Ungovernable ferns and the horizons of conservation in late industrial ecologies

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Abstract

How might overabundant ferns vitalize and pressure political ecologies of landscapes and wildlife conservation? This ethnographic article interrogates the relational worlds of humans, animals, and the fern species known as the 'bracken fern' (the *Pteridium* spp.) which thrives in and around a post-extraction iron-ore site in southern India. Forest officials have characterized the fern's slow "monopolization" of the Kudremukh National Park as threatening the area's celebrated biodiversity. Drawing on contemporary histories of the region's industrial past, on the proceedings of the Western Ghats Committee meetings, and the ongoing work of pteridologists and state forest department, the article analyses the ways in which the 'invasive' bracken fern's spatial dispersal, its proliferating tendency, and biophysical properties requires constant human efforts in controlling its spread. The article argues that resituating the fern's materiality, the anxieties its dispersal provokes, and the scientific studies highlighting its bioremediation potential reveals paradoxical challenges to normative practices of conservation which focus on fixed spatial zones. By doing so, I show how planning for conservation is a fraught process when the plant life in question is mobile and reflect on the need for new imaginaries of conservation practices in multispecies and industrial ecologies.

Key Words: ferns, industrial ecologies, biodiversity, conservation, multispecies, political ecology

Resumen

¿Cómo es que la sobrepoblación de helechos revitaliza y ejerce presión en las ecologías políticas del paisaje y la conservación de vida silvestre? Este artículo etnográfico cuestiona los mundos relacionales de humanos, animales y la especie de helecho conocida como 'helecho bracken' (*Pteridium* spp.), que prospera en y alrededor de sitios donde se extrae mineral de hierro en el sur de la India. Autoridades forestales han caracterizado la "monopolización" lenta del helecho en el Parque Nacional Kudremukh como una amenaza a la biodiversidad celebrada en el área. A partir de historias contemporáneas del pasado industrial de la región, de las actas de reuniones del Comité de las Gahts Occidentales, así como el trabajo en curso de pteridólogos y del departamento estatal forestal, este artículo analiza las formas en las que la dispersión 'invasiva' del helecho bracken, su tendencia a proliferar y sus propiedades biofísicas, requieren esfuerzos humanos constantes para controlar su

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propagación. El texto argumenta que, al resituar la materialidad del helecho, las ansiedades que provoca su dispersión y los estudios científicos que resaltan su potencial de bioremediación, se revelan retos paradójicos a las prácticas normativas de conservación que se enfocan en zonas espaciales fijas. Al hacer lo anterior, demuestro cómo la planeación para la conservación es un proceso tenso cuando la vida vegetal en cuestión es móvil, y reflexiono en torno a la necesidad de nuevos imaginarios para las prácticas de conservación de ecologías multiespecie e industriales.

Palabras clave: helechos, ecologías industriales, biodiversidad, conservación, multiespecie, ecología política

ಸಾರಾಂಶ

ಅನಿಯಂತ್ರಿತವಾಗಿ ಬೆಳೆಯುತ್ತಿರುವ ಜರೀಗಿಡಗಳು ಸಾಂಪ್ರದಾಯಿಕವಾಗಿ ಬಳಕೆಯಲ್ಲಿ ಇರುವ ವನ್ಯಜೀವಿ ಸಂರಕ್ಷಣೆಯ ಕಥನಗಳನ್ನು ಪ್ರಶ್ನಿಸುತ್ತದೆ. ಜನಾಂಗಶಾಸ್ತ್ರೀಯ ಪದ್ಧತಿಯ ಹಿನ್ನಲೆಯಲ್ಲಿ ಈ ಲೇಖನವು ಮಾನವರ, ಪ್ರಾಣಿಗಳ, ಕಬ್ಬಿಣದ ಅದಿರನ್ನು ತೆಗೆದು ಬಿಟ್ಟಿರುವ ದಕ್ಷಿಣ ಭಾರತದ ಸ್ಥಳದ ಮತ್ತು ಸುತ್ತಮುತ್ತ ಅಭಿವೃದ್ಧಿ ಹೊಂದುತ್ತಿರುವ ಪ್ಟೆರಿಡಿಯಂ ಅಕ್ವಿಲಿನಮ್ ಅಥವಾ 'ಬ್ರೇಕನ್ ಫರ್ನ್' ಎಂಬ ಜರೀಗಿಡದ ನಡುವಿನ ಪ್ರಪಂಚವನ್ನು ಅನ್ವೇಶಿಸುತ್ತದೆ. ಜರೀಗಿಡವು ನಿಧಾನಗತಿಯಲ್ಲಿ ಏಕಸ್ವಾಮ್ಯವಾಗಿ ಹರಡುತ್ತಿರುವುದು ಕುದುರೆಮುಖ ರಾಷ್ಟ್ರೀಯ ಉದ್ಯಾನದ ಪ್ರಸಿದ್ಧ ಜೀವವೈವಿಧ್ಯತೆಗೆ ಮಾರಕವಾಗುವುದು ಎಂಬ ಅಭಿಪ್ರಾಯ ಅರಣ್ಯ ಅಧಿಕಾರಿಗಳಲ್ಲಿರುವುದು ಕಂಡು ಬರುತ್ತದೆ. ಪ್ರಸ್ತುತ ಲೇಖನ ಜರೀಗಿಡವು ವೇಗವಾಗಿ ಬೆಳೆಯುತ್ತಿರುವುದನ್ನು ನಿಯಂತ್ರಿಸುವಲ್ಲಿ ಮಾನವನ ನಿರಂತರ ಪ್ರಯತ್ನಗಳ ಅಗತ್ಯವನ್ನು ಈ ಪ್ರದೇಶದ ಕೈಗಾರಿಕಾ ವಲಯದ ಪ್ರಸಕ್ತ ಇತಿಹಾಸ, ಪಶ್ಚಿಮ ಘಟ್ಟಗಳ ಬಗೆಗಿನ ಸಮಿತಿಯ ಸಭೆಗಳ ನಡಾವಳಿಗಳು, ಪೆರಿಡಾಲಜಿಸ್ಟ್‌ಗಳ ಮತ್ತು ರಾಜ್ಯ ಅರಣ್ಯ ಇಲಾಖೆಯ ಪ್ರಸ್ತುತ ಕೆಲಸಗಳ ಹಿನ್ನಲೆಯಲ್ಲಿ ವಿಶ್ಲೇಷಿಸುತ್ತದೆ. ಸ್ಥಿರ ಪ್ರಾದೇಶಿಕ ವಲಯಗಳ ಮೇಲೆ ಕೇಂದ್ರೀಕರಿಸುವ ಸಾಂಪ್ರದಾಯಿಕ ಸಂರಕ್ಷಣಾ ರೀತಿಗಳಿಗೆ ಬದಲಾಗಿ, ಜರೀಗಿಡದ ಪರಿಚಲನೆ, ವಿಷಕಾರಕ ಅಂಶಗಳು ಹಾಗೂ ಜೈವಿಕ ಪರಿಹಾರ ಸಾಮರ್ಥ್ಯವು ಹಲವು ವಿರೋಧಾಭಾಸದ ಸವಾಲುಗಳನ್ನು ಒಡ್ಡುವುದರಿಂದ ಇದರ ಬಗ್ಗೆ ನಾವು ಯೋಚಿಸುವ ರೀತಿಯನ್ನು ಮರು ಪರಿಶೀಲಿಸಬೇಕು ಎಂದು ಈ ಲೇಖನವು ವಾದಿಸುತ್ತದೆ. ಈ ಸಮಸ್ಯೆಗಳನ್ನು ರಾಜಕೀಯ ಪರಿಸರ ವಿಜ್ಞಾನದ ಪರಿಧಿಯಲ್ಲಿ ಕೇಂದ್ರೀಕರಿಸುವುದು ಸಂರಕ್ಷಣೆ ಮತ್ತು ಜೀವವೈವಿಧ್ಯತೆಯ ಬಗ್ಗೆ ಯೋಚಿಸಲು ಹೊಸ ಮಾರ್ಗಗಳನ್ನು ತೆರೆದಂತಾಗುತ್ತದೆ. ಅದುದರಿಂದ, ಈ ಲೇಖನವು ಕೈಗಾರಿಕಾ ಚಟುವಟಿಕೆಯ ಇತಿಹಾಸ ಇರುವ ಬಹು ಜೀವಿಗಳು ನೆಲಸಿರುವ ಪರಿಸರಕ್ಕೆ ಸಂಬಂಧಪಟ್ಟ ಹಾಗೇ ಪರಿಷ್ಕರಿಸಿದ ಸಂರಕ್ಷರಣಾ ವಿಧಾನಗಳ ಅಗತ್ಯವನ್ನು ಒತ್ತಿ ಹೇಳುತ್ತದೆ.

ಪ್ರಮುಖ ಪದಗಳು: ಜರೀಗಿಡಗಳು, ಕೈಗಾರಿಕಾ ಪರಿಸರ ವಿಜ್ಞಾನ, ಜೀವವೈವಿಧ್ಯ, ಸಂರಕ್ಷಣೆ, ಬಹುಜಾತಿಗಳು, ರಾಜಕೀಯ ಪರಿಸರ ವಿಜ್ಞಾನ

1. Introduction

> Wherever there is newly cut land or one that is relatively poor in organic content in the soil, you'll find ferns…they need good drainage conditions and not stagnation, which is why you will find them on slopes. Kudremukh has high humidity, the soil has a moisture of seventy percent. In these conditions, and *because of human interference and disturbance* through mining, ferns thrive there… (italics, my own)
>
> Dr. Smitha Hegde, Pteridologist[2]

In 2018, Dr. Smitha Hegde, a pteridologist who has worked with ferns over two decades, shared these words with me in an interview. I showed Hegde photographs of a plant that lined the hiking trails and state highways inside the Kudremukh National Park (KNP), located in the biodiverse

[2] Personal interview with the author, 2018. All quotes by Dr. Smitha Hegde in the article are from a set of interviews conducted in 2018 and 2019, unless noted otherwise.

Western Ghat mountain ranges in southern India; she had immediately declared "bracken fern!" An invasive plant with a thriving presence, the Pteridium aquilinum commonly referred to as the bracken fern has been classified as "a worldwide distributed aggressive weed species…" (Vetter, 2010).[3] Due to its extensive proliferation, the fern has been a source of concern. For instance, in its Revised Management Plan for Kudremukh National Park (2003-2013), the Kudremukh Wildlife Division identified three main threats that 'invasives' posed to the park.[4] In the plan, and in subsequent newspaper articles which quoted forest officials, the invasive ferns were described in three ways:

1) threatening the national park's celebrated biodiversity,
2) affecting the food options and health of the herbivores who live and feed in the region's grassland forests, and
3) rendering the national park susceptible to forest fires during the dry season (KWD, 2003-2013).

Over the years, ferns in Kudremukh have also been part of scientific studies, included in field guides for their multiple uses and harms, to display the national park's biodiversity.

When I asked Smitha why she had begun studying ferns, she responded on an autobiographical note. Her father had worked in a public sector bank, which meant the family often moved around the country for work reasons. However, she "did not look at this movement as a disadvantage" even though it had involved changing multiple schools.

> Change always brings about more resilience in an individual, so it does in my ferns. The harsher the environment, the lesser the nutrition, the more vigorously they come back, and they adapt. So, I connect with my plants in that way, in terms of resilience to stress. It's a myth that we grow only when everything is fine … Despite the loss of nutrients, they (ferns) can adapt, and that is very fascinating for me when it comes to plants.

Smitha's interpretation of change as a precursor to adaptive and 'resilient' ferns is striking—in that according to evolutionary biology environmental changes might often also result in extinction (Frankham & Kingsolver, 2004). Environmental changes have also been interpreted more broadly within political ecology, geography and anthropology, which eschew nature-society dualisms, and argue for expanding the exclusive focus on human practices to engaging with the ethical and political implications of interspecies interactions (Münster, 2016; van Dooren *et al.,* 2016). Taking a relational enquiry to human and more-than-human life, van Dooren argues that multispecies life and death are "situated in webs of interactions" and are "relationships of co-evolution and ecological dependency" (2014, p. 4). While political ecology too has long questioned conservation practices as tied to discrete spatial units and bounded territories or as restricted to groups of species (Robbins, 2019 p. 181), specific attention to the liveliness of other-than-human beings which challenge conservation paradigms is undertheorized.

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[3] While initial literature considered the *Pteridium* species to comprise mainly the Pteridium aquilinum subtype, more recently the category has been subdivided into more than ten kinds. Therefore, "ferns which belonging to the genus *Pteridium* are collectively called brackens…" (Gil Da Costa et al. 2024). Therefore, throughout this article, I utilize the bracken fern in my narrative of the fern, and use Pteridium aquilinum specifically when I reference/quote studies published in scientific journals.

[4] Hereafter, the revised management plan is cited as (KWD 2003-2013) in the article.

This article argues that Hegde's scientific studies offer a complicated account of ferns that resist the framing of invasive plants solely as a menace. Hegde's research on the thriving of *Pteridium* species and other ferns within Kudremukh's industrial ecologies suggests that lifeforms which possess "resilience to stress", and their capacity to absorb heavy metals, signposts new horizons of toxicity and ecological value. Foregrounding the profusion of the invasive bracken fern, this article reads Dr. Hegde's studies on the fern's ecological properties as challenging the normative conservation tactics which seek to enclose the national park as a zone of desirable ferns and the elimination of undesirable ones. In *A field guide to the ferns of Kudremukh National Park* (Hegde & Sajeev, 2013), a picture booklet prepared by Dr. Smitha Hegde with the help of another taxonomist and the support of the Kudremukh Wildlife Division, not only lists the fern's names, key features, and habitats, but also their medicinal, nutritional, and other cultural uses, such as dyes or in rituals. Elsewhere, ferns are viewed as valuable to biodiversity and for their potential for biotechnological applications as fertilizers, bioabsorbents, or as bioinsecticides (Fernandéz & Sierra, 2022, p. 707). Thus, the biodiversity studies of ferns carried out by pteridologists like Hegde make visible how the Kudremukh National Park contains unconventional forms of biodiverse life due to the varied human and other-than-human disturbances over the years.

In taking this approach, the article does not seek to fetishize capitalist megaprojects such as iron-ore mines as contingent for the flourishing of biodiverse life. This is especially important to note in the context of India where environmental scientists have repeatedly critiqued the Indian State of Forest Report for "simplifying" the definitions of forests by expanding it to include commercial plantations such as coffee, tea, and rubber (Lele, 2025), and for "misleading" quantification on the overall state of forests by including one-year old trees and bamboo plantations to show an increase in forest cover (Shah, 2024). Rather, following Tsing *et al.,* and their approach to "patchy" landscapes, this article traces a range of social relations to examine how "ecology, capital and human and more-than-human histories" interface in this multiuse landscape (2019, p. 186). The article analyzes plant life within post-extraction ecologies conceptualized as degraded, and in the context of the landscape's own industrial histories to track how the liveliness of ferns evades wildlife conservation practices in Kudremukh.

2. Methods

Building on the above terrain, the article offers four interconnected conceptual frameworks to delineate a political ecology of ferns in the Kudremukh region in southern India (Figure 1, 2). First, I draw on the political ecology of invasives to delineate how some ferns come to be coded as desirable and undesirable. Second, I engage with insights from ethnographies of other-than-human landscapes to explore how fern mobility disturbs conservation ideologies which are entwined with concepts like protected territories. Third, since the ferns' presence and proliferation overlap with (and exceed) the landscapes of iron-ore extraction, I draw on emerging research of industrial and multispecies ecologies. Fourth, I track the specific ways in which invasive ferns engender and resist forest management practices which seek to constrain their spread. In tracking these relational worlds of humans, animals, extraction landscapes, and 'ungovernable' ferns, this article seeks to answer: how do 'lively' ferns in Kudremukh vitalize and/or pressure discourses of landscape and wildlife conservation?

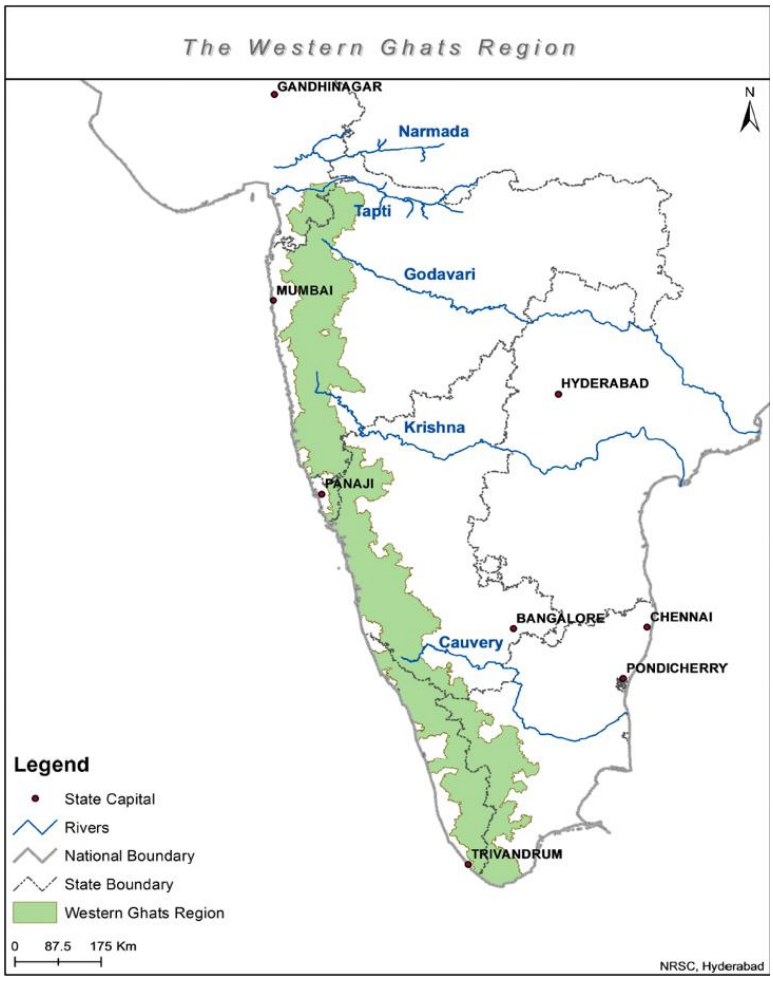

Figure 1: The Western Ghats region and the origin of major rivers. This map was originally included in the High-Level Working Group on Western Ghats, more popularly known as the 'Kasturirangan Committee Report' (2013, p. 40).

The article employs interdisciplinary methods to answer the above questions. The primary empirical materials are based on ethnographic walks and hikes in the Kudremukh National Park in multiple stints between 2017 to 2019, and on open-ended interviews and informal conversations with the pteridologist conducted in Mangaluru city between 2018 and 2020. The latter was essential in gauging how scientific experts who have worked in the KNP understand the material properties and "feral dynamics" (Bubandt & Tsing, 2018) of ferns like the *Pteridium*. The ethnographic fieldwork and interviews are combined with content analysis of primary sources such as *The field guide to ferns in the Kudremukh National Park* (Hegde & Sajeev, 2013) and published newspaper articles to examine the official and popular discourse around ferns in Kudremukh. The empirical analysis is further triangulated with a document analysis of key sections from the Revised Forest Management Plan for the Kudremukh National Park (KWD 2003-2013), reports of the Western Ghat committees constituted by the Planning Commission of India, and the Report of the Western Ghat Expert Ecology Panel (WGEEP, Gadgil *et al*. 2011). These documents provide a window into the work performed by

state forest officials to contain the fern's proliferation within the KNP, and reveal more generally, how the forest department framed its biodiversity priorities, the park's management and its future.

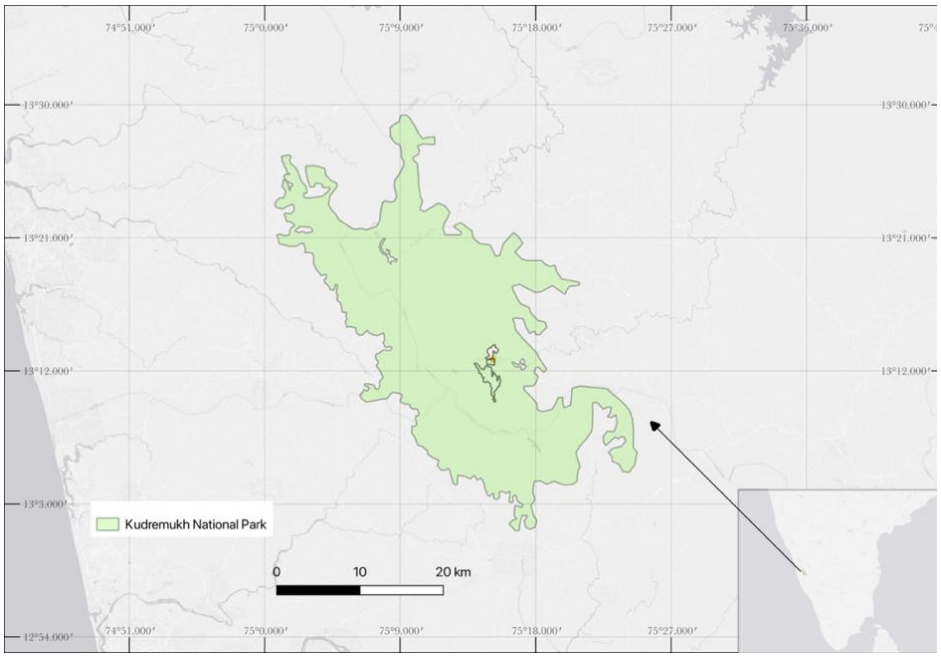

Figure 2: The map depicts the location of the Kudremukh National Park area in south India. This was created using the open-source software QGIS 3.43.

3. Political ecology of invasives

Not all ferns are deemed 'invasive.' Among the earliest flora on Earth between 250 to 300 million years ago, ecological studies of ferns point to their staggering biodiversity (nearly 1,000 species), and their uses as food, medicine, and agriculture (Sharpe *et al,* 2010). While ferns were edged out by seed-bearing plants in the course of their evolutionary histories, biologists have often drawn attention to their thriving presence in landscapes shaped by natural and anthropogenic disturbances (Walker & Sharpe, 2010). The extensive debates around the nomenclature of 'invasive', 'alien', 'feral', 'domestic', 'introduced', and 'native' plants are not only interdisciplinary, but also revealing of the political, emotional, and ethical values at stake in these terms.[5] For instance, while some Anishinaabe community members view introduced species as threats, others invest plants with personhood, relate to them as family members involved in reciprocal relationships with people; as capable of communicating; and, even characterize them as members of "nations" who migrate (Reo

[5] Scholars working across cultural and ecological registers of such nomenclature offer productive discussions on the affordances and limitations of these categories. For instance, taking the example of street dogs in India, Mann Barua and Anindya Sinha (2023, p. 2212) argue that the term "ferality" is fraught, and leverage its double-edged tension to analyze how oppressive social orders produce ferality, even as feral beings themselves might suggest new ways of occupying cities against imposed governance practices. Referencing the racialized histories of terms like "native" in social contexts, John Hartigan (2014) offered that even as such categories are unstable, they might help extend the domain of social analysis to include plants and transspecies interactions in addition to human beings.

& Ogden, 2018). In Indonesia, the Upper Bian Marinds "blame" the invasive oil palm and "pity" it for how it lends itself to human control (Chao, 2023, p. 6). Thus, groups such as indigenous communities have long related to plants via alternate frameworks outside 'native/non-native/invasive' distinctions.

Broadly in the sciences, the classification of plants as 'invasives' reveals the underlying logic of fields like conservation biology, invasion ecology or restoration ecology where ecological relationships are analyzed "explicitly with regard to an a-priori baseline" (Robbins & Moore, 2013, p. 4). In these, invasive plants, or 'Invasive Alien Species' (IAS) are characterized as threatening biodiversity and ecosystem services (Kannan *et al*., 2013), and human livelihood and well-being (Shackleton *et al*., 2019). Even as 'native/alien' categories continue to be dominant within invasion ecology, scholars argue that in times of environmental change, ideas of 'fixed nature' are untenable, and that such hybrid landscapes demand new conceptual categories (Gibbs, Atchison, & Macfarlane, 2015, p. 58). Recent debates in the field move beyond questions of 'pristine nature' towards invasive plant management and policy recommendations due to the recognition that invasives have always spread through human activities, in addition to dispersal because of insects, birds, water and geological processes (Head *et al.,* 2015). Such concerns have also been brought to bear on the Western Ghats mountain ranges which have been identified as one among major "invasion hotspots" in India (Adhikari, Tiwary, & Barik, 2015).[6]

Outside of ecology, these framings have been extensively debated since the labels 'native', or 'alien' do not indicate plant characteristics but rather indicate dispersal and movement outside of their assigned boundaries (Warren, 2021). It is worth noting that such boundaries, even within international agreements, are often aligned with the territories of nation-states, i.e. the very construction of conservable spatial zones is linked to the modern state's ordering of its territories to protect its resources (Neumann, 2004; Peluso, 1993). In this conservation model, national parks like Kudremukh function as enclosures. Therefore, when *Pteridium* ferns, even within defined enclosures such as national parks, exceed their desirable numbers and function, they are characterized as 'invasive.'

Within political ecology, scholars have analyzed the effects of 'invasives' in relation to social landscapes. Christian Kull and Haripriya Rangan show, for instance, how certain plants come to be categorized as weeds (and therefore, as 'threats') through the interplay of three scalar processes:

1) the operational scale, where aspects of time, space and power shape social activity and biophysical phenomena,
2) the observational scale, where such phenomena are sought to be measured and controlled, and
3) the interpretive scale, which involves "translating" the phenomena through "narratives" and a hierarchy of values (Kull & Rangan, 2015, p. 488).

[6] Using methods such as Ecological Niche Modeling combined with data from the Global Biodiversity Information Facility, the authors deduced two significant reasons why biodiversity hotspots like the Western Ghats "coincide with invasion hotspots": 1) the territory is "climatically suitable" for the invasive alien species which have similar requirements to native plants, and 2) the territory possesses an "environmental gradient", which when combined with anthropogenic pressures like agriculture, grazing, or industry contributes to variable resources/nutrients which in turn encourage the growth and spread of invasives (Adhikari, Tiwary, & Barik, 2015, pp. 11-12).

It is precisely the categorization of plants as "out of place", and their ability to "intrude and irritate" human social boundaries that then provoke new conceptualizations of multispecies ecologies (Virens, 2023).

Similar insights are present in the ethnographies of plant-human worlds where the actions of mobile plants challenge simplistic ideas of multispecies agency. Laura Ogden (2011) shows how the red mangrove's dense network of rhizomatic roots aid in stabilizing a "highly mobile" landscape in the Florida Everglades, even as the wider landscape is shaped by the movements of people and by numerous other-than-humans such as alligators, snakes, and water flows, among others (pp. 88-89). More broadly, in multispecies anthropology, the discourse around "invasive species" has been most extensively explored in the case of animals and tensions around their "moral worth" (Clark, 2015) or their "killability" (Bocci, 2017).

Building on these findings, I argue that the political ecology of invasive plants exposes the following paradox: on one hand, when the abundance of some plants becomes a source of (human) anxiety in a specific sociocultural context, plants are classified as weeds, "invasives," or "out of place." On the other, when the presence of specific plants has use-value, whether as food (for humans or animals), medicine, biodiversity, or as part of landscape aesthetics, the plants are coded as desirable and "in-place." Such anxieties or desires often reflect the wider discourses around nature-based resources where social and political processes shape their creation, production, and valuation across different time spaces (Ferry & Limbert, 2008).

For instance, in the case of Kudremukh, the same landscape has been valued differently across the span of a century. In the early 20th century, the British colonial state employed geologists to create a resource map of Kudremukh, while in the late 1970s the postcolonial Indian state established an iron-ore mine in the area to meet its developmental and foreign exchange goals. In the late 1990s and early 2000s, the mobilization of civil society groups including doctors, renowned writers, and Hindu religious leaders alongside conservationists around environmental issues led to the recognition of its forests and biodiversity (Assadi, 2002).

This broad shift towards the selective valuation of resources and biodiversity is also visible in *A field guide to the ferns in the Kudremukh National Park*. The "Uses" section under the bracken fern highlights that the fern's "leaves have been used in a steam bath as a treatment for arthritis," as a "poultice of pounded fronds" to alleviate soreness, and as "a very good source of cloth dye of black and brown colour," even as the concluding sentence cautions that "recent findings have implicated the plant as a carcinogenic due to its compound ptaquiloside," and that its "fronds are reported to be fatal for grazing animals" (Hegde & Sajeev 2013, p. 67). Thus, discourses about the bracken fern in both the revised management plan and in Hegde's studies were not explicitly focused on its native or alien provenance; rather, they focused on the fern's uses and its harmful effects on the landscape, and on other life such as on the park's herbivores such as deer and other grazing animals.

3. Politics of conservation in multispecies territories

During a hike inside the Kudremukh National Park (Figure 2) in 2018, the park's endemic *shola* grassland forests were visible in all directions. Carved into the nooks of hills, these *shola* clusters play an important function in a region that receives heavy rainfall annually: they shelter diverse manner of animal and plant life and keep the soil—always susceptible to erosion in the monsoons—in place. *Sholas* refer to the tropical 'grassland mosaics' which occupy the upper altitudes (between 1,200 m to 2,650 m above sea level) of the biodiverse Western Ghats mountain ranges in southern India (Robin & Nandini, 2012). Our guide, also a local resident, directed our attention to the blue signboard put up by the Forest Department which proudly announced the presence of lion-tailed

macaques as a significant feature of the park (Figure 3). The information text explained that this species is "one of the rarest macaques in the whole world," is "endemic to the Western Ghats," was an endangered species, and "an arboreal mammal which eats fruits, leaves, and insects." The signpost is significant since the presence of lion-tailed macaques and their wide distribution in Kudremukh's *shola* forests have been cited as crucial to the area's classification from a collection of Reserved Forests to a national park in 1987 (Sridhar, 2010, p. 378-379).

Figure 3: A forest department signboard depicting three species of monkeys inside the national park. The shola grassland forests are in the backdrop. Source: Author.

However, that morning on the trail, we had only come across leeches, birds in the distance, and the dogs from the village accompanying us on the hike. We had noticed, however, the copious fronds of a plant throughout. The plant was green and lush in different places, it erupted from the walls next to highway paths; elsewhere it was dry and almost purple, cracking at the slightest touch; in some patches, it was burnt black, traces of the Forest Department's controlled burning exercises to keep the plant in check. Sheaves of the bracken fern had also lined the State Highway 66 which cut through the length of the national park. It had appeared especially abundant in the areas adjoining the now decommissioned mining township.

The Kudremukh National Park, like other Protected Areas (PAs) and biodiversity hotspots, is a territorial configuration. While such territories appear 'natural', they are socio-natural formations produced through a combination of "human imagination, social practices and knowledge systems" (Boelens *et al.,* 2016, p. 2). Territories are therefore products of relations, a result of enclosure

strategies and boundary practices (Bakker, 2010). What makes territories conceptually distinct from space and place, is that they are always regulated as "juridico-political" entities, i.e., "the area is controlled by a certain kind of power" (Foucault, 2007, p. 154). Forests, national parks, and reserves are some examples of territories which play a significant role in normative conservation efforts worldwide. Often, territories of conservation are created as spaces for "pristine" nature and have historically emerged in response to the loss of biodiversity or extinction narratives (Adams, 2016). In these, the role of the state and of humans in making, maintaining, or defying territories through legal rules, movement, property, infrastructures, security and conservation regimes is well-established (Sivaramakrishnan, 1999; Lund & Peluso, 2011). In the Indian context, usually it is the state or a private conservation group which championed a "wildlife first" policy, often at the expense of dispossessing forest inhabitants (Kodiveri, 2018; Margulies, 2018). Yet the exclusive focus on human actors and discourses in multi-species landscapes like Kudremukh obscures the dynamics of other-than-human entities like the bracken ferns which challenge the management of forest territories.

In the past decade, in a departure from the foundational trends of conservation with a focus on human action, scholars in cultural geography and anthropology have attended to the shared relations between humans and other-than-humans within territorial regimes (Aiyadurai, 2016; Mathur, 2021; Athreya *et al.,* 2013; Aisher & Damodaran, 2016), even as some point out that a "multispecies consciousness" has long existed on ground especially among indigenous groups (Wijumanai, 2022). However, alongside these accounts, human-plant relations and their implications for spatial regimes are undertheorized. Therefore, in thinking with conservation territories via plant dynamics, I build on work by Sarah Besky and Jonathon Padwe who frame "multispecies territoriality" as involving "profusions of meetings and intersections" which cannot be reduced to the actions of a single species (2016, p. 20-21). Instead, as Besky and Padwe argue, plant biodiversity projects are regulated through an inclusion of the desired level of plant richness and with the exclusion of entities perceived as a threat to those 'biodiverse' ecologies.

In a similar vein, political ecologists have recently reckoned with how aspects of place, the specific lively qualities of the plants, and contours of shared plant and human entanglement are essential in delineating a "vegetal politics" (Head *et al.,* 2014, 2015). As Alyssa Paredes (2021, p. 72) asks in her discussion of women's' activism around weeds in urban Japan, "how do plants trigger collective action…?" Jake Fleming (2017), for instance, articulates a "vegetal political ecology" showing how plant actions and human partnerships together make visible the "broader environmental contestations" of a walnut-fruit forest in post-Soviet Krygyzstan (pp. 27-28). Developing a political ecology of weeds, Argüelles and March (2022, pp. 45-46) reference the "plantiness" of weeds within agriculture, specifically its biological capabilities which trigger environmental politics across locales and scales. Examining the invasive *Mikania* creeper in plantations in Assam, Mann Barua (2023, p. 18) delineates the "vegetal geography" in which the hyperabundant plant has "cascading effects," from impacting Adivasi work and subsistence practices to the degradation of elephant habitats.

In the Kudremukh Park's management plan, the fern's material properties, its propensity for uncontrolled spread, and recursive relationship to fire were marked as an ongoing challenge to be contained. Tracking the human and institutional actions towards the bracken fern inside the Kudremukh National Park highlights the fern's ecological impacts (such as its contribution to the yearly forest fires, the disruption of the herbivore food chain) and also its spread and movement. These features all reconsider assumptions of conservation as rooted in territoriality. In contrast to animals, plants are often viewed as static entities, rooted in place. However, the ever-growing scientific literature analyzing plant movement shows that plants not only move in the sense that their seeds scatter and take root due to external elements (breeze, a passing animal, bees etc.), but also that they move *in place* during their growth. For instance, in "Can plants move like animals?" plant

biologists share observations of the movement of pea shoot tendrils towards a support structure captured with a time-lapse camera (Simonetti *et al.,* 2021, pp. 12-13).[7] The experiment shows that pea shoots can regulate their tendril apertures and the velocity of their "grasping" depending on the thickness of the support. Therefore, in taking the movements of plants as my starting point of analysis, I follow the work of political ecologists and animal geographers who move beyond anthropocentric frames to bring critical posthumanism in dialogue with political ecology (Argüelles & March, 2022; Margulies & Bersaglio, 2018).

Utilizing the lens of vegetal politics, the article grapples with the implications of plant dynamism on a range of human, institutional, and other-than-human entities. These impact and are affected by the bracken fern's spread and movement. There is a range of nuanced work on plant agency (Myers, 2015), especially in the context of plantation forms. For instance, Sophie Chao (2022) and Mann Barua (2023) work with the theoretical lens of agency in the context of invasive plants such as the oil palm and the *mikania* creeper respectively, via their interlocutors from indigenous communities who already theorize the specific plant behavior as such. In the context of this article, interlocutors such as the pteridologist, the forest department or the popular sources represented the fern's proliferation, such as its "qualities" and "behavior," in reference to its action (i.e. spread, movement etc.) instead of "agency." While movement is easier to discern in the case of invasive plants, since the scale of their presence ("geographic range expansion") can be easily observed, it is just one of the many factors that contribute to the determination that a plant is an "invasive" (Lockwood *et al.,* 2013, p. 17).

The Forest Department's anxieties around invasive ferns within the Kudremukh National Park can be better contextualized alongside the postcolonial Indian state's move to nationalize forests through the creation of the Wildlife Protection Act in the 1970s, when hunting had "decimated wildlife" (Lele, 2019, p. 23-24). Political ecologists have read the inauguration of this Act as the moment when forest governance regimes became focused on wildlife. In the Act, in addition to hunting and poaching, the "introduction of exotic species" was also outlined as a threat (Kannan *et al.,* 2013). In the intervening years, progressive legislation such as the Forest Rights Act (2007) have recognized forests as ecological and social spaces integral to the livelihood of forest dwellers, even as few conservation practices have diverged from the "fortress conservation" paradigm related to Protected Areas (Rai *et al.,* 2021). However, attention to the vegetal politics of other-than-humans remains underexamined in relation to conservation. Thus, alongside the undesirable biological effects on animals, humans, and territory, 'invasives' are marked as such by diverse historical, social-political and cultural investments in controlling their spread and are further complicated by their presence within Kudremukh's industrial ecology of mining.

5. Politics of industrial ecologies

On a long enough timeline, the history of ecology is one of a series of unexpected encounters, as landscapes themselves are continuously transformed by interspecies interactions, and by the histories of their management and domestication (Bubandt & Tsing, 2018, p. 6). Ethnographies which reckon with the long socio-histories of forests and industrial processes shaping landscapes have referred to them as "post-industrial natures" (Sivaramakrishnan & Vaccaro, 2006), as sites where political and ecological life endure even amidst the "global rubble of capitalist ruination" (Latour *et al.*, 2018). In some cases, multispecies beings have flourished precisely in such accidental ecologies

[7] The authors refer to this study as "kinematics of nutation." Their study makes and supports the claim that a Central Nervous System (CNS), thought to be the basis of movement, "…is not required for adaptive perceptuomotor transformations… " (Simonetti *et al.,* 2021).

(Kirkseym, 2015). Within political ecology, scholars have largely explored "political-industrial ecology" in the context of quantifying resource flows and energy geographies (Pincetl & Newell, 2017), in terms of urban metabolisms and the production of urban spaces (Newell & Cousins, 2015), and politicized chemicals and toxicity produced as part of industrial production processes (Huber, 2017). While these studies highlight resources, energy flows, industrial processes, and they view urban formations as composed of wild and domestic more-than-human dynamics (Barua & Sinha, 2023) – some even arguing against limiting the study of urban metabolisms to the boundaries of cities (Tzaninis *et al*., 2021) – there is little emphasis on the other-than-human dynamics of landscapes in contexts where historic industrial activity overlaps with forest ecologies.

In contrast, Elaine Gan, Anna Tsing and Daniel Sullivan (2018) combine the lenses of natural history field observations and ethnography to offer a distinct methodological approach to industrial ecologies where human and non-human trajectories are examined in their relation and influences on one another. Focusing on interspecies interactions between the lodgepole pine, red deer, birch, and fungi in an abandoned coal mining landscape in Søby in Denmark, the authors juxtapose a series of diachronic "events and encounters" to outline how industrial ecologies are shaped by other-than-human others (Gan *et al.,* 2018, p. 40). Building on their approach, this article examines the natural histories of ferns as they proliferate in industrial ecologies, to show how the dynamics of landscapes, human actions and ferns interact and influence the trajectory of one another.

The present-day site of the Kudremukh National Park was once home to the Kudremukh Iron Ore Company Limited (KIOCL) between 1978 and 2006. The central government-run company was viewed as a "symbol of modernity" (Assadi 2002). Employing thousands of employees, KIOCL sold iron ore to international markets such as Iran, China, Romania, and Japan, among others. On 31st December 2005, the Indian Supreme Court of India ordered the closure of the mine after conservationists petitioned that the region's *shola* grassland-forests habitat, including the flora and fauna, were ecologically valuable. What made the environmental argument more compelling was that three of south India's freshwater rivers, the Tunga, the Bhadra, and the Netravati, originate in Kudremukh (Sridhar, 2015). As part of the judgement, the mining area (50 km^2) was to be incorporated into the surrounding National Park (600 km^2). Over the years, the mining site was decommissioned. Today, the Kudremukh National Park is an industrial ecology: an assemblage of national and state highways, cut and blasted landscapes, some rusting mining infrastructure, a township in different stages of decay, soils with mining waste, regenerating hilltops, human settlements, biodiverse other-than-humans, and the *shola* grassland-forests.

In 2000, a local newspaper article documented leakage from KIOCL's pipeline carrying the iron ore slurry, which had led to 10,000 tons of ore deposits into the drinking water stream in Karkala, a town near the mine site (Joseph, 2000). Accompanied by an inset photo of the thick grey sludge, the article stated that the slurry had been carried by downstream currents over a twenty-kilometer stretch. While the role of iron-ore mining and its contribution to the high sedimentation of the Bhadra river ecosystem during the monsoons via hydrological studies has been well-established (Krishnaswamy *et al.,* 2006), there has been no such study to comprehensively track the extent and effects of the mining waste in the Kudremukh National Park in the post-closure years. With two decades of iron ore extraction and transportation, it is reasonable to assume that the occasional breakdown of infrastructure has led to mining waste leaching into the soils.

Elsewhere, in news reports, Hegde narrated how the iron ore content of the "mineral rich" soil and the "fire lines" made by the forest department had encouraged the "toxic bracken fern's … rapid colonization in the area", which contributed to "habitat loss for deer" (Harsha, 2013), even as "nutritionally insignificant and toxic" bracken ferns had overpopulated the "fire ravaged areas" (Jayaraj, 2016). The link between anthropogenic landscapes such as Kudremukh, when combined

with insights from the pteridologists' studies (discussed in the following section 6), such as its counterintuitive spore response to techniques like burning, its proclivity for spread, and ability to absorb heavy metals from the soil make the Kudremukh National Park an unexpected industrial ecology.

6. Conservation of the Western Ghats territory and biodiversity

While conservationists' and environmentalists' strategies in the 1990s were predicated on returning the Kudremukh National Park to its original "pristine" status, this belief continued to endure in the aftermath of the mine's closure. To better understand how invasive ferns subvert territory formation, it is crucial to gauge how the forest department practices conservation as a management strategy and their anxieties around how the fern "monopolizes" the National Park, as is visible in the revised management plan (KWD, 2003-2013 p. 43). Further, as political ecologists have noted, the forest bureaucracy in India often performs contradictory roles (Lele, 2019, p. 27), which makes it essential to resituate these management actions within the Indian state's wider policy and planning approaches wherein the Western Ghats are framed as a "natural laboratory."

Kudremukh is located within the 1,600 km Western Ghats mountain ranges which are a popular site for Indian science and conservation studies. These ranges, often referred to as a biodiversity hotspot, have also been a site of intermittent and continuous state planning over four decades.[8] However, despite four decades of planning and concrete research efforts—in the form of national committees, fact-finding reports, public consultations, and numerous scientific studies—any substantial ecological protections remain on paper only due to the diversity of the region and the developmental, ecological and social stakes in play (IANS, 2022). The Western Ghats first entered popular consciousness with the Save Western Ghats Movement in 1986, when environmental activists undertook a 100-day march across the southwestern coast from Kerala to Goa to highlight the effects of human interventions in the region (Sekhsaria, 2017). However, its transition from a landscape and natural formation into a specific site of state planning began in 1972, when the Planning Commission of India constituted the Development of Western Ghats Hill Area Cell High Level Committee and Secretary Committee in 1979, as part of the Hill Areas Development Programme.

The hill areas of India were viewed by the Central Government as requiring unique planning interventions since they were "poorly developed," faced increasing population pressures, and had unique climactic and geographical attributes (Planning Commission, 1979). Between the Fifth Five Year Plan (1974-1978) and the Seventh Five Year Plans (1985-1990) of the Central Government in New Delhi, there was a noticeable shift in the way the state approached the Western Ghats. This shift is noted in the Ninth Five Year Plan (1997-2002) which states that while the strategy for the Hill Areas Development Programme "has been evolving over time," that the focus of interventions was mainly "beneficiary oriented" in the former, while the focus of the Seventh Five Year Plan shifted to "eco-restoration, eco-preservation, and eco-development" (Planning Commission, 1997).[9] That is, the

[8] The Critical Ecosystems Biodiversity Fund defines "biodiversity hotspots" as those which 1) contain at least 1,500 species of endemic life (i.e., found nowhere else on Earth); and 2) are "threatened terrestrial areas" which have lost "at least 70 percent of its primary vegetation." https://www.cepf.net/our-work/biodiversity-hotspots

[9] "Special Area Programmes." *Ninth Five Year Plan 1997-2002. Vol-2.* The plan lists the following ecological and environmental problems which "…include increasing pressure of population on land and vegetation; submergence of forest areas under river valley projects, encroachment on forest lands; clear felling of forests for raising tea, coffee, rubber, and other plantations; mining operations, soil erosion, landslides; shifting cultivation; and declining wildlife population."

emphasis went from the "need for development" to support the region's population, to the landscape needing protection from development activities and its importance for the future of human life.

In 2010, this planning trajectory culminated in the creation of the Western Ghats Ecology Expert Panel (WGEEP), chaired by Madhav Gadgil, the renowned Indian biologist. Set up by the Ministry of Environment and Forests, the special panel was presented as urgent on account of the "environmental sensitivity and the ecological significance of the region and the complex interstate nature of its geography, as well as the possible impacts of climate change on this region" (Gadgil *et al.*, 2011, p. 3).[10] Over the course of seventeen months, the overall process involved fourteen multi-day meetings, expert presentations, public consultations with a wide range of stakeholders, and field visits to the six states concerned (D'Souza, 2020, p. 422); the result was a 522 page report. The report identified two major phases of degradation in the Western Ghats: the first, when the British grew and harvested timber in large quantities to build the railway system; and the second, the "explosion of forest-based industries such as paper, plywood, polyfibres, and matchwood" in the post-Independence years (Gadgil *et al*., 2011, p. 11). The panel's objectives were to first map the boundaries of the 1,500-km long mountain ranges; then to identify ecologically sensitive areas (ESAs); and finally to recommend a management plan for these areas. Kudremukh is referenced as a "classic case of mining pollution" to be avoided (p. 33).

The WGEEP report refers to the Western Ghats as a "laboratory" at two points, with slightly different inflections: first, when one expert states that "the Western Ghats is a living laboratory" (Gadgil *et al*., 2011, p. 263); and the second, when Gadgil stresses that "the entire Western Ghats could be made a model for sustainable living and a laboratory for fashioning development programs compatible with nature conservation and social justice" (2011, p. 305). The trope of the laboratory brings two senses of the term together. In the first, paired with "living," it presents the Western Ghats as an anachronistic paradise for its time, representing what Guannig and Klimburg-Witjes referred to as the "scientific index of biological life" (2021, p. 343). In the second, the Ghats are an experimental site for policies which can work to mediate social and ecological concerns.

However, making laboratories has always been a contentious process, as Elizabeth Hennessy (2018) discusses in her work on the Galapagos Islands, similarly characterized as the "natural laboratory of evolution." Hennessy (2018) shows how making the Galapagos "a laboratory" involved a range of territorial practices which not only naturalized the "conservationist government of life" on the islands but also assumed that "only non-human species that had evolved in place in evolutionary deep time were meant to thrive" (p. 486). The "laboratory" metaphor also finds mention much earlier, in the revised management plan for Kudremukh National Park, in which the park is described as a "living museum" and a "natural laboratory" (KWD, 2003-2013, p. 6). Prepared in 2003, at the height of KIOCL's mining operations inside the park, the management plan continues to be a guiding document two decades after its initial formulation. Such management plans, the document's Foreword indicates, are often the precursor to formal programs.[11] The contrasting "museum" and "laboratory" metaphors appear indicative of the desire to enclose the National Park within a certain ideal type of landscape. However, the report's own section on "Forest Types" chafes against this double vision.

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[10] Ministry of Environment and Forests (MOEF) order (March 4, 2010) cited in *Report of the Western Ghats Ecology Expert Panel* (Gadgil *et al.,* 2011).

[11] The plan was uploaded to the Karnataka Forest Department's website in 2019, under the section on management plans. The foreword states that the document is the collective work of numerous forest officers. However, apart from that of the Deputy Conservator of Forests, no other designations and roles are provided. It is also difficult to ascertain the range of scientific studies alluded to in the formulation of these plans, since no specific studies are cited. Despite these omissions, the document is important since it provides a roadmap of the Forest Department's key concerns with respect to Kudremukh in the early 2000s.

For example, the revised management plan states that while to the "untrained eye" the forests appear to be of an Evergreen type, the National Park is dominated by Grasslands (187.78 km^2), followed by Semi-Evergreen (121.10 km^2) and Secondary-Evergreen forests (110.27 km^2) (KWD, 2003-2013, pp. 31-32). Among the other types of land use within the National Park are areca or coffee plantations (0.21 km^2) and the Mining Dump (0.28 km^2). The coverage area of the "secondary evergreen" forests in the Kudremukh National Park confirms that at least 18.33 percent of the park's land cover/forests (600 km^2), comprise regenerated forests. Regenerated forests are those which emerge in the aftermath of human activity through time (Chokkalingam & De Jong, 2001). I cite these figures to suggest that the forests of the Kudremukh National Park, like much of the Western Ghats was never "untouched" or "pristine" (Morrison & Lycett, 2019), as is routinely presented by the Forest Department and in conservation accounts at the height of the environmental protests against the iron-ore mine.[12]

The management plan also states that "a large part of the vegetation was destroyed, and extensive grasslands were created" by people who live inside the forest (KWD, 2003-2013, p. 25). However, scholars studying *shola* grassland forest biomes elsewhere have shown that such a belief not only is incorrect in that *sholas* are vegetation types that can be traced to the Pleistocene era (Morrison & Lycett, 2019; Sukumar *et al.,* 1995) but also that it repeats the colonial misperception of the *shola* as "degraded forests" (Joshi *et al*., 2018). Further, recent interdisciplinary research on the impact of past land-use on land cover (such as on contemporary forests) supports the interpretation that such classifications typically tend to be based on presumed land use instead of actual land use. To determine the relationships between land use and land cover accurately, the researchers argue, we must work with two kinds of empirical data: for instance, historical or archaeological data to determine past use, and palaeoecological data to determine land cover (Morrison *et al.*, 2021, pp. 5-7). While the management plan does not cite examples of long-term human activity or land use which might account for these diverse forest types in Kudremukh, the contemporary human-led pressures on the landscape in the early 2000s are mentioned. Overall, the revised management plan identifies seven types of "threats" in Kudremukh:

1) Mining and habitat fragmentation
2) Fire
3) Collections of NTFP (Non-Timber Forest Produce)
4) Poaching
5) Grazing
6) Encroachments, and
7) Other Interferences (KWD, 2003-2013, p. 62-71).

After the mine's closure, the park's yearly fire outbreaks in the dry season between January and May are classified as an urgent threat. Due to outbreaks of fires, the Forest Department has been closing the Park's trails to visitors between January and June. So, while driving through the park or a homestay is possible, no treks or walks are permitted within the boundaries during the dry season (Figure 4). In recent years, the fire surveillance apparatus now includes cameras installed at key traffic

[12] More generally, and in addition to the questions of conservation, the Kudremukh National Park was embroiled in contentious and violent sociopolitical struggles in the early 2000s, including by organizations advocating for peasants and indigenous communities against state plans for their rehabilitation and relocation outside of the national park, and by Naxals (armed guerilla group members) based in the Western Ghats (cf. Assadi, 2004 and Sridhar, 2019 for a history of the social movements in the Kudremukh region).

areas inside the park, in addition to foot patrols by the forest guards. The Forest Department also carries out advanced burning to prevent a buildup of dry biomass to reduce the intensity of fire (KWD, 2003-2013, p. 65).

Figure 4: "If you see fire, inform the following number." This signboard in Kannada asks visitors to let the Forest Department know in case they spot fires in the landscape.

The revised management plan blames the park inhabitants (forest dwelling communities) for fires on account of their cultivation practices. The report mentions that areas which are subject to frequent burning are "gradually been taken over by the bracken fern" and determines that more research is required on "Grassland and Fire ecology especially the invasion of the ferns" (KWD, 2003-2013, p. 111). The growth of ferns is contextualized against the Forest Department's assessment of the Kudremukh grasslands which "as a range ground, are poor in quality;" are "coarse and non-browsable"; and their consumable-quality grass (for the park's herbivores) is "surprisingly small." Therefore, the key pressures are "fire, stress, grazing," which encourages the growth of "the Nilagirianthus, Heyneanus and the bracken fern, which then monopolize the site" (KWD, 2003-2013, p. 43). The technical report on the soil sample survey conducted in the Kudremukh National Park corroborates this anxiety, as the report describes the area as "facing colonization by a weedy fern called the Pteridium aquilinum" (Bhat *et al.,* 2018, pp. 344-352). To secure national parks then is also to uphold a "hierarchy of life forms" (Clark, 2015), where some forms of biodiverse life are preferred over others.

Thus, while invasive ferns are only one among the threats to the Kudremukh National Park, their relationship to the forest fires heightens the risk they pose for the Park's biodiversity. Bracken ferns are thus a paradoxical entity, potentially desirable as a phytoremediator, and for its capacities to absorb heavy metals present in the soil and water (Sajeev & Hegde, 2022). They are also viewed as undesirable by the forest department as when they over spread large areas of the park, and as per recent studies, continue to elicit scientific concern due to the presence of carcinogenic compounds (Gil Da Costa *et al.,* 2024).

7. Kudremukh's "ungovernable" ferns as challenging spatial control

Dr. Hegde's initial research on ferns in 2000 involved analyzing them for their biotechnological applications. While ferns were viewed mainly as decorative ornamental plants or as food, they were also beginning to be appreciated as potential agents that could clean air. She concentrated her study within the Mangalore city limits, located close to 80 kms from the Kudremukh National Park. When she first started her research, she was surprised how ferns "were amazing at growing absolutely anywhere … they grew on buildings, on pipes, asbestos or metal sheets." Due to the "microscopic spores at the base of the leaf", they were also "good at dispersing." These initial studies of ferns were documentary and identificatory, and framed through the lens of potential for future value. For instance, the biodiversity booklet on ferns Hegde prepared for the Kudremukh Forest Department (Hegde & Sajeev, 2013) details the range of fern species present in the Western Ghats, alongside information on their respective "preferred habitats," "key formal features," and traditional uses (such as its medicinal properties used to solve skin ailments, or respiratory troubles), and notes on their potential for industrial applications, such as in biopesticides, or as dye.

In her subsequent research, Hegde shows how ferns thrive in "disturbed" landscapes when combined with the "right topographical and weather conditions." She argues that as an anthropogenic landscape intensively shaped and utilized with activities such as mining, housing, transportation, and ecotourism over two decades, disturbance in the Kudremukh region specifically aids the excessive presence of certain ferns. Counterintuitively, "the greatest diversity of ferns is in fact next to the roadsides," and the deeper one went into the tropical forest, the lower the diversity of ferns (Figure 5).

In 2013, the Principal Conservator of Forests (Karnataka) appealed to members of the Fern Society in Mangalore requesting researchers to visit Kudremukh to see if they could offer any solutions to the repeated instances of fires inside the National Park. The Kudremukh Forest Department's attempts to control the fires within the Park involved creating 'fire lines' in areas with a high density of bracken fern biomass, with twenty-foot spaces each marked as a plot, which are then systematically burnt. However, these interventions have a Sisyphean quality in more ways than one. During an interview in 2018, Hegde outlined the futility of this exercise by explaining the effect of heat on the fern's spores:

> The spores of this plant need heat to propagate. When the Forest Department employs "fire lines" to kill the plant, a lot of carbon is generated, which adds fertility to the soil. The burning succeeds in culling the visible part of the plant, but the fern's rhizomes (underground stems), which are deep under the soil are not affected. Rather, the spores thrive on this carbon, using the heat to propagate. They emerge again within 20 days, when [the fern] can grow as much as three feet and then spread…and it is often the first thing that comes back….

It appears then that fire not only encourages the bracken fern's presence but also that it works with the plant's material properties in ways that exacerbate its propensity to spread and "colonize" other vegetation (Bhat *et al.,* 2018). The speed at which the fern regrows results in a 'light-intensive' canopy shade, which in turn prevents the grass from growing in abundance, and limits grass availability for the herbivores in the park. The plant's properties thus challenge ideas of boundaries, territories, and fixity.

Such fires are not novel occurrences inside the park ecosystem. The grasslands in Kudremukh are bi-phasic (i.e., they dry out in the dry season and grow rapidly in the rainy season) and have evolved with fire. Such relationships are highly specific and may lead to different consequences in other grasslands. For instance, conservationists studying landscapes in southern India point out that the idea that burning vegetation was categorically bad emerged during the era of colonial forestry when Indian forests were viewed mainly as sources for growing timber. However, examining the history of burning practices by the forest dwelling and indigenous Soliga community in the Bilgiri Rangaswamy Temple Wildlife Sanctuary (BRT) in Karnataka shows how low intensity early summer fires (called *taragu benki* or "litter fires") were used to maintain healthy forests. Unlike in Kudremukh, the fires in the BRT have an opposite effect on invasives like Lantana, because the fires can destroy its seed in the soil. Based on insights from fire ecology, the authors argue that not only should fires be revaluated as a conservation strategy, but that the "natural baseline for forests in India must include fire" as a component, since plants and vegetation have evolved through time with fire patterns (Thekeakara *et al*., 2017, p. 23).

Planning for territories is a fraught process especially when the life in question is mobile. The fern's proliferating tendency because of its material properties, such as its rhizome and spore response to specific conditions of fire and soil nutrients, rendered knowable through scientific knowledge, reveals the material and conceptual limits of normative conservation tactics as tied to the maintenance of Protected Areas and national park territories. A close look at the details in the revised management plan (KWD 2003-2013) reveals that Kudremukh's forests are a composite of multiple vegetation types—mostly grasslands such as *sholas* and savannahs, followed by evergreen and secondary forests—which render their management at odds with the vegetation's own ecological histories of change through time.

Pteridologists like Dr. Hegde and her team have continued to document the biodiversity and the spatial distribution of the ferns in Kudremukh in recent years. For instance, one study to document the area's pteridophyte richness and biodiversity consisted of surveys across each of the three mountain ranges, west to east, inside Kudremukh National Park. A total of 46 fern species were collected during this process. Morajkar and Hegde determined that the Pteridium aquilinum, a terrestrial type of fern, was the "most commonly found and commonly distributed" pteridophyte in the area, along with the D. Linearis which dominates the park's vast grasslands (Morajkar & Hegde, 2021 pp. 850-852). Their article concludes with a warning that that the "hotspot is likely to face the disappearance of its diverse pteridophyte flora due to the weedy species."

Elsewhere, biologists attribute the Pteridium aquilinum's "success" to the plant's morphological characteristics, the shape of its frond, its ability to thrive in a wide range of soil types and in landscapes that are "disturbed" (Amouzgar *et al.,* 2020). In their recent work, pteridologists also show how a range of ferns exhibit the capacity to remediate contaminated environments polluted by heavy metals like arsenic or organic compounds like insecticides and pesticides. The acidic soil aids the fern's presence, even as the metals present in such soils are absorbed by the fern. In one such study, the Pteridium aquilinum is referenced as being able to absorb at least eight types of heavy metals (Sajeev *et al.,* 2022, p. 632), even as the authors highlight that such studies remain largely "laboratory oriented" (p. 643). How then do we interpret bracken ferns in Kudremukh, whose toxic properties

make them harmful to grassland animals, whose thriving is linked to anthropogenic changes, and who also have the capacity to absorb harmful chemical compounds from the soils and potentially contribute to sustainable futures?

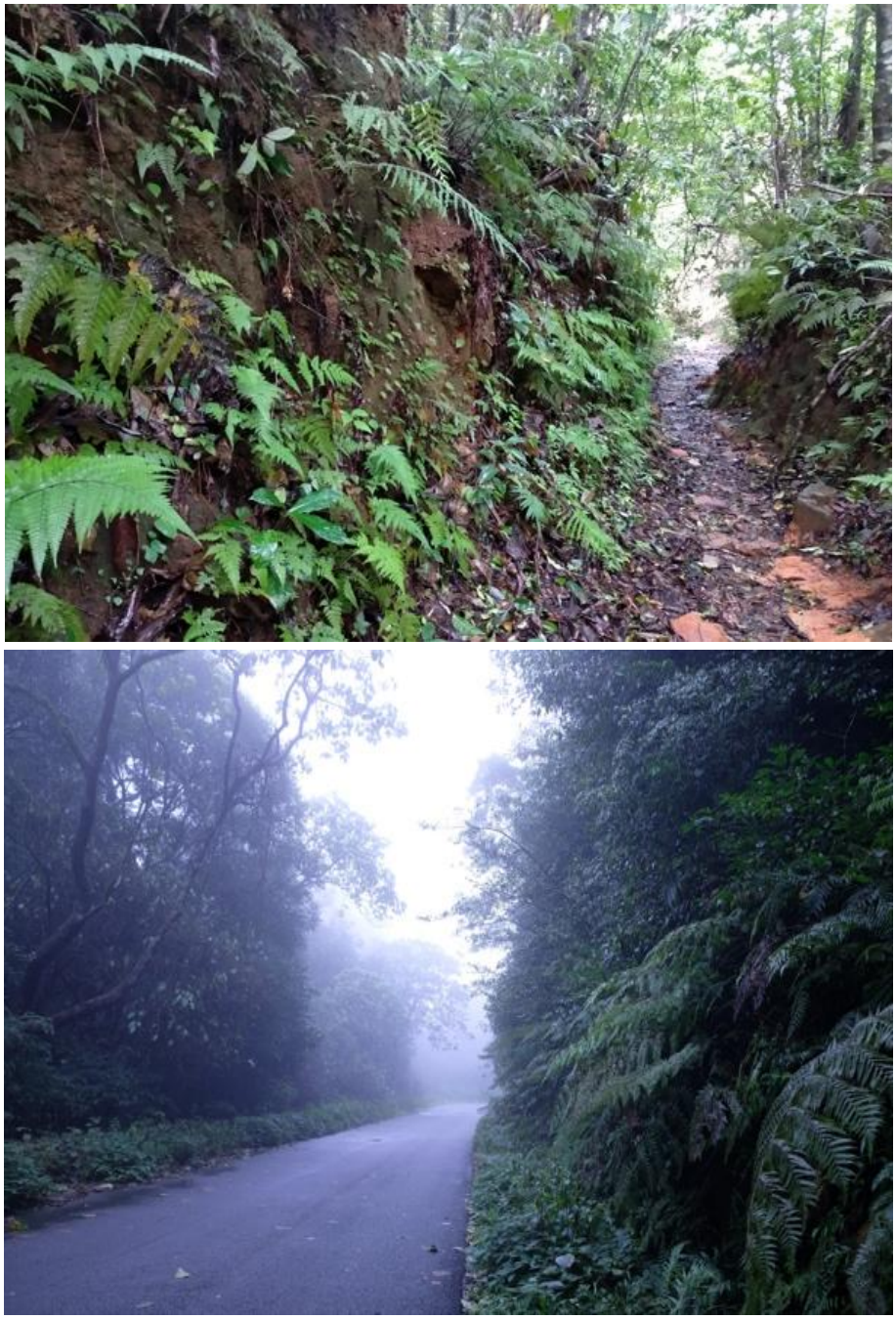

Figure 5: Ferns lining one of the hiking paths (top) and the State Highway 66 (bottom) inside the Kudremukh National Park. Photo: Author.

8. Conclusion: Horizons of conservation in late industrial ecologies

Ferns are not the conventional objects of conservation goals in protected areas and national parks. They are a sign of biodiversity *and also* a menace. Ferns enter chains of value when they are sought for their medicinal and biotechnological properties, as evidenced in the picture booklet produced by Dr. Hegde (Hegde & Sajeev, 2013); they escape attempts to circumscribe them within market or biodiversity discourses, for example when their properties are deemed invasive or toxic to humans and other-than-humans. The presence of some ferns marks the cycles of human-initiated industrial disturbance overground; subsurface, they draw heavy metals present in the soil into their living cells. Bracken ferns actively test the limits of forest management, showing how attempts to freeze an idea of territory or of a desirable forest will always find their match in the movement of unruly species, and in the encounters of humans and plant actions.

Studying the Pripyat marshes in the Chernobyl zone in Ukraine with the help of biologists and a long-term resident, Kate Brown (2019) reflects on the need for "a new kind of literacy" to read such landscapes where layers of human activity through time interact with rhythms of other-than-human life. In this vein, thinking with the ecological properties of the bracken fern alongside the social histories of Kudremukh's iron-ore extraction, the decades of legal environmental protections reveal that existing conservation responses do not account for late industrial ecologies shaped by human and plant activity. Industrial ecologies like Kudremukh are distinct in that the disturbance caused by the presence of mining and industrial or manufacturing activities actively helps some non-human life thrive while being detrimental and harmful to humans and other types of non-human life inside the park.

The actions of invasive ferns then suggest new openings: what other imaginaries of wildlife conservation might be possible within industrial ecologies? In *Emergent Ecologies,* Eben Kirksey (2015, p. 4) shows how biologists are increasingly reckoning with "novel ecosystems" shaped by human disturbances, even as other biologists show how ecosystems have always been shaped by the "loss" of species and by new multispecies assemblages over time. Therefore, in one sense, invasive ferns in Kudremukh gesture to the need for approaches to conservation and territories that exceed the usual apocalyptic and salvation framings (Langwick, 2018).

In another sense, showing how ferns resist efforts to inscribe them within normative discourses of conservation and biodiversity also demands careful engagement with changing baselines and the politics of other-than-humans within layered anthropogenic landscapes. A political ecology attentive to industrial ecologies demands a "gesture of translation" across disciplinary boundaries to better understand how "social and biophysical processes produce one another" (Rademacher *et al.,* 2023, p. 138). Therefore, by bringing together disparate and interdisciplinary sources—such as emerging scientific studies on pteridophytes, decades of policy interventions in the Western Ghats, forest management techniques and their histories, and popular discourses, this article illuminates the seductive quality of the idea of 'native' ecosystems within normative conservation paradigms, and the need to value industrial ecologies so they can be better lived with.

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