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Corresponding author(s): Zou Zou Kuzyk

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Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed
☐	☒ The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒ A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒ The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☐	☒ A description of all covariates tested
☐	☒ A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒ A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒ For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☐	☒ For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☐	☒ For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☐	☒ Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	No software was used
Data analysis	R-package is noted and referenced

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

The in situ water salinity, δ18O, and nutrients data generated in this study have been deposited in the CanWIN data repository hosted by the University of Manitoba, Centre for Earth Observation Science under the Eeyou Coastal Habitat accession code [https://doi.org/10.34992/6354-e007].
The ice core salinity and δ18O data are in the same repository [https://doi.org/10.34992/zd7j-jq80]. The CTD and mooring data from 2016-2017 are also in this repository [https:// doi.org/10.34992/cd02-8a75], as are the CTD and mooring data from other years of the study [https://doi.org/10.34992/2enm-0h29]. Sediment

core data generated in this study have been deposited in CanWin [https://doi.org/10.34992/a2j8-fa74]. Eelgrass data generated in this study are deposited in the Dryad digital repository [https://doi.org/10.5061/dryad.37pvm cvpk]. River biogeochemical data are available online [https:// doi.org/10.5683/ SP3/7EQN2S]. Data from interviews with Indigenous land users that support the findings of this study are available under restricted access to maintain the privacy and confidentiality of the research contributors from the Cree Nation where it was gathered. Access to this information can be obtained by contacting E. Rabbitskin and M. Leblanc at Niskamoon Corporation.

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	Our research methods respected the privacy of material in interviews, consistent with established FAIR and CARE principles.
Reporting on race, ethnicity, or other socially relevant groupings	This work fully complies with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 22018). The ethical obligations surrounding informed consent in research involving Indigenous Peoples align with Article 9.1 of the TCPS. Additionally, this study adhered to the principles outlined in individual Research and Information Sharing Agreements executed between the principal investigator and the respective First Nations Governments.
Population characteristics	Through formal interviews, Eeyou from 27 coastal traplines eyou participated in recording their knowledge between July 2019 and June 2022 iproducing a total of 66 semi-structured and participatory mapping interviews.
Recruitment	The study engaged 95 Eeyou land users, including tallymen and elders (self-identified and vetted through the First Nation).
Ethics oversight	The Behavioural Research Ethics Board of the University of British Columbia approved the components of this research that relied on formal interviews with Eeyou people (H20-02942)45. T

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☐ Behavioural & social sciences ☒ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Ecological, evolutionary & environmental sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Time series of shoot density data for eelgrass (Zostera marina) meadows and eelgrass cover data from historic monitoring were analyzed using generalized additive mixed models to detect eelgrass changes. The Investigators were not blinded to allocation during experiments and outcome assessment. For analysis of environmental time series, a Pettitt test (a non-parametric test for change points) and two-tailed Mann-Whitney test (assessing difference in medians) around the best change point year of 1998 were applied. The null hypothesis was no step change ($p < 0.05$ comparing before/after 1998 for all variables). Experiments were used to test the nutrient and light limitation hypotheses. In the former, we experimentally manipulated plot-level water column nutrient concentration in situ at two sites and compared eelgrass growth in manipulated and control quadrats66. At each site, we set up 3 parallel transects at least 5 m from the edge of the meadow using SCUBA and randomly assigned experimental treatments to 25 cm × 25 cm quadrats every 5 m along each transect. To assess the ability of eelgrass to grow under low light conditions, we used 8 whole, randomly selected shoots collected from within the experimental array at each site to construct production–irradiance (PI) curves. We applied a detection and attribution process, increasingly emphasized in global change assessments, to synthesize evidence and infer the causes of the eelgrass social-ecological system collapse in Eeyou Istchee (Figure 1). This approach, centred on a causal model linking eelgrass health to environmental drivers, pressures, and biological feedbacks (Figure 2), integrates scientific records, recent fieldwork, and Eeyou knowledge.
Research sample	In addition to newly collected field data, data from Hydro-Quebec eelgrass monitoring (1982-2009) was analyzed. Using the video footage from HQ eelgrass cover sites, we visually estimated the eelgrass cover in percentage in 10% increments. When eelgrass was present, the minimum cover was set at 5% (0% when eelgrass was absent). The eelgrass cover was estimated on five to seven randomly selected image stills on each video, resulting in 5–20 observations per site per year.
Sampling strategy	For new field collections, eelgrass shoots were collected at numerous locations (typically ~25-30 sites per summer) and water properties were measured at the same sites. We haphazardly collected 5–15 eelgrass shoots at each site, by snorkeling, diving, or with a rake. We measured total eelgrass shoot length (cm) on each shoot. We also estimated eelgrass cover (%) at sites consistent with method described above.
Data collection	We sampled water using a Niskin bottle (summer) or Kemmerer (winter) and in southern labs measured colored dissolved organic matter, suspended sediments, nutrients, and salinity. Field teams including 3-6 personnel (professors, graduate students, post-doctoral fellows and Eeyou land users from local First Nation) also used a YSI and Castaway instrument to make in situ measurements of water temperature and salinity. Salinity, temperature, and pressure timeseries were collected at 5 min intervals using CT2X loggers (Seametrics). Downwelling light (measured as photosynthetically active radiation, PAR) data were collected at 5 min intervals using

	LI-192 underwater quantum sensor (LICOR Biosciences) connected to a RBRsolo logger.
Timing and spatial scale	The project spanned 2017 - 2022 and encompassed the entire east coast of James Bay Canada (coastal traditional territory of Eeyou Istchee).
Data exclusions	No data were excluded.
Reproducibility	Experiments were conducted to test the nutrient limitation hypothesis using a design that manipulated plot-level water column nutrient concentration in situ at two eelgrass bed sites and compared eelgrass growth in manipulated and control quadrats.
Randomization	Not relevant outside experiment described above in which quadrats were randomized. Field sampling design was informed by Indigenous knowledge.
Blinding	Investigators were not blinded to group allocation during data collection and/or analysis.

Did the study involve field work? ☒ Yes ☐ No

Field work, collection and transport

Field conditions	Field work was completed during all seasons.
Location	Field work was completed at locations distributed widely in the eelgrass habitat and adjacent coastal marine region of eastern James Bay, Canada.
Access & import/export	Indigenous knowledge and Western science were both central to this study, influencing planning, data collection, analysis, synthesis, result presentations, and final reports. A Steering Committee with both local and regional representation reviewed all proposed work and results. Sites were accessed with permission of the tallyman (designated head of the land users for each coastal trapline, which is a land area stewarded by a family, where they hold hunting and trapping rights).
Disturbance	There were no negative effects of the sampling. Tallymen and/or Eeyou land users from each coastal trapline participated in sampling for each respective trapline.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☐	☒ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Dual use research of concern

Policy information about dual use research of concern

Hazards

Could the accidental, deliberate or reckless misuse of agents or technologies generated in the work, or the application of information presented in the manuscript, pose a threat to:

No	Yes	
☒	☐	Public health
☒	☐	National security
☒	☐	Crops and/or livestock
☒	☐	Ecosystems
☒	☐	Any other significant area

Experiments of concern

Does the work involve any of these experiments of concern:

No	Yes	
☒	☐	Demonstrate how to render a vaccine ineffective
☒	☐	Confer resistance to therapeutically useful antibiotics or antiviral agents
☒	☐	Enhance the virulence of a pathogen or render a nonpathogen virulent
☒	☐	Increase transmissibility of a pathogen
☒	☐	Alter the host range of a pathogen
☒	☐	Enable evasion of diagnostic/detection modalities
☒	☐	Enable the weaponization of a biological agent or toxin
☒	☐	Any other potentially harmful combination of experiments and agents

Plants

Seed stocks	Eelgrass (Zostera marina) samples were collected. At each site, aboveground eelgrass biomass was collected using a 3x3 array of 0.0625-m2 quadrats distanced 20–30 m apart (total of nine quadrats per site) at 1–1.5 m depth.
Novel plant genotypes	Not applicable.
Authentication	Not applicable.