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Effects of climate change and local industry on shallow lakes in the Athabasca Oil Sands Region, Alberta, Canada

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Freshwaters in the Athabasca Oil Sands Region (AOSR) are threatened by increasing regional air temperatures and reduced moisture, and contaminants and land disturbance associated with the extraction and upgrading of the region's bitumen. We use paleolimnological techniques to determine limnological and ecological conditions prior to industrial activities, examine transitions in shallow lake systems over time, and investigate the relative contributions of climate change and aerial inputs of contaminants from local industry. Temporal trends in whole lake primary production from 23 strategically-selected lakes show that recent increases above pre-industry levels are independent of lake location relative to the centre of the regional industry, deposition of bioavailable nutrients, and contaminant-inferred industrial impact. The asynchronous timing of the primary production increases among lakes also provides no strong evidence of aerial fertilization attributable to local industry. Rather, significant correlations between inferred primary production and increasing temperatures suggest that climate warming in all seasons plays an increasingly important role in the systems' elevated primary production. Detailed downcore analysis of biological proxies from multiple trophic levels, primary production, and industry contamination from a representative industry-impacted AOSR lake, in conjunction with regional climate records, finds increasing complexity in benthic habitat, potentially driven predominantly by warming conditions. Our work identifies transitions in aquatic conditions and ecological communities over relevant time scales, and characterizes the relative roles of climate change and local bitumen industry in structuring AOSR lakes.