more vulnerable to temperature induced nitrogen loss than the interior ecosystems. We suggest that climate warming and elevated loading of nitrogen from terrestrial to aquatic ecosystems will have major implications for the quality of water in freshwater and coastal marine ecosystems.

Introduction:

The nitrogen inputs to terrestrial ecosystems and subsequent loadings to aquatic ecosystems have been doubled and changed the nitrogen cycle as population and human activities increased over the past century. These resulted in the changes of species composition, diversity, dynamics, productivity and functioning in many terrestrial and aquatic ecosystems. One of the consequences of human alternation of the nitrogen cycle is the eutrophication of marine and freshwater ecosystems. Anthropogenic sources of nitrogen in terrestrial and aquatic ecosystems largely result from manure and commercial nitrogen fertilizer applications in agriculture lands, increased biological nitrogen fixation from atmosphere due to the increased culture of nitrogen fixing crops, increased atmospheric nitrogen deposition as a result of increased nitrogen emission from industries, and increased human, animal, and industrial waste discharges to surface water. Nitrogen sources to aquatic have been well recorded and analyzed, and linked in terms of their impacts on water quality of aquatic ecosystems in the United Stated and other countries. Understanding the factors and processes regulating large landscape patterns of stream nitrogen components, concentrations, and loadings and the factors is complex and is of fundamental interests to global scientific communities working in the areas of environmental quality under changing climate.

Methods:

British Columbia (BC) is Canada's westernmost province and one of North America's most mountainous regions. Its 94.78 million hectares of land span 11 degrees of latitude and 25 degrees of longitude, and offer remarkable topographic, climate, and vegetation contrasts, with coastal mountains and islands in the west, plateaus in the central region, rocky mountains in the east, and an extension of prairie plains in the north-east corner. About 59.63 % of British Columbia land is covered by natural forests. Natural grasses and other non-wood plants occupy 35.47%, agriculture 2.6%, urban and rural settlement 0.3%, water 1.9%, and mining 0.1%. Crop and pasture lands are mainly distributed in Central and Southern Interior and Vancouver Island. Total population is 4,039,198 based on the census by the Government of British Columbia in 2005. About 70% of the population lives in the cities of Vancouver and Victoria and surrounding areas. Furthermore, Ecoregion and Ecoprovince also represent the impacts of vegetation type, topography and soil variations as they are represented in the classification system of British Columbia ecosystems. Geographical locations and ecological characteristics of each Ecoprovince.

Results:

The data showed that the mean concentration of stream water total nitrogen in British Columbia was 0.37 mg l-1, with the highest of 0.90 mg l-1 in Southern Interior ecosystems and the lowest of 0.22 mg l-1 in the Northern Boreal Mountains ecosystems (NBM). On average, dissolved organic nitrogen accounted for 60.23% of total nitrogen, while the inorganic forms of NO3-N, NH +-N, and NO -_N accounted for 23.16%, 10.45%, and 6.16%, respectively. DON consistently made up the majority of stream 4 2 water nitrogen in all the ecosystems of British Columbia. Our results showed that British Columbia ecosystems produced the proportions of stream nitrogen components similar to those observed in the ecosystems of South America. The nitrogen concentrations showed strong landscape patterns across British Columbia. The concentrations of different components of nitrogen showed the following landscale patterns: in the south of British Columbia, the concentrations of all components of nitrogen were higher in the South Interior ecosystems and decreased from the South Interior toward to west, the Coastal Mountains, and to east, South Mountains Interior; in the central of BC, the concentrations of all components of nitrogen decreased from the South Interior to North Boreal Mountains through Centre Interior and Southern Boreal Interior; and the Peace and Taiga Plains had medium nitrogen concentrations. The stream nitrogen concentrations generally decreased from south to north within each Ecorpovince.

Conclusion:

Our analysis of legacy effects of prior climate conditions indicates that climate variability and extremes strongly interact with N storage accumulated over multiple decades and as a result lead to elevated DN loads compared to DN loads following average precipitation years or wet-dry transitions. The high DN-load anomalies resulting from prolonged or more intense dry spells might explain the increasingly extensive hypoxia in the Chesapeake Bay, and possibly also in other coastal waters, despite the basin-wide nutrient-reduction efforts over decades. If long dry spells as well as hurricane-strength precipitation were to become more preva-lent, the risks of extreme N loading and eutrophication would increase. Conversely, a return to less variable conditions would reduce risks. Thus, effective mitigation strategies might benefit from accounting not just for decreasing anthropogenic N inputs and mean climate trends on decadal time scales but also for changes in interannual climate variability and extremes.