

## Research Article

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# The balance between critical thinking and paradigm thinking in the Arctic: Scientific cooperation across theoretical divides

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**Abstract**

Kuhnian' paradigms are a commonly used method of explaining the structure of knowledge production within the social sciences; however, in some ways, they are also in opposition with Popperian' critical thinking. The opposing approaches surmount to a comparative analytic method – Kuhn advocates undertaking science that is incommensurable, discipline-specific and ideologically and metaphysically fixed in nature; whilst Popper advocates science that is pluralistic, rebellious, interdisciplinary, and ideologically and metaphysically adaptable. This article utilises a systematic literature review of key peer-reviewed articles, book chapters and online articles from respected sources relating to Arctic scientific cooperation during and since the Cold War in order to provide a qualitative data source for comparative theoretical analysis. This article analyses key trends in Arctic environmental decision-making since the Cold War utilising a comparative critical constructivist framework based on epistemological challenges visible in the “Science Wars” between Thomas Kuhn and Karl Popper. By applying two of the foundations of social science (critical thinking and paradigms) to Arctic International Relations and Geopolitics, this article assesses the state of Arctic science cooperation and; the potential for Arctic science cooperation to solve wicked environmental problems. The article concludes that there are power relationships within the epistemological background to environmental decision-making which impacts science cooperation in the Arctic and; current trends in Arctic decision-making further propels the Arctic along a trajectory of environmental degradation.

**Introduction**

As described in “The Global Arctic” (Heininen & Finger, 2017), the Arctic is intrinsically connected to the rest of the world through the Earth System, the economic system, the cultural and governmental system and provides a setting for an interdisciplinary exploration of critical Geopolitics and International Relations. This article utilises theoretical approaches from Thomas Kuhn and Karl Popper, building upon a critical constructivist view of Arctic Geopolitics to include “many actors and many factors” (Heininen, 2018), New perspectives in Critical Geopolitics provide an avenue to critically understand the relationship between actors and the world around them to include values, aims, identities, the actors relationship to facts and the interrelationship between these factors (Heininen, 2018). Classical Geopolitics, on the other hand, can provide foundations to explore the concept of power through analysis of the spatial factors influencing state interactions and decisions (Wegge & Keil, 2018).

The article consists of an introduction to the research area, explanation of the comparative analytic methodology used concerning Popper and Kuhn, a literature review of scientific cooperation in the Arctic to provide a data source for analysis, an analysis separated into three topic areas (The Arctic as a Borderland of Ideologies, The Arctic Council (AC) as a Vessel for Paradigmatic Balance and The Arctic as a Testing Ground for Science) and finally, a conclusion. The aim of a systematic literature review is to accumulate the best available knowledge on a topic and can have positive applications in informing policy decisions (Victor, 2008). Comparative analysis is a frequently utilised methodology within Politics and International Relations which allows for a logical approach to be maintained within a core research area – in this case scientific cooperation in the Arctic during and since the Cold War – analysed from two different epistemological positionings.

The Arctic region has experienced Colonial and Neoliberal behaviours, since the first explorers documented their journeys and living and non-living resources were extracted to European markets (Bertelsen, 2020; Einarsson, Nymand Larsen, Nilsson, & Young, 2004). Numerous studies have documented the trajectory within the Anthropocene in which development is conjoined with environmental degradation, and shadows of Colonial and Neoliberal practices remain as imprinted legacies (see e.g. Finger, 2016). As the Arctic natural environment changes as well as the political landscape, the Arctic continues to be a key region regarding

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natural resource extraction and economic development (Heininen et al., 2020). Both Kuhn and Popper can be seen as writing from within the discipline of the Philosophy of Science which has direct relevance to the Arctic region due to the strong links between science and governance in Arctic decision-making shown through institutions such as the AC. The AC utilises science and Indigenous Knowledge (IK) to inform reports and assessments for environmental decision-making purposes (Arctic Council, 2022a). Science can be perceived as a structure built upon facts, but the concept of a fact can be challenged from multiple metaphysical perspectives including due to the potential subjectivity of facts and the concept that we can actually “know” anything (Maxwell, 2017). Popper likens the acceptance of factual statements to the conclusions reached by a jury: “By its decision, the jury accepts, by agreement, a statement about a factual occurrence – a basic statement, as it were” (Popper, 2020), whilst he describes science as piles built on “swampy ground” (Popper, 2020). Kuhn, on the other hand, views science as a constant evolution which is sometimes shattered and rebuilt (Bird, 2004).

Science in the Arctic can be expensive to undertake due to the harsh climate and distance between major towns and cities, and therefore, collaboration is required. This cooperation may set the foundations for interdisciplinary and cooperative research (Bertelsen, 2020; Heininen et al., 2020). Scientific diplomacy in the Arctic refers to functional cooperation between States and other actors, such as researchers, in order to directly and/or indirectly practice scientific collaboration to maintain a semblance of peace, work together to maintain common interests or, work against a common threat (Goodsite et al., 2016; Heininen, 2021). For example, States or other actors such as Indigenous communities may functionally cooperate to manage natural resources within an area or form an alliance against those who may be seen to hold different ideologies. The Arctic States have been collaborating functionally on environmental protection and sustainability since the Arctic Environmental Protection Strategy (AEPS) which was pursued originally under a Finnish agenda, partly as a confidence-building exercise (Arctic Council, 1991). AEPS (1991) recognises the importance of “Cooperation in scientific research . . . in order to propose further cooperative action.” Despite the stability since the Cold War in the Arctic, tensions still remain between Russian vis-à-vis Western epistemologies as well as, Arctic States as actors vis-à-vis China as an actor, of which these tensions are reduced through scientific cooperation, known as science diplomacy (Bertelsen, 2020). Ideologies are considered, in this article, as a set of beliefs and ideas which can be formulated and utilised by actors (Freedon, 2006).

### *Paradigms vis-à-vis critical thinking: an analytic method?*

Through juxtaposing Popperian “critical thinking” vis-à-vis Kuhnian “paradigm thinking,” this article assesses the state of environmental decision-making and scientific cooperation in the Arctic. Whilst the analysis of paradigms is a commonly utilised method in the social sciences and critical thinking is assumed to be integrated within the scientific method, few studies combine the epistemological debates of Popper and Kuhn as a methodology (Kivunja & Kuyini, 2017). Bloor (1971) questions whether the debate between Popper and Kuhn reflects two paradigms in science (Table 1). The study employs a critical constructivist comparative approach to the Arctic (as a case study) from the Cold War era to today utilising two scientific frameworks (critical thinking and paradigm thinking) to discuss trends in Arctic environmental

**Table 1.** Popperian critical thinking vis-à-vis Kuhnian paradigms.

Popperian critical thinking	Kuhnian paradigm thinking
Knowledge sharing, e.g. The Arctic Wildland Fire Sharing Circle (2022) led by the Conservation on Arctic Flora and Fauna (CAFF) (Arctic Council, 2022b) shared remembering as an Indigenous research method (Porsanger, 2004)	Incommensurable science, e.g. different styles of thinking within disciplines for example, whether geoengineering is a climate danger or a saviour (Oberheim & Hoyningen-Huene, 2018; Wagner, 2021).
Interdisciplinary, e.g. The University of the Arctic as a platform for collaborative research, The Arctic Yearbook (Heininen, Exner-Pirot, & Plouffe, 2012).	Discipline-specific, e.g. post-early 1970s when data gathering on pollution revealed a serious danger from pollution issues resulting in political action (Paigen, 1982).
Should challenge the norm, e.g. The publication of the Arctic Human Development Report (AHDR) (Einarsson et al., 2004) integrating the human and natural sciences in order to improve environmental decision-making; The Calotte Academy as a travelling academic symposium (UArctic Thematic Network (TN) on Geopolitics and Security, 2022)	Should adhere to the norm, e.g. international agreements aimed at protecting the Arctic environment which have been created in response to monitored empirically recorded environmental threats for example, The Agreement on the Conservation of Polar Bears (1973), The Stockholm Convention on Persistent Organic Pollutants (2001) and The Arctic Fisheries Agreement (2021). (Arctic Portal, 2022)
Ideologically and metaphysically adaptable, e.g. the merging of different ways of seeing the world for joint projects such as the AC project led by Chief Michael Stickman of the Arctic Athabaskan Council, Salmon Peoples of the Arctic (Arctic Council, 2015).	Ideologically and metaphysically fixed, e.g. some topic specific research approaches that can be found in climate change (Bhaskar, Frank, Hoyer, Naess, & Parker, 2010).
Rebellious, e.g. lobbying utilising evidence at international conferences regarding serious environmental risks such as uranium mining or climate change (Nuttall, 2013).	Conservative, e.g. traditional scientific assumptions should be followed until shown to be fallible such as evolutionary theory or other widely adopted scientific approaches (e.g. see (Latour, 1996) or Ingold (2012) for discussions into epistemological frameworks of science).
Pluralistic, e.g. Critical Geopolitics to take into account many actors and many factors rather than more Realist-based approaches, holistic understandings of the world.	Homogeneous, e.g. Conferences and Organisations that exclude specific actors based on ideologies for example the reformed Arctic Council that operates without Russia (Arctic 360, 2022).

decision-making and cooperation and the debates’ influence on environmental security. This study links to a wider body of work analysing a perceived “crisis in research” which details potentially dangerous or bad scientific practices. Found issues include a lack of replication of scientific studies, result-driven publications (with studies with null results or that disprove the hypothesis not gaining publication status), and funding-driven science which may promote interest-led science (Latour, 2004; Mazzocchi, 2015; Schooler, 2014). Thus, through examining the debate between two basic aspects of science (paradigm and critical thinking) – this study hopes to provide new evidence concerning how different theoretical approaches infiltrate the epistemology of Arctic environmental decision-making and environmental cooperation.

### Paradigm theory

There are “paradigms” that have been spoken of since the late 1700s of Greek etymology relating to patterns of ideas and concepts, and there is Kuhn’s concept of Paradigms as laid out in “The Structure of Scientific Revolutions” (1962) which sets out to explain scientific practices (Wray, 2011). Originally intended to explain scientific inquiry in the natural sciences, Kuhn claims he did not intend for his theories to be picked up by social scientists and was critical of the use of the concept of paradigms in the disciplines of Geopolitics and International Relations (Walker, 2010). The concept of paradigms is frequently misappropriated, and interrogation of the term is little undertaken within Arctic research (Kivunja & Kuyini, 2017). Paradigms can be best understood as a life cycle: firstly, an idea is born based on concrete scientific achievement within a metaphysical and physical framework based on the disciplinary matrix and another built upon that and so on (Kuhn, 1962). According to Walker (2010), who was critical of paradigms due to what he considered to be their restrictive properties: “By restricting vision and breadth, a paradigm guides scientists narrowly but productively to questions linked to those already agreed-upon core concerns.” Kuhn explains that science is propelled by exemplars who represent the best in their fields (Bird, 2004). Science follows this pattern of “normal science” until exceptional science occurs (when something happens that deems the original science obsolete) and a “paradigm shift” occurs (Kuhn, 1962). In normal science, “theories, instruments, values and metaphysical assumptions that comprise the disciplinary matrix are kept fixed” (Bird, 2004). For Kuhn, it is not possible to conduct science from outside of the paradigm without compromising research integrity, and scientists should not attempt to collaborate with others outside of the paradigm (Walker, 2010). According to Kuhn (1962), scientists from different disciplines are not able to speak the same language and therefore produce meaningful research through collaboration (known as incommensurability). For Kuhn, following “normal science” and thus, adhering to norms, was necessary for scientific discovery (Rowbottom, 2011). Reisch (2016) relates the focus on “incommensurability” in Kuhn’s work as being a product of Capitalist over Socialist ideologies in the throgs of the Cold War (1947–1989). Walker (2010) argues that “Kuhn’s paradigms resemble ideologically based regime types that vie for monopolistic control of the polity. Once established, these regimes restrict competition and perpetuate their narrow claims, even in the face of discordant evidence.”

### Critical thinking

Popper is most known for his “falsification theory” (1963) which rejects classical reductionist views of the scientific method in favour of trying to disprove theories scientists believed to be correct. He spent a great deal of time, like Kuhn, thinking about how scientists should behave and how science evolves (Rowbottom, 2011). Popper and Kuhn vehemently disagreed on whether to maintain paradigm or critical thinking in the scientific tradition. According to Lakatos, “The clash between Popper and Kuhn is not about a mere technical point in epistemology. It concerns our central intellectual values” (Lakatos, 1976). For Popper, it is fundamentally important that scientists do everything they can to try to disprove dominant discourse within an open collaborative working method. Popper argued Rationalism “is an attitude of readiness to listen to critical arguments and to learn from experience.” (Popper, 1945). Speaking after the end of

World War 2, Popper can be seen as part of a movement of knowledge sharing, including the sharing of blueprints for atomic bombs and other military secrets (Chance, 1996). Popper did not entirely advocate the removal of the necessity for some dogmatism in science. For Popper, if a scientist moves too quickly from his work without building an argument, he/she may not have the time to formulate an educated opinion (Rowbottom, 2011). A key difference between Kuhn and Popper is that the latter advocated methodological pluralism and critical discussion, whilst the former supported a focused approach to science (Walker, 2010).

### Scientific approaches during the Cold War

During the Cold War (1947–1991), IR was defined primarily by Realist competition between the Soviet Union and the United States which led to the militarisation of the Arctic and a large expansion of State-funded technoscientific outcome-led projects which were subject to strict national security restrictions. These projects often had links to the war effort resulting in environmental degradation from nuclear accidents and radioactive wastes (Exner-Pirot, 2020; Heininen, 2018; Oreskes & Krige, 2014). Simultaneously, Arctic States engaged in cooperative scientific activities on projects that were mutually beneficial such as Space Exploration (Sagdeev, 2007). Globally, and in the Arctic, science and the military have had an uneasy relationship due to testing and violent actions based on the collaboration between science and the military on both human and non-human subjects (Lanzarotta, 2020). Harrison (2014) argues that the Cold War both propelled the rapid extraction of natural resources, including from Indigenous lands, and created Realist discourses that enforced a colonial attitude towards Indigenous peoples (IPs) including as valuable resources to be subjectified. The “iron curtain” was a term coined by Churchill to separate the Western “sphere” from the Soviet “sphere” (Churchill, 1946).

### Scientific approaches post-Cold War

After the Cold War, Classical Geopolitical approaches gave way to a dualism of discourses representing both Classical and Critical approaches (Agnew, Checkel, Deudney, Mitzel, & Guzzini, 2017; Heininen, 2018). Scientific personnel were disbanded and frequently headhunted by the “other side” (Fuller & Popper, 2003). Multilateral cooperation was required to clean up some of the dangerous environmental impacts which coincided with a global recognition in environmental issues (Heininen, 2018). This environmental awakening was conjoined with a more open-minded collaborative approach to science including the practice of sending young researchers to witness and participate in science on the other side of the former “iron curtain” (Heininen, 2022).

The post-Cold War scientific community contained complex power relations that scientists would have to engage within, including espionage and fear of reprisals (Wolfe, 2018). Gorbachev’s Murmansk speech can be seen as the catalyst for the Arctic States to proceed to engage cooperatively through institutions such as the Arctic Council, with the input of various actors including Non-Governmental Organisations, International Government Organizations, Non-Arctic States and regions and municipalities (Heininen & Nicol, 2007). Constructivism became mainstream in IR after the Cold War and presses the influence of multiple perspectives, contextual factors and value systems upon the construction of knowledge as individuals or groups

(Zehfuss & Maja, 2002), as well as being linked with peace, stability and the study of peace (Guzzini, 2004; Heininen, 2018).

The Arctic Council has been the primary decision-making institution for the region since the end of the Cold War and includes the Arctic eight (A8), the Permanent Participants (PPs), Observer States as well as some relevant International Governmental Organisations and Non-Governmental Organisations (Koivurova, 2012). Institutions such as the AC have the ability to produce, collect and transform knowledge as well as through agenda setting or issue framing (Barry, Davíðsdóttir, Einarsson, & Young, 2020; Binder, 2016; Young, 2004). The members of the AC interact with a variety of other global actors and entities. Events in the Arctic do not occur in a bubble but follow a global narrative, for example, the environmental agenda has developed globally alongside the Arctic environmental protection movement (Heininen, 2018; Käpylä & Mikkola, 2015). Science provides a collaborative focus across the Arctic States and has provided a backbone of problem definition and action in the AC. The Arctic Councils' work is undertaken through six Working Groups (WGs) located in various Member States, as well as through task forces and expert groups, which run as needed (Bailes, 2013). The WGs were created to carry out the mandates of the AEPS under the 1991 Rovaniemi Process (Stone & Reiersen, 2021). WGs have a variety of project partners and engage with PPs to varying extents depending on the project. WGs have different ways of managing engagement with scientific processes and concepts (Barry et al., 2020).

The Arctic has been a testing ground for interdisciplinary work propelled by the necessity of multidimensional environmental problem solving, especially in terms of climate change (Heininen, 2011; Heininen & Nicol, 2016). Heininen et al. (2020) found that the policy documents of key Arctic actors prioritise "Science and Education" in order to solve environmental problems, whilst the purpose of research is ambiguous but often aimed at supporting economic activities. In addition, the Arctic States aim to pursue economic and social development simultaneously with environmental cooperation, and this paradox can be seen throughout the Arctic States' Arctic strategies. This pattern is reflected in the activities of the AC. For example, in the 2021 AC Strategy, the AC declares "The Council will contribute effectively to social and economic development, climate change mitigation and adaptation towards low emission societies, and environmental protection throughout the Arctic." As Arctic States continue to push development and environmental protection through value-oriented and Rationalist arguments with science at the forefront of environmental decision-making, it is necessary to reflect on how conceptual understandings of science informs dualistic environmental decision-making (Heininen et al., 2020).

Science is used in addition to IK in the Arctic Council, in which IK is understood as: "a systematic way of thinking applied to phenomena across biological, physical, cultural and spiritual systems. It includes insights based on evidence acquired through direct and long-term experiences and extensive and multigenerational observations, lessons and skills. It has developed over millennia and is still developing in a living process, including knowledge acquired today and in the future, and it is passed on from generation to generation." (Inuit Circumpolar Council, 2015). As such, IK can be understood as another knowledge gathering and transmission practice to positivist assertions of modern science gained through the scientific method. Porsanger (2004) writes in regard to Indigenous methodologies: "Our purposes" are those of IPs, and "our own perspectives" are the Indigenous approaches that allow Indigenous scholars to decolonise theories,

develop Indigenous methodologies and use Indigenous epistemology; these approaches allow Indigenous scholars to make visible what is special and needed, what is meaningful and logical in respect of IPs' own understanding of themselves and the world." Pluralistically speaking, "other" Knowledge to Western Knowledge exists, holds its own spaces (sometimes shared spaces) and has a different history to Western Knowledge. In the Arctic, IK both reflects alternative value and knowledge systems based on different metaphysical assertions and histories and becomes part of IPs' political activism in the Arctic (Wheeler et al., 2020). Held (2019) writes "Academia has almost exclusively been focusing on Western paradigms and approaches to research . . . This manifestation of ontological oppression is a result of Western science being exported around the globe from Europe alongside imperialistic and colonial attitudes" (Thambinathan & Kinsella, 2021).

The 2014 Russian annexation of Crimea resulted in some level of diplomatic breakdown through the reduction of political communication channels; however, for the most part, this did not spill over into Arctic environmental cooperation except for the creation of more Realist dialogue (Käpylä & Mikkola, 2015). The 2020 COVID-19 pandemic led to changes to the policy-science-media-society interface with politicians utilising scientific recommendations to create emergency legislation, sometimes against national constitutions. The events were complicated by overwhelming access to information with a lack of clarity in the processes of knowledge production and of the interests of the knowledge holders (Buck, Geden, Sugiyama, & Corry, 2020; Heininen, 2021). During the pandemic, governments utilised scientific recommendations as a rationale to reduce basic security concepts such as freedom and democracy in order to reduce virus spread and trust in governments varied (Algan, Cohen, Davoine, Foucault, & Stantcheva, 2021; Heininen, 2021). Thus, media headlines and diplomatic priorities quickly saw a shift in international politics from a focus on environmental decision-making to pandemic decision-making. Work in the AC during the pandemic shifted when possible to primarily online meetings as in-person meetings became impossible and some projects were impossible to run (WWF Arctic Programme, 2022). Throughout the period of pandemic politics and environmental politics, the perception of the societal value of science was not static and actors utilised the scientific findings in order to support their versions of what the current and the future world should look like (see Gad, Jakobsen, & Strandsbjerg, 2017) for a study of the politics of sustainability which sheds some light on the utilisation of concepts for political purposes in the Arctic). Actors' visions for the future may be complexified by their interests, metaphysical positioning, and emotional condition, as well as, other factors such as social status and role, culture, material wealth, and the actors' perceptions of risk (Maxwell, 2017).

After the 2022 military invasion of Ukraine by Russia, the Arctic Council was "paused" and Russia was uninvited from international conferences, such as the Arctic 360, as part of an international effort to condemn the military invasion (Arctic 360, 2022). The joint declaration of the AC States (excluding Russia) states that "Canada, the Kingdom of Denmark, Finland, Iceland, Norway, Sweden, and the United States condemn Russia's unprovoked invasion of Ukraine and note the grave impediments to international cooperation, including in the Arctic, that Russia's actions have caused . . . Additionally, our States are temporarily pausing participation in all meetings of the Council and its subsidiary bodies, pending consideration of the necessary modalities that can allow us to continue the Council's important work in view of

the current circumstances” (US Department of State, 2021). Such boycotting of Arctic Council meetings was not a completely new activity as the US and Canada had already agreed to boycott meetings held or chaired by Russia due to the 2014 invasion of Ukraine (Käpylä & Mikkola, 2015). Russia Today and Sputnik were banned in several European Countries after the 2022 Ukraine invasion (Council of the EU, 2022). As the Arctic's natural resources become more accessible due to climate change, many warn that the Arctic could become a new venue for a competitive resource race (Käpylä & Mikkola, 2015); however, this is balanced by comparatively peaceful politics in the Arctic since the Cold War (Heininen, 2019).

## Analysis

### *The Arctic as a borderland of ideologies*

Whilst the Pluralistic and Relativistic consideration of “other knowledges” are considered imperative for decolonisation of environmental decision-making, Universalist considerations are also important to protect human rights, for example to respect other knowledges as not “less” than the dominant scientific discourse (Lakatos, 2018; Teffo, 2011). Thambinathan and Kinsella (2021) argue that critical thinking and cross paradigm collaborations are vital to decolonise research; however, studies do highlight the difficulties of including IK in Western scientific studies due to misunderstanding of the concept and misappropriation of meaning (Wheeler et al., 2020). From a Khunian perspective, if it is important for scientists to remain “fixed” in their metaphysical and epistemological parameters, then there would be little room to integrate IK and modern science. There would, on the other hand, be potential for IK and Western science practitioners to focus within their own paradigms. Given the specialist environmental and cultural knowledge contained within IK, from a Popperian perspective, commensurable, interdisciplinary science may produce potential solutions to wicked environmental problems. The meaning of science can be seen as important for those in power, particularly in relation to non-Western sciences and other knowledges such as IK. If, for example, IK is reflected as equal to science, then community transmission, stories, unwritten observation and values will be given equal weight in decision-making to empirical evidence and the “scientific method,” thus questioning certain institutions’ legitimacy who champion Western science as dominant.

### *The Arctic council as a vessel for paradigmatic balance*

If functional cooperation and norm-setting utilising science in the Arctic acts as a force for cooperation across different ideologies and out-of-region actors, a paradigm can be seen as a useful tool both for maintaining a paradigm of peace and as a tool to manage the ideological compliance of out-of-region actors; however, utilising paradigms leads to the questions: who is outside of the paradigm, why and for what purposes are actors functionally cooperating to make the exclusionary concept relevant? The Arctic Council Strategic Plan 2021–2030, for example, focuses on economic growth vis-à-vis environmental protection and emphasises the competence of the AC and Arctic States above other actors (Arctic Council, 2021). Given the evidence supporting functional Neoliberal cooperation in the Arctic (see references to economic development in Arctic Council Strategic Plan 2021–2030 for current example), this leads to considerations as to what extent science is a tool to utilise environmental cooperation for natural resource extraction purposes. Thus, this would support analysis

by Heininen et al. (2020) belying the ambiguous and economic-centred work focus of Arctic States’ attitude towards research. Given the links between resource extraction, development and environmental degradation, this could be a concerning trend given environmental security challenges. It is possible therefore that actors who do not conform to the status quo may end up outside of a paradigm that is perhaps intended to maintain sovereignty over natural resources. Recent events in Ukraine could lead to further questions regarding environmental cooperation vis-à-vis resource extraction when analysing Russia’s current position outside of the Arctic environmental cooperation paradigm, whilst the AC is paused (without Russia’s support). For example, what are the current priorities of the Arctic States?

The Arctic Council was created from the auspices of the Rovaniemi Process of 1991 which directly relates to a deliberate attempt to maintain peace in the Arctic post-Cold War (Bertelsen, 2020). Given this, questions concerning science’s position through the Cold War and towards environmental protection could be asked regarding whether the era should be viewed as two separate paradigms, “war science” and “environmental science,” or a pattern of Colonial and Neoliberal science dominated by subjectification and environmental deterioration. Certainly, throughout both living and nonliving resources have been harvested with science as a tool. The pause of AC activities based on “out-of-region” events leads to questions about the institutions’ ability to act as a vessel for balancing Russian and Western paradigms of thought. The recent breakdown of dialogue within the AC may be evidence of a Kuhnian “pre-paradigm period” lacking consensus. For Popper, it would be likely an indicator of a power hegemony that has been brought to light. In addition, the institutional structure of the AC (with the States holding sole voting rights) leads to the prevalence of dominant scientific discourses driven by Arctic States’ interests. Although the AC (and other international organisations) have helped to push the Indigenous Rights agenda, there are substantial limits to the pluralistic merging of science and IK in the AC, due to the ACs’ top-down structure and the Arctic States’ Colonial and Neoliberal histories which leave a legacy within practices and ideologies of environmental decision-making.

### *The Arctic as a testing ground for Western science*

It is easy to recognise the need for specialisms in the Arctic, such as climate change modelling and virologists, but also for cross-discipline and cross-paradigm thinking which may develop the knowledge of a specialism, for example, the benefits an IR specialist may gain from understanding environmental systems, the consideration of the wider environmental and social impacts in pandemic legislation, and multinational cooperation on shared environmental problems, all represent the potential benefits of “cooperative” thinking. This leads to considerations as to whether there is a middle ground between critical and paradigm thinking (in the Popperian and Kuhnian sense). The topic of critical thinking compared with paradigm thinking has further relevance in what can be termed the current “age of information” and its relationship with the COVID-19 pandemic. The general population was asked to “trust” in the scientific paradigm, and critical thinking was made difficult due to misinformation and social messaging through the media and other channels (Hamilton & Stafford, 2020). Asking non-specialists to form an opinion on the pandemic clearly holds extreme challenges supporting some notions of the need for linear scientific thinking; however, without critical thinking, dangerous hegemonies of power may be left to form

including totalitarian and authoritarian political systems. Similar issues can also be seen in the banning of Russian media sources so that both the public and decision-makers cannot gain access to information from “across the iron-curtain.”

Within the social sciences, paradigms are often used as a post-modernist tool to explain power hegemonies; however, there is a juxtaposition between this, and the reality of Kuhns’ theory, as he advocates staying within scientific parameters and adhering to dominant power structures and discourses. If a linear scientific agenda is set and adhered to strictly whilst adhering to norms of key institutions and actors, there is a danger that the norm will be set by actors who do not place environmental security high up on their agendas. In addition, a crisis of research leads to the financial support of research that furthers political agendas and other interest-focused actors. Looking back to Gorbachev’s Murmansk speech, if such forces “resistant to change . . . who cater directly for the military-industrial complex” do exist, taking a Popperian stance to dismantle the dangerous hegemony may seem like a rational solution to improve environmental security, whilst maintaining the current scientific trajectory may be dangerous considering the human and environmental impact of economic development and war. From a Kuhnian perspective, perhaps now would be the time for a paradigm shift.

## Conclusion

This study finds that both critical thinking and paradigm thinking can be seen in the Arctic, and both conceptual frameworks for scientific activity present threats and opportunities. The Popper–Kuhn debate provides a mechanism to further unveil the ethics behind knowledge utilisation which is particularly relevant for IK and other ways of thinking that do not represent those who maintain a power hegemony. This article shows that whilst “paradigm thinking” may allow a paradigm of peace and cooperation to be maintained under certain parameters, utilising such processes may cause scientific cooperation to remain within Colonial and Neoliberal structures connected to environmental degradation. The article concludes that actors may remain or be further pushed outside of the current paradigm. Critical thinking and commensurable science may produce opportunities for a move towards a green-shift which breaks down wicked environmental problems and dangerous power hegemonies. However, it also presents challenges with regard to knowledge and resource ownership.

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