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ARBOR

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Humanities | Social Sciences | Sciences

ARBOR

JOURNAL OF UNDERGRADUATE RESEARCH

ABOUT THE ARBOR

The Arbor Journal of Undergraduate Research is the premier undergraduate journal for the Arts and Sciences, seeking to publish, highlight, and celebrate the best of undergraduate Arts & Science research at the University of Toronto. The Arbor Journal offers the unique opportunity for undergraduate students to gain experience in copyediting, peer-editing, publication and partaking in the role of the editorial board.

Following its inception by the Arts and Science Students' Union (ASSU), Arbor has set out to promote the work of undergraduate students at one of the most distinguished research universities in the world. The University of Toronto is a premier venue for conversations about cross-disciplinary research, and Arbor hopes to showcase the research talent of the university's undergraduate students through an annual issue featuring the best from the humanities, social sciences, life sciences, and physical sciences.

Inspired by the multi-disciplinary nature of the Faculty of Arts and Science's academic environment, this volume of the Arbor Journal features mosaics constructed from digitised photos of shards of actual broken pottery, ceramic, and art sourced from across open-source databases. Many of the mosaic pieces do not have listed or traceable origins but nonetheless come together to create new artwork. We hope that you enjoy Volume Seven of the Arbor Journal.

LETTER *from* THE EDITORS

Dear Students of the Faculty of Arts & Science,

It is with great pride that we bring you the seventh edition of the Arbor Journal of Undergraduate Research. This journal could not have been completed without our sixteen incredible editorial board members, who worked rigorously to shortlist submissions, refine papers, and format our final journal. We extend them our deepest thanks. We must also thank our fellow executives and president at the Arts & Science Students' Union, who continually offered their feedback and support in getting Arbor to publication.

Arbor continues to highlight exceptional in-course student research from the Humanities, Social Sciences, and Sciences. We found this year that while there was considerable diversity within the topics for each section, there were also clear repeating motifs within articles — navigating one's relationship to the land, maintaining mindfulness, achieving freedom. These are broader themes which connect our student body across their individual disciplines. Our cover is emblematic of this realization: the Faculty of Arts & Science is a mosaic, in every sense of the word, but we are also a community with similar values.

At the heart of all this are the talented authors whose work continues to drive the calibre of excellence that Arbor represents. The brilliance of and diversity within their writing shines through every page, and the undeniable value that they will bring to each of their careers and chosen life paths using such skills is clear.

To our readers: we thank you for your continued support and endorsement of undergraduate research. We hope that this edition communicates the true distinction that marks the Faculty of Arts & Science.

Sincerely,

Sandini Kodikara
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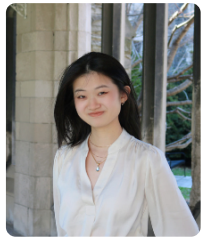

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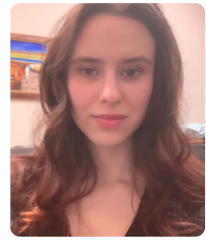

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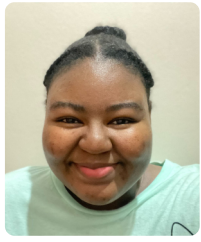

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ENDURANCE AND EROSION

The Role of the Poet in Irving Layton's "The Cold Green Element"

JOY XU

In "The Cold Green Element," Irving Layton transforms the Canadian landscape into a space where artistic creation and destruction share a heartbeat, becoming indistinguishable and staging an inquiry into the act of creation itself, demanding to know the cost of making art. Through violent imagery such as the hanging poet (8-10), lightning-struck trees (17-18), and proliferating murdered selves (28-30), Layton reveals a paradox at the heart of the artistic process; poetry is sustained not by serenity or transcendence, but by immersion in the very chaos that it seeks to shape, forcing the poet to search for meaning in a world that mirrors his own volatility. Borrowing from Nietzsche's contrast between Apollonian form and Dionysian frenzy, Layton recasts the artist's struggles into a Canadian idiom of survival, where the harsh northern landscape forces endurance to become the measure of creativity — both sustaining art and threatening to corrode the artist. Crucially, the poem achieves this fusion through its syntax, utilizing long, enjambed sentences broken by short interjections, so that the rhythm mimics the struggle between discipline and surrender, oscillating just as the poet might. Read in this light, "The Cold Green Element" defines the role of the poet as the one who must plunge into despair rather than transcend it, transforming suffering into vitality in a world filled with indifference — serving the very purpose of artistic creation.

This confrontation between art and indifference takes its most brutal form early in the poem, when creation itself becomes a public execution. The poem's first violent image of the dead poet hung from the city's gates (Layton 8-10) exposes the cost of creation in a world that turns suffering into spectacle. The body of the poet, displayed at the gates or threshold of the city, becomes a symbol of how art is both desired and disavowed. By hanging the poem at the liminal threshold between civility and nature, Layton suggests that society celebrates artistic vitality only once it has been neutralized. The unempathetic crowds, which "depart daily to see it, and return / with grimaces and incomprehension" (Layton 11-12), turn the gruesome scene into a ritual, consuming the poet's body as a spectacle. The movement within these stanzas reinforces the mechanicality of the repetitive motion, with the syntax pushing relentlessly forward which denies the narrative any pause for sympathy, thus mirroring the public's detachment as they pass the corpse. Through this rhythmic indifference, Layton critiques a society capable of witnessing suffering without understanding it. Their complacency reduces agony into an exhibition, captured in the chilling image of lifelessness: "if its limbs twitched in the air / they would sit at its feet / peeling their oranges" (Layton 13-15). The oranges embody the public's appetite for art stripped of feeling, peeling away the bitter, violent skin encircling the craft to indulge in the sweet fruits of the artist's labour. As Joel Deshaye observes in "Celebrity and the Poetic Dialogue of Irving Layton and Leonard Cohen," Layton feared scrutiny, sheltering

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himself in a literary persona to appease the public's desire for "compelling entertainment" (4), negotiating the tension between private voice and public display in his works. This insight reinforces the image of the dead poet as more than a metaphor of suffering — it embodies Layton's self-conscious reflection on how an artist survives in the glare of publicity, enduring consumption to preserve expression. Thus, the role of the poet is revealed to be the bearer of exposure and distortion, serving persistently to give form to meaning even as it is devoured.

Furthermore, after the spectacle of the poet's public death, Layton turns inward to explore creation as a mechanism of survival. The violence of exposure transforms into a more intimate confrontation with endurance when the speaker turns to:

> embrace like a lover
> the trunk of a tree, one of those
> for whom the lightning was too much
> and grew a brilliant
> hunchback with a crown of leaves. (Layton 16-20)

"Embrace" in this poem collapses distance, as the tree — split by lightning — is accepted by the poet who presses himself against it, indicating that damage must be nurtured. The "brilliant hunchback" (Layton 19-20) that grows from the scar embodies the paradox running through the poem, as it challenges notions of distorted beauty, disfigured renewal, and physical immersion in loss. The opposition of "brilliant," a word invoking light and vitality, against "hunchback," a term of deformity and burden, marks a shift in Layton's mediation on art, as creation is no longer framed as defiance against destruction but in coexistence with it. The fusion of radiance and disfigurement insists that creation emerges not from perfection, but from damage. In this way, renewal is disfigured: growth continues, but bears the mark of what nearly destroyed it, also drawing the body of the poet into the metaphor, as the act of creation forces contention with critique and immersion within pain to shape new work. Layton's vision here recalls Nietzsche's conception of art as a balance between the Apollonian form and Dionysian chaos (Bennett and Brown 506; "Friedrich Nietzsche"): the tension between shaping order and surrendering to the forces that undo it. The poet's embrace of the wounded tree visibly reconciles these two visions, coexisting brilliant beauty with the disfigured hunchback, revealing that creation depends on harmony between restraint and rupture. Through this moment, Layton extends the meaning of art to include endurance: the ability to remain within devastation and still produce form and to transform suffering into the condition of survival.

However, immersion into suffering is not without consequence; the poet's endurance, once a means of survival, may begin to corrode the boundaries of their selfhood, creating conflicting or fragmented identities. Having accepted pain as integral to creation, the artist must now face the toll of that acceptance, realizing that to continuously create means to continuously suffer and destroy. This fracture takes its most haunting form when the speaker observes "my murdered selves / [that] sparked in the air like the muted collisions / of fruit" (Layton 29-31). This image fuses vitality with violence, suggesting that each act of creation demands the death of an earlier self. By comparing the bursting of fruit to the deaths of the self, Layton transforms decay into ripeness; each collision releases both the sweetness of life and the stillness of loss. The oxymoron of "muted collisions" captures the paradox central to this process, as the death of the poet's former selves does not occur in a violent manner, but rather appears as a quiet inevitability, showing self-obliteration as a natural beat in the rhythm of creation.

Yet these murdered selves also echo Layton's fear of public perception, as previously noted by Deshaye, the poetic personas constructed to endure the audience's demand for compelling entertainment expose the cost of self-display, as each incarnation serves as a "self" to be sacrificed to sustain art. Through this lens, the murdered selves that sparked in the air become emblems of both exhaustion and renewal, illustrating how the artist's persistent endurance corrodes their individuality even as it perpetuates creation. Each spark marks a moment of vitality born from erasure — a brief flare of artistic life costing the poet another fragment of their identity. The murdered selves thus represent both creative evolution and self-dismemberment, which is understood as an inevitable cost for an artist existing under scrutiny. The poet's role as a perpetual reconstruction, therefore, reveals that art exists not only to transcend suffering but to survive fragmentation.

In "The Cold Green Element," Layton situates artistic creation within the paradox of survival: to create art is to endure destruction and preserve meaning through loss. The poet's movement from public execution to intimate embrace to self-dismemberment charts a progression from spectacle to solitude to dissolution, revealing that the vitality of art depends partially upon the artist's willingness to inhabit pain rather than transcend it. As Deshaye (4) suggests, suffering and scrutiny are inseparable from perception — a consequence of creation Layton understood well enough to shield his voice by assuming the poet's role as a scapegoat for public cruelty and apathy. Ultimately, the poem suggests that the function of art lies not in escaping chaos but in shaping it, rendering even despair productive. The poet survives not despite destruction, but through it by transforming ruin into the language of endurance, making creation an act of defiance against indifference and scrutiny.

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VEILED AND VALIANT

A Comparative Analysis of Gendered Resistance to French Colonialism in Algeria and Tunisia

ATROOBA SHAHID

"Decolonization is always a violent phenomenon."[1] Political theorist Frantz Fanon aptly used this phrase to describe the French colonial occupation of North Africa. The French first arrived in Algeria in 1830 and asserted a brutal form of settler colonialism to decentralize the powerful tribal groups that centered its political system.[2] French colonial rulers aimed to consolidate power by militarily intervening in various regions, dismantling the tribes' authority, and subsequently establishing colonies governed by French officials with extensive administrative powers.[3] Eliminating kin-based identity structures and segregating traditional communities was at the heart of the French colonial scheme in the state.[4] In Algeria, this colonial scheme had a substantial impact on destabilizing the country, as opposed to the French protectorate of Tunisia.[5] France's colonial strategy in Tunisia was diametrically opposite to its endeavours in Algeria. Upon their arrival in 1881, the French opted for co-sovereignty with the Tunisian Bey, reaffirming his rule and administrative structure while acting as the de facto power bearer.[6] Unlike in Algeria, this strategy minimally disrupted Tunisia's pre-existing balance of power: by relying less heavily on military and armed occupation, the French reinforced the preceding centralized bureaucracy and used existing institutions as their instrument of colonization.

Given Algeria's violent colonization, resistance to colonial rule and French authority gained momentum and culminated in the Algerian War of Independence and the Tunisian independence movement, respectively. This paper will demonstrate that colonial laws and policies shaped gender-based independence in both Algeria and Tunisia by shaping female resistance and national determination struggles. While both Algerian and Tunisian women resisted French colonial rule, Algerian women participated more visibly in armed struggle due to the exclusionary nature of settler colonialism, whereas Tunisian women primarily engaged through public discourse and civic engagement, acting within the indirect structure of protectorate rule. These contrasting modes of resistance illustrate how gendered colonial policies and nationalist strategies shaped women's roles both during the colonial period and in post-independence national memory. This paper will first analyze colonial gendered laws and

[1] Mildred P. Mortimer, *Women Fight, Women Write: Texts on the Algerian War* (University of Virginia Press, 2018), 164.

[2] Mounira M. Charrad, *States and Women's Rights: The Making of Postcolonial Tunisia, Algeria, and Morocco* (University of California Press, 2001), 120.

[3] Charrad, *States and Women's Rights*, 121–123.

[4] Ibid., 121.

[5] Ibid., 120.

[6] Ibid., 116.

policies in Algeria and Tunisia before moving into gendered resistance in independence movements in both states. Finally, the paper will conclude with post-independence views on gender in both states.

COLONIAL ASSERTIONS OF GENDER

First, France's expedition in Algeria was rooted in the mission *civilisatrice* (civilizing mission), which aimed at assimilating each man and woman into the ideal French citizen.[7] To achieve this, it turned to family law. The French keenly observed that Islam was the foundation of Algerian identity, and thus strategically amended Islamic legal frameworks in ways that appear to be minor.[8] They routinely accepted the family law of various regional tribes, but often under the premise that the community would accept French authority.[9] French colonial policy also allowed Algerians to take family matters to the Islamic *sharia* court, whereas all other legal cases were subject to French law.[10] In 1882 and 1930, the French manipulated marriage law by requiring Algerians to publicly register their marriage with *qadis* (Sharia court judges).[11] In 1959, marriage was made a civil matter, thus taking it out of the private Islamic sphere it was previously in.[12] These colonial policies and changes in family law demonstrate how French rulers transformed these private, domestic matters into responsibilities of the colonial state that were subject to administrative amenability. In doing so, although many aspects of Islamic law remained unchanged, France tightened its grip on Algeria through direct intervention in family matters. This strengthened its bureaucratization and, more importantly, undermined patrilineal kin-based relations. Furthermore, in its focus on dismantling Algerian originality to facilitate access to power, the French administration concentrated its efforts on the veil, which they saw as representing the status and symbol of Algerian women.[13] This created the following political doctrine: to destroy Algerian society and its potential for resistance, the first step was to conquer the woman.[14] French policy, therefore, dehumanized veiled women and subjected them to the colonial male gaze: when Algerian women dropped the veil, they were exoticized and circulated like "new" trophies for all to see and admire. "This woman, who sees but can't be seen, frustrates the colonizer."[15] French efforts to "save" veiled women by encouraging them to subvert centuries of male subjugation and "liberate" themselves by removing the veil had a dual purpose: to subjugate women to French conceptions of gender and sexuality and to conquer the Algerian man, because unless the wife was won over by foreign ideals, the husband would not be so easily convinced of such values.[16]

On the other hand, the French administration in Tunisia led with a civilizing mission in mind, approaching gender differently. The French weakened tribal systems and implemented a *laissez-faire* (letting matters take their own course) approach to family law by strengthening bureaucratic centralization.[17] To assert control through Tunisia's existing bureaucracy — without dramatically changing family law, unlike in

[7] Ibid., 114.
[8] Ibid., 132.
[9] Ibid., 134.
[10] Ibid., 134–135.
[11] Ibid., 137.
[12] Ibid., 138.
[13] Frantz Fanon, *A Dying Colonialism* (Penguin Books, 1970), 37.
[14] Fanon, *A Dying Colonialism*, 37–38.
[15] Ibid., 44.
[16] Ibid., 39.
[17] Charrad, *States and Women's Rights*, 115.

Algeria — France sought to avoid intervention in the state's Islamic legal system by legitimizing the Bey's rule.[18] However, when the French established their own courts alongside existing Islamic ones, they enabled Tunisian women to engage in legal forum shopping — in other words, choosing which jurisdiction better suited their needs — in order to escape biased legal norms, especially when it came to family law; France had legalized divorce in 1884.[19]

FEMALE RESISTANCE IN ANTI-COLONIAL STRUGGLES

Women's resistance during the anti-colonial struggle in Algeria took a radical, visible approach. Many women joined the Front de Libération Nationale (FLN) and participated in intelligence roles, communication, medical support, and providing nourishment.[20] This diversity of engagement demonstrates the vast, often dangerous roles women took on in the fight for liberation: for example, historian Djamila Amrane, née Danièle Minne, was a bomb carrier for the FLN and witnessed first-hand the sacrifice of female combatants.[21] Women who engaged in guerilla warfare often fulfilled multiple roles — they instructed local villagers on sanitation and politics and tended to the wounded.[22] For women participating in urbane warfare, the veil also served a dual role in resisting colonial rule. Women donning the veil could pass through European zones undetected and unassuming while carrying crucial messages or weapons.[23] By indulging these colonial stereotypes of their 'passiveness,' Algerian women weaponized French dehumanization to serve the national liberation agenda. On the other hand, unveiled female combatants were also crucial to the FLN cause. During the Battle of Algiers, when French troops established checkpoints in indigenous parts of the city, unveiled young women moved easily through the city by passing as Europeans.[24] The fluidity of the veiled/unveiled woman illustrates that by complying with colonial rhetoric — either to shed the veil or conform to the oversimplified notion of women who wore it — Algerian women asserted agency over their bodies and the right to choose while simultaneously using this autonomy to repel aspects of French domination. Moreover, male FLN members actively encouraged women to take up arms. It should be noted, however, that their male counterparts tied this initiative to the broader issue of independence as opposed to inherently seeking to ameliorate women's conditions.[25] On the contrary, women hoped their participation would result in additional freedoms and rights after independence.[26] Aside from resistance to colonial rule through armed struggle and FLN efforts, Algerian women also resisted through public discourse. Feminist writer Djamila Debèche organized conferences on the topic of female emancipation, focusing on national liberation as the impetus for advanced freedom for women.[27]

Conversely, female resistance in Tunisia took a subtle form and was

[18] Ibid., 132.
[19] Mary Dewhurst Lewis, *Divided Rule: Sovereignty and Empire in French Tunisia, 1881–1938*, (University of California Press, 2014), 62–63.
[20] Charrad, *States and Women's Rights*, 185.
[21] Mortimer, *Women Fight*, 22.
[22] Meredith Turshen, "Algerian Women in the Liberation Struggle and the Civil War: From Active Participants to Passive Victims?" *Social Research* 69, no. 3 (2002): 891.
[23] Mortimer, *Women Fight*, 33; Fanon, *A Dying Colonialism*, 61–62.
[24] Mortimer, *Women Fight*, 32.
[25] Wunyabari O. Maloba, *African Women in Revolution* (Africa World Press, 2007), 55.
[26] Charrad, *States and Women's Rights*, 183.
[27] Ibid., 185.

intertwined with reformist feminism as opposed to direct action. Women engaged in political activism through social and legal channels such as the press. Women who were members of political parties contributed to publications and opinion articles to call women to join the nationalist cause for their homeland.[28] Many women were also influenced by Tahar al-Haddad's *Our Women in Law and Society*, a book that called for social reform in family law and the status of women.[29] His position on female emancipation led to the creation of *Leila*, a women's magazine dedicated to promoting discussion on the status of women in relation to national liberation.[30] Tunisian feminists and female critics organized literary clubs to engage in debates and discourse on various topics pertaining to women, including family law, national independence, and unveiling as a form of female agency.[31] Contrary to the colonial unveiling efforts in Algeria, similar efforts in Tunisia were led from within the society. This demonstrates how Tunisian women, although participating on a smaller scale relative to Algerian women, resisted colonial rule by tying feminist issues to the broader issue of independence, arguing that expanding women's rights would aid anti-colonial efforts. Moreover, women also directly participated in civic engagement as a form of activism. The Muslim Union of Tunisian Women (UMFT) was created by B'chira Ben M'rad to instruct women in democratic freedoms and encourage them to support their homeland's liberation struggle.[32] The UMFT would organize political rallies, collaborate with the Neo-Destour Party and their nationalist agenda, and organize events and activities aimed at educating women about the power of their participation against colonial domination.[33] Other organizations, such as the Association of Young Muslim Women or the Society of Muslim Women, focused on education as a form of resistance, implementing Islamic scholastic endeavors to counter the French schooling system.[34] These civic and social welfare undertakings by Tunisian women elucidate how they negotiated space for themselves within traditionally patriarchal structures and entered the public sphere through means that could be backed by precedent cases. Contrary to direct Algerian intervention, Tunisian women focused on gradual reform through political activism and the press rather than radical combatism. Both approaches reflect the different methods of French colonial rule — direct assimilation in Algeria, thus requiring direct military resistance, and Tunisia's protectorate status, which ensured that change could be promoted through local institutions and frameworks.

POST-INDEPENDENCE CONCEPTIONS OF GENDER

While Algerian women generally participated in liberation efforts, most left the resistance scene after independence; at times, they were even rejected by civilian society.[35] Female combatants were praised and admired for their service, but they were seen as unsuitable for marriage because of their frequent interactions with men.[36] This demonstrates that while men and women were treated relatively equally during liberation efforts, social attitudes after independence reverted to conservative attitudes

[28] Jane D. Tchaïcha and Khédija Arfaoui, *The Tunisian Women's Rights Movement From Nascent Activism to Influential Power-Broking* (Routledge, 2017), 25.
[29] Charrad, *States and Women's Rights*, 216.
[30] Charrad, *States and Women's Rights*, 217.
[31] Tchaïcha and Arfaoui, *Tunisian Women's Rights*, 23.
[32] Ibid., 25.
[33] Ibid., 25-26.
[34] Ibid., 26.
[35] Turshen, "Algerian Women," 892.
[36] Ibid., 893.

that excluded women from the public sphere. Politicians claimed that Algerian women already had the rights they were demanding and should disregard Western feminist ideals that threatened to corrupt their society and traditional values.[37] Decades later, the 1984 Family Code restored and legalized male dominance in the domestic and public spheres.[38] Post-colonial Algeria therefore deemed women as having served their purpose during the war and acknowledged their efforts; however, they expected women to return to their domestic duties and families post-independence. In effect, they "lost their citizenship" after Algeria's independence, as Houria Imache Rami, a female FLN member, noted.[39]

Post-independent Tunisia saw a contrasting reaction to women in the public realm. Habib Bourguiba, the first President of Tunisia, reformed the Code of Personal Status (CPS) to revolutionize women's rights and freedoms, which included abolishing polygamy, requiring mutual consent in marriage, equal right to education, and a juridical process for divorce.[40] This enabled women to enter the public sphere and effectively participate and contribute in the public domain. While Bourguiba was committed to egalitarian gender reforms under a liberal interpretation of Islamic law, he remained apathetic to women's integration into political structures, which remained limited under his presidency.[41] Bourguiba's post-independent reforms thus demonstrate his vision to achieve modernity through secularist means by distancing the population from its Islamic tradition. Interestingly, this differs from the colonial administration's approach, which sought to legitimize Islamic rule. This indicates that while women's rights were ameliorated after liberation, this came with caveats, namely distancing from Islamic understandings of gender equality.

CONCLUSION

In conclusion, colonial laws and policies shaped independence in both Algeria and Tunisia from a gender lens. These practices shaped female resistance to colonial rule and engagement in the national liberation endeavours of each state. Algerian women engaged in direct intervention, often armed struggle and FLN efforts, while Tunsian women participated in public discourse, the press, and civic engagement. These diametrically opposite modes of resilience demonstrate that decolonization occurs in a variety of ways and moulds women's roles during both the colonial period and in post-independence national memory.

[37] Maloba, African Women, 56.
[38] Ibid., 60.
[39] Turshen, "Algerian Women," 894.
[40] Aitemad Muhanna, "Islamic and Secular Women's Activism and Discourses in Post-Uprising Tunisia," in *Rethinking Gender in Revolutions and Resistance: Lessons from the Arab World*, eds. Maha el Said, Lena Meari, and Nicola Pratt (Zed Books, 2015), 207.
[41] Muhanna, "Islamic and Secular Women's Activism," 208.

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BEAUVOIRIAN INSIGHTS INTO EUGENE O'NEILL'S *LONG DAY'S JOURNEY INTO NIGHT* AND SUSAN GLASPELL'S *TRIFLES*

PHOENIX MOGGACH

In Eugene O'Neill's *Long Day's Journey Into Night* (1956) and Susan Glaspell's *Trifles* (1916), a parallel can be drawn to Simone de Beauvoir's existential feminist text *The Second Sex* (1949). In an examination of Beauvoir's philosophical treatise, Beauvoir takes the position that women have fulfilled the role of the inessential other while men have historically claimed the essential self. One finds a shared resonance between the central female figures in O'Neill and Glaspell's plays with the didactic female form in Beauvoir's philosophical undertaking. In this vein, Mary, the maternal figure in *Long Day's Journey Into Night*, escapes her disillusioned existence within the confines of the domestic realm through the use of morphine. Meanwhile, in *Trifles*, the female characters Mrs. Hale, Mrs. Peters, and, although not present on stage, Mrs. Wright, occupy a comparable position of subjugation. As the title suggests, they are associated with the "trifles" of the world, the realm of the household, which the male characters perceive as inconsequential. This essay will argue that the female protagonists in both *Long Day's Journey Into Night* and *Trifles* embody Simone de Beauvoir's central hypothesis: that women are cast as the inessential other in a society that defines their identity solely in subordinacy to men. This essay will first examine and define *The Second Sex*'s locus as a feminist text and its terminology that will be used for the analysis of the two plays. The essay will then survey O'Neill's meditation on the "otherness" of Mary's position in the family dynamic — emphasising her yearning for an identity that is separate from her present one, which is defined by her tumultuous family life. Finally, this essay will examine the female characters of Trifles and their relation to the Beauvoirian notion of immanence, only for it to be transmuted to the transcendent in the respective text. Through an examination of the presence of Beauvoir in these respective plays, one finds the women isolated within the categorical "otherness" of their subjugated existence, reflecting the rigidity of gender norms.

In the introduction to *The Second Sex*, Beauvoir begs the question: what is a woman? To Beauvoir, man "represents both the positive and the neutral, [...] whereas woman represents only the negative, defined by limiting criteria" (xv). This suggests that man does not have the confining physiological and psychological traits that a woman has: "man ignores the fact that his anatomy also includes glands, [...] and that they secrete hormones" (xv). Thus, man is separated from the woman as he "apprehends [the world] objectively" (xvi) — objectively in the sense that he has none of the "peculiarities" that a woman's body has. Through this, "man defines woman not in herself but as relative to him" (xvi); man becomes the autonomous being while woman is the nonautonomous being. As a result, Beauvoir uses a reinterpretation of the Hegelian notion that a person defines themself as the "essential subject (the 'self')" while all others are the "inessential object (the 'other')" (Tolan 321). This reinterpretation of Hegel allowed Beauvoir to

establish the idea that women have been historically situated as the inessential other while men have been positioned as the essential self. This terminology, man as the essential self and woman as the inessential other, will be used to excavate the depiction of female existentialism in both *Trifles* and *Long Day's Journey Into Night*.

Another Beauvorian idea that will be examined in the respective plays is the notion of immanence and transcendence. Immanence refers to a notion of "confinement or restriction to a narrow round of uncreative and repetitious duties" (Beauvoir 65). If immanence is the repetition of duties performed in service of mundanity, then transcendence is the escape from such reiterative life. Transcendence refers to the "freedom to engage in projects [...] that mark the untrammeled existent" (63) — An existential mode in which one transcends staticity and affirms selfhood by actively asserting oneself in the temporal unfolding of existence. As expressed by Beauvoir, man is traditionally allotted the transcendental qualities while woman is stuck in immanence. However, this is subverted in *Trifles* through the female characters' usage of the trifles of everyday "domestic labors [...] that imprison [woman] [...] in repetition and immanence" (63), such as knitting, which subverts its traditional passivity by transforming it into a springboard for the active assertion of their convictions. Such a display of Beauvoirian immanence is less subversively handled in *Long Day's Journey Into Night*. Mary's marginalisation by her male counterparts leaves her confined to the repetitive tasks of domestic life, making her the very embodiment of immanence.

Long Day's Journey Into Night explores female-to-male familial dynamics through the relationships between Mary and her male counterparts: Tyrone, the father, James, the eldest son, and Edmund, the sick and youngest son. Throughout the play, Mary is alienated from the men of the family as they leave her deserted in the family home to pursue their social endeavours: "All [...] Tyrone likes is to hobnob with men at the Club or in a barroom" (O'Neill 42). Even her sons "are the same way" (43), and — as a result of her desertion there — Mary has "never felt it was [...] [her] home" (42). This suggests that Mary is left bound to the home without being able to socialize like the men do, creating a subjugated role in the household. Furthermore, as Beauvoir notes, a woman "delights in the display of her 'interior'" (Beauvoir 528), the curated self that becomes "a well-defined process of identification" (629). This is reflected in Mary's incessant worry about her appearance as well as her household's decor — the former relating most strongly to her lamenting her aging figure and the latter denoting her home's apparent simplicity. Mary, when Tyrone and James are clipping the hedge, states: "There go the Chatfields in their new Mercedes. It's a beautiful car, isn't it? Not like our secondhand Packard" (41), suggesting that Mary is aware of "the expression of [...] [a family's] standard of life, its financial status, its taste, and [...] [its] view to other people" (528). This is shown further when Mary, noticing Tyrone's "filthy old suit" that she's "tried to make him throw away," suggests that "he ought to have more pride than to make such a show of himself" (41). Thus, Mary is positioned "*looking out the window [...] with an undercurrent of lonely yearning*" (42), wishing to "make a good showing, combin[ing] [...] her pleasure of being seen" in a way that reflects her interior — the narcissistic ego (528). Mary is unable to define herself in the workplace, presumably due to her rehabilitation and being unable to find solace in the homely life, as is shown by her continual statements that the home does not feel like a home. As a result, Mary turns towards her addiction to morphine as a means of escaping the confines of not fitting in the domestic sphere or workplace. Mary is unable to find a notion of identification separate from her past self, a self that is temporally dislocated, which morphine grants her access to.

Beauvoir, in the chapter titled "The Narcissist," suggests that the "reality of

man is in the houses he builds, [...] but woman, not being able to fulfil herself through projects and objectives, is forced to find reality in the immanence of her person" (Beauvoir 630). In *Long Day's Journey Into Night*, the male figures — Tyrone, James, and Edmund — are situated in opposition to Mary's "immanence" as transcendental (630). This immanence in Mary's character is demonstrated by her repetitive temporal longing for the past: rejecting the present for fragmented memories in an opiate induced haze. In a scene that reflects her rejection of the present through her abuse of morphine, Mary reminisces on her wedding dress in contrast with her present position within the Tyrone household. Mary does not regard the practical implications of marriage, but is obsessed with the adornment of the dress, shown in "how [she] [...] fussed and worried" (O'Neill 97). Rather than "fulfill[ing] herself through projects and objectives" in the present — creating a kinetic future, Mary turns to the immanence of her past that is static, forcing her to live in a repetitive mode of existence. In a Beauvoirian sense, Mary has a double-self: "the shy [and] [...] gay convent girl" who reflects an innocence prior to the marriage of an "actor" (97), and the present self who is shackled to this interior history, "she seeks to find the dead child within herself, even to revive it" (633). Furthermore, O'Neill depicts a simulacra of immanence, wherein Mary "creates a twin through inward dialogue" (633) that "examines [herself] [...] in the mirror" (97). The inward self of Mary becomes a labyrinthine of narcissistic tendencies to remove herself from the confining patriarchal structures of marriage, reflecting the Beauvoirian idea that because "masculine activities are forbidden from her" (629), Mary finds refuge in the "immanence of her person" (630). However, this immanence ultimately leads to her being "Ineffective [...] [and] isolated, [...] because no object of importance [in the present] is accessible to her" (630).

In comparing Susan Glaspell's *Trifles* to *Long Day's Journey Into Night*, one finds that the same Beauvoirian notions examined in O'Neill's play are subverted in Glaspell's play. The play opens on "*a gloomy kitchen* [...] *left without having been put in order*[,] [...] [showing] *signs of incompleted work*" (Glaspell 141). Glaspell, through the metaphorical imagery of a disrupted kitchen showing "signs of incompleted work" (141), suggests that Mrs. Wright has removed herself from the shackles of immanence, or the repetitive work Beauvoir notes in domestic work — assuming the transcendental mode typically allotted to men. This poses an ironic foreshadowing of the play's ultimate subversion of Beauvoir's hypothesis: woman as the inessential other and man as the essential self. However, to execute the ironic reversal of Beauvoir's position, Glaspell first establishes an emphasis on the male characters' supposed importance by introducing them by their economic roles, as well as placing a visual hierarchy and spatial power difference through staging. As Beauvoir notes: "A man is socially an independent and complete individual; he is regarded first of all as a producer whose existence is justified by the group he does for the group" (Beauvoir 426). This suggests that man is allotted individuality and separation from his peers, whereas women are a conglomerate whose existence is defined not individually or by their economic role, but by the trait of being a woman. In this sense, by Glaspell having the sheriff and court attorney "*followed by the two women*" (141), there is an indivisible distinction between the two women, as if they were simply trifles to the crime scene. Glaspell reinforces a metaphorical and visual subordinacy in having the women "*stand close together near the door*" while the men separate — shown through the sheriff "*stepping away from the stove as if to mark the beginning of official business*" (141). Thus, the spatio-temporal dynamic of the staging presents a clear distinction between the supposed "*official business*" of the men, by their division in economic role, and the — as the title ironically suggests — trifles of the women's role in the crime scene. Through this, the play's opening suggests that the men

are subjective individuals who are made distinct by their transcendence in their economic role as well as spatio-temporal distinctiveness.

However, while the women are spatiotemporally subjugated as an indivisible pair in the play's opening, shown through the staging, the women are granted a descriptive authority in terms of their distinct characteristics. While the men are cast together as "*in middle life*" or simply being "*a young man*" (Glaspell 141), Mrs. Hale and Mrs. Peter are both psychologically and characteristically specified, foreshadowing their importance in the text of the play as acute interpreters. Mrs. Peter is a "slight wiry woman, [with] a thin nervous face," while Mrs. Hale "is larger and would ordinarily be called more comfortable looking, but she is disturbed [...] and looks fearfully" around the room (141). The notion that Mrs. Hale "looks fearfully" around the room suggests a subjective self that the men are not granted. Mrs. Hale and Mrs. Peter are granted an authoritative interpretation of the room by their described emotions — being disturbed or nervous. Glaspell, by specifying their characteristics as separate from the men who remain without description, prefigures their eventual narrative centrality.

In the chapter titled "The Married Woman," Beauvoir states, "the husband is the productive worker, he is the one who goes beyond the family interest to that of society, [...] he incarnates transcendence" while "Woman is doomed to [...] the care of the home — that is to say, to immanence" (429-8). By establishing the male characters as the productive workers separate from the domestic household, Glaspell subverts this by having the evidence excavated by the immanence of the female characters. The "trifles" (Glaspell 144), or the domestic arrangements that the male characters ironically view as unimportant, become the mode through which truth is uncovered. Mrs. Hale and Mrs. Peters find a quilt and "wonder if [Mrs. Wright] was going to quilt it or knot it," to which the male characters laugh, suggesting that the quilt is of no importance. However, Mrs. Hale notes that it appears to have one part "nice and even" while the other part "all over the place" (148). Through this, Glaspell depicts the intuitiveness lacking in the male figures, whereas Mrs. Hale is able to infer that Mrs. Wright must have been "nervous about" something. This moment reveals that the female characters are granted deeper insights through their position in the repetitive immanence of the household. As the scene progresses, Mrs. Peters comes across a bird cage in a cupboard. The symbolic representation of the birdcage becomes an essential piece of evidence to Mrs. Hale and Mrs. Peters, as they recognise the battered birdcage as emblematic of Mrs. Wright's psychological state, comparing Mrs. Wright to a bird: "she was kind of like a bird herself — real sweet" (150). As they continue to look around the house for "trifles," they come across a red box containing a bird in it with its neck broken. Mrs. Hale and Mrs. Peters immediately piece together the symbolic configuration of the bird — a songbird presumably silenced by Mr. Wright–as Mrs. Hale suggests: "No, Wright wouldn't like the bird — a thing that sang. She used to sing. He killed that, too" (151). Mrs. Hale makes the connection that the silencing of Mrs. Wright is an attack on her self-expression, ultimately embodied by the songbird who no longer sings. The patriarchal household silences Mrs. Wright from achieving self-hood separate from the domestic role; thus, her subjectivity becomes nullified. In granting Mrs. Hale and Mrs. Peter's interpretative authority, the characters become distant from the usual immanence of their positions, transcending the household through their reading of household items as evidence for the truth of the crime. In a moment of reclamation of autonomy, the women hide the evidence of the bird and allow Mrs. Wright the freedom of transcendence.

Through a Beauvoirian critical framework, one finds that *Trifles* and *Long Day's Journey Into Night* share a congruence in their depictions of the respective female

characters. In *Long Day's Journey Into Night*, Mary is represented as alienated from the male characters of the play, causing her to seek a removal from the present failures of the household through morphine. As a result, Mary is confined to the immanence of her person, ultimately being stuck in the past without the remedy for becoming a transcendent figure. On the other hand, the female characters in *Trifles* are shown to be figures stuck in the immanence of the household rather than the self. However, Glaspell subverts the notion of immanence by using it as the essential tool in which Mrs. Hale and Mrs. Peter are able to excavate for the truth of the crime scene. As a result, the female characters of *Trifles* become essential for the narrative's overarching resolution of truth. Beauvoir's existential feminist text, *The Second Sex*, becomes a unique tool in interpreting the treatment of the female characters of either text.

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THE POWER OF OBEAH AND SLAVE REBELLION IN EARLY COLONIAL JAMAICA

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In the eighteenth century, Jamaica's mountainous terrain marked its topography: to the east, mountains held the island's highest vantage point, and to the west, Cockpit Country veiled a rainforest marked by steep-sided hollows rendering the area impenetrable to colonizers and a natural defence base for the Maroons. Derived from the Spanish *cimarrón*, meaning "fugitive" or "wild one," the term maroon refers to Black people (and others) who escaped from captivity, as well as their descendants, and challenged enslavement on plantations and mines owned by European colonizers throughout the Americas, founding independent communities in the "bush," or wilderness. The Maroons formed two main groupings: the Windward Maroons of Jamaica, who descended from "Spanish negroes" and inhabited loosely confederated communities in the eastern mountains, and the Leeward Maroons, who were Akan and Twi-speaking "Coromantee" from the Gold Coast and maintained an autocratic and traditional Ashanti lifestyle.[1] Both groups exhibited military prowess against British power and were strengthened by their spiritual ties to obeah. Rooted in pre-colonial spirituality, obeah is a word Europeans applied to African practices that they acknowledged acted powerfully on people's bodies and minds. While names of spirits and deities varied across the circum-Caribbean, the bedrock of obeah rests upon the dialogue of energies between the divine realm, the ancestors, and human beings in the visible and (in)visible worlds and the understanding from Meritah (Africa) that the dead need to be cared for and respected with the capacity to affect the lives of their descendants.[2]

Despite the law's pretensions of neutrality, colonial authorities could not furnish a precise legal definition of obeah, a vagueness and ambiguity that betrayed settler-colonial uncertainty over what constituted the ceremonial complex. This paper analyzes the role of obeah in the inceptive period of African resistance to chattel slavery in Jamaica within the broader colonial framework of the early Atlantic world. As one of

[1] Kathleen Wilson, "The Performance of Freedom: Maroons and the Colonial Order in Eighteenth-Century Jamaica and the Atlantic Sound," *The William and Mary Quarterly* 66, no. 1 (2009): 55.

[2] Diana Paton, "Witchcraft, Poison, Law, and Atlantic Slavery," *The William and Mary Quarterly* 69, no. 2 (2012): 243. Meritah is the Indigenous name for the region known today by foreigners as Africa. Informed by my journey as an initiate of the Dogon temples of Western Meritah, descending from the Nile Valley Civilization, the concept 'Africa' is traced to the Medu language (hieroglyphics): *afri* ("to boil, burn") + *ka* ("spirit"), with Afrika[ns] understood pejoratively as "burnt spirit." The designation 'Africa' derives exactly from the Greek Ἀφρικανός (Aphrikanós), meaning "[persons] of Africa," with a semantic analogue in αἴθω (aithō, "to kindle or burn"), from which Αἰθίοψ (Aithiops, "burnt-faced") is formed. For linguistic context, see Raymond O. Faulkner, *A Concise Dictionary of Middle Egyptian* (Oxford: Printed for the Griffith Institute at the University Press, 1962), 3, 5, 73; for αἴθω and Ἀφρικανός (translated as "of Africa"), as distinct from Ἀφρική (the Roman province) or Λιβύη (Libýē), see Anatole Bailly, *Le Grand Bailly: Dictionnaire grec–français* (Paris: Hachette, 1935), 330; and Richard J. Cunliffe, *A Lexicon of the Homeric Dialect*, expanded ed. (Norman: University of Oklahoma Press, 1963), 14.

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the oldest historical articulations of an "Other," the colonial construction of "Africa[n]" has been defined since antiquity by Greek counterparts as being darker-skinned and as maintaining a privileged relationship, or intimacy with the divine world. Fear of the other, as defined by Sartre, refers to any consciousness outside of oneself (*autrui*). The dichotomy between anti-obeah legislation and colonial fascination for African knowledge systems reveals Western conceptualization of obeah. In the First Maroon War (1728–1740) and the Coromantee War, also known as the 1760 Tacky's Rebellion, the power of obeah incited the genesis of Black-led revolts, wherein obeah women maintained substantial spiritual and political influence. In reaction, the criminalization of obeah disclosed European colonists' dual fascination with and anxieties about Meritah-derived (African) ceremonial way of life and traditional knowledge systems.

In the First Maroon War and the Coromantee War, the power of obeah and divination was instrumental in Maroon resistance to colonial subjugation. As Barbara Kopytoff describes, both men and women played significant roles among the Leeward and Windward Maroons.[3] As a result, the spiritual protection accorded by obeah emerged as an integral part of the Maroons' guerrilla warfare strategy. Notably, in the First Maroon War of 1730, the Leeward Maroons, led by Cudjoe in central Jamaica, and the Windward Maroons, led by Nanny and Quao from the east of the island, killed half of the 95 British militia soldiers.[4] Nanny, a legendary leader and tactician of the Windward Maroons, allegedly used obeah to deflect bullets fired by the British and massacre the soldiers with a machete.[5] Throughout colonial sources, Nanny is referred to as "the rebel's old obeah woman" and characterized as a violent threat to colonial security.[6] Accused by army officer Philip Thicknesse of sentencing a white emissary to death, his description of Nanny reflects her power: "The old Hagg … had a girdle round her waist, with (I speak within compass) nine or ten different knives hanging in sheaths to it, many of which I doubt not had been plunged into human flesh and blood."[7] Thus, Thicknesse's account reaffirms Nanny's power and reputation among British colonial authorities, as obeah ignited fear among British colonists. This fear is most notably observed in colonial reports and legal language. By the end of the First Maroon War, the power of obeah began to be perceived as a threat to the colonial structure, as it went hand-in-hand with Maroon land sovereignty and assertion of independence.

After the events of the Coromantee War, obeah concretized itself as a cultural repository, a defence against violent domination, and a subject of slaveholders' attention. The Coromantee War, or Tacky's Revolt, constituted the most threatening rebellion to the planter class in a British colony in the eighteenth century. In 1760, enslaved Africans revolted against colonial authorities, with the perceived aid of obeah practitioners.[8] As enslaved people across significant parishes in Jamaica successfully seized power, albeit briefly, it took British forces months to inflict sufficient military damage to regain control.[9] Similar to the First Maroon War, female figures arose as central to slave revolts

[3] Barbara Klamon Kopytoff, "The Early Political Development of Jamaican Maroon Societies," *The William and Mary Quarterly* 35, no. 2 (1978): 298.

[4] Bev Carey, *The Maroon Story: The Authentic and Original History of the Maroons in the History of Jamaica, 1490–1880* (Kingston: Agouti Press, 1997), 208–210.

[5] Kenneth M. Bilby, *True-Born Maroons* (Gainesville: University Press of Florida, 2005), 150–156.

[6] Jenny Sharpe, *Ghosts of Slavery: A Literary Archeology of Black Women's Lives* (Minneapolis: University of Minnesota Press, 2003), 36.

[7] Philip Thicknesse, *Memoirs and Anecdotes of Philip Thicknesse* (printed for the author, London, 1788), 123.

[8] Randy M. Browne, "The 'Bad Business' of Obeah: Power, Authority, and the Politics of Slave Culture in the British Caribbean," *The William and Mary Quarterly* 68, no. 3 (2011): 451.

[9] Diana Paton, "The Emergence of Caribbean Spiritual Politics," in *The Cultural Politics of Obeah: Religion, Colonialism and Modernity in the Caribbean World*, (Cambridge: Cambridge University Press, 2015), 17.

through accounts of obeah. According to Bush, in the 1760 revolt, an enslaved woman named Cubah was speculated by British slave owner Edward Long to be the true leader of the unrest. In his account, he describes a wooden sword used by Cubah as a signal for war, as well as her active involvement in the war: "when her majesty was seized and ordered for transportation … she prevailed upon the Captain of the transport to put her ashore again on the Leeward part of the island, and continued her subversive activities for some time until she was eventually recaptured and executed."[10] Despite the limited available evidence, Cubah's commitment to the uprising and her use of forces outside Western comprehension are indisputable.

According to Diane Paton, those with the appropriate training and specialist knowledge used spiritual means both to protect and to attack others, whereby physical substances could exert pharmacological reactions and provoke powerful effects dependent on the ritual context in which they were consumed, touched, or simply placed in proximity to a person.[11] Historically, a catch-all term for "ancient magic" or *pharmakeia*, poison and witchcraft were associated through the Latin term *veneficium*, denoting the making or doing of poisoning. Hence, protection against spiritual attack was a crucial aspect of daily life for the enslaved. Terms for such potent substances were defined in European languages as "poison" — an early modern translation shaped by European associations between women and poisoning and sorcery, yet one that can confuse when assumed to be literal. Thus, the intersection of obeah practice and women's participation in revolts is highlighted through Cubah and Nanny. Moreover, the timing and prevalence of the Coromantee War are framed adjacent to the Seven Years' War, occurring from 1756–1763, as the first "global war," fought between Britain and France for hegemonic supremacy through proxies in North America, India, and at sea. Thus, the perceived use of obeah in the Maroons' ongoing resistance to the British posed a severe threat to the empire. The timing of the Tacky Rebellion with the Seven Years' War exposed room for weakness: an internal threat to white supremacy was taxed on top of an external threat to imperial control. As such, the former is used to contextualize the subsequent criminalization of obeah practices in Jamaica.

Following the Coromantee War, the anti-obeah legislation passed in 1760 criminalized obeah as a capital crime and set the stage for spiritually empowered enslaved people leading or abetting large-scale rebellions across the circum-Caribbean. First appearing in British colonial law and enacted the same year as the revolt, the act described obeah as "the wicked Art of Negroes going under the appellation of Obeah Men and Women, pretending to have Communication with the Devil and other evil spirits."[12] Entitled "An Act to Remedy the Evils Arising from Irregular Assemblies of Slaves," it prohibited "making use of any Blood, Feathers, Parrots Beaks, Dogs Teeth, Alligators Teeth, Broken Bottles, Grave Dirt, Rum, Egg-shells or any other Materials relative to the Practice of Obeah or Witchcraft in order to delude and impose on the Minds of others."[13]As Diana Paton has noted, the decision to accord legal status to an African-derived word instead of solely legally generalizing obeah as witchcraft further indicates the extent of the threat obeah presented. By denoting a specific inventory of materials in the 1760 legal text, British legislators disclosed a level of study and engagement with those materials in an effort to limit the presence of obeah in enslaved communities. Moreover, by specifying "Obeah or Witchcraft," the term obeah is

[10] Kopytoff, "The Early Political Development," 28.
[11] Paton, "The Emergence of Caribbean Spiritual Politics," 17.
[12] Katharine Gerbner, *Archival Irruptions: Constructing Religion and Criminalizing Obeah in Eighteenth-Century Jamaica* (Duke University Press, 2025), 19–20.
[13] Paton, "The Emergence of Caribbean Spiritual Politics," 17.

connoted with witchcraft. As a result, legal language was used to criminalize spiritual African practices and equate obeah to European witchcraft. Convicted obeah practitioners were sentenced to deportation from the island and thus slavery elsewhere, or put to death.[14] While other colonies did not immediately legislate comparable anti-obeah legislation, by the late 1780s and continuing through legal emancipation in 1833, most British Caribbean colonies followed in prohibiting obeah as a capital offence. More precisely, the anti-obeah legislation passed in Jamaica became a blueprint for colonial lawmakers throughout the region. Thus, within the historical record, the spiritual influence exerted by enslaved Maroon women is assessed as partly responsible for the prompt response of the colonial system to obeah-associated revolts.

Furthermore, in reaction to obeah practices, colonists also held an epistemological fascination with African knowledge systems, as evidenced by their incorporation into eighteenth-century empirical epistemologies. Throughout the historical record, colonial intrigue and empirical reasoning about obeah function as a prototype of the colonial mind and the fears that animated it.[15] Due to European misapprehension of African Caribbean cosmogony in the late eighteenth century, colonists believed obeah to be a phenomenon that could be quantified, studied, and explained through empirical reasoning.[16] In an account, Edward Long attributes the alleged "supernatural powers" of obeah to "the natural operations of some poisonous juice, or preparation."[17] In another printed account, Griffith Hughes described the "Magical Apparatus" of an "Obeah Doctor": "two Earthen Basons, a Handful of different Kinds of Leaves, and a Piece of Soap."[18] As such, colonists endeavoured to locate obeah's power in the "natural properties" of material objects used by obeah practitioners. The maintained fascination with obeah, furthermore, encompasses colonial authorities and writers alike. One of the most widely circulated eighteenth-century accounts of obeah was Benjamin Moseley's description of obeah in the Treatise of Sugar, which defines obeah for his colonial audience. Moseley's narrative infuses gothic imagery in listing ingredients that "compose" obeah and presents the "mythical powers" of obeah as a fictive story.[19] Thus, obeah is understood as an epistemological mystery to colonists, as their failure to locate its natural causes demonstrates that obeah exceeds empiricism.

In conclusion, in Jamaica, the power of obeah was expressed through enslaved African insurgencies and gained notoriety within the colonial framework. Immediately after the Coromantee War, the passing of anti-obeah legislation indicated Western fear and recognition of obeah. Similarly, colonists' attempts to empirically study African knowledge systems exposed bias and lack of understanding; however, their desire to understand obeah in order to mimic its effects indirectly legitimized the tradition. Following Tacky's revolt, the enactment of anti-obeah laws across the circum-Caribbean allows the historical record to quantify the magnitude of threat African spiritual systems posed to slavery and colonization.

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[14] Diana Paton, "Obeah Acts: Producing and Policing the Boundaries of Religion in the Caribbean," *Small Axe: A Caribbean Journal of Criticism* 13, no. 1, (2009): 5.

[15] Kelly Wisecup and Toni Wall Jaudon, "On Knowing and Not Knowing About Obeah," *Atlantic Studies* 12, no. 2 (2015): 136.

[16] A cosmogony is a description of existence as perceived by a particular people; it dictates natural order, behaviors, and the truths through which life is intelligible. For cosmology vs. cosmogony, see *The Oxford Handbook of the History of Modern Cosmology*, 1st ed., Oxford Handbooks (Oxford: Oxford University Press, 2019), v–xiii.

[17] Ibid.

[18] Ibid., 133.

[19] Ibid., 138.

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BETWEEN COMMITMENT AND CONTROL

International Human Rights Norms and the Struggle for Customary Land Rights in Vietnam

CHLOE GERGI

In Ninh Thuận, government plans to construct nuclear power plants threaten to sever the Cham Indigenous Peoples' centuries-old connection to their sacred lands. This conflict between development and cultural preservation is depicted in Nguyễn Trinh Thi's *Letters from Panduranga*, a poetic narrative that intertwines personal reflections, ethnography, and archival traces (*Letters From Panduranga – Nguyen Art Foundation*). Trinh Thi's artwork reveals the enduring struggles of Indigenous communities in Vietnam to protect their ancestral lands from state-led development projects, reflecting a broader, systemic tension between centralized governance and the preservation of cultural and land rights.

Land in Vietnam is not merely an economic resource — it forms the foundation of identity, culture, and spirituality for 53 recognized ethnic minority groups. However, this connection between people and their land has been systematically eroded through colonial, post-colonial, and modern policies. French colonial rule initially disrupted communal land systems and entrenched centralized ownership models that disregarded Indigenous practices and created enduring inequalities. Post-colonial reforms, such as collectivization and economic liberalization, continued to sideline Indigenous customs, alienating ethnic minorities from their ancestral territories. These historical legacies persist in contemporary land governance, where state policies often prioritize economic growth and national control over the recognition of customary land rights.

Despite resistance from Vietnam's government, international advocacy has increasingly called for the protection of Indigenous land rights. This paper investigates how international human rights norms shape Vietnam's approach to customary land rights, and considers what this reveals about the country's land decolonization process. I argue that while international frameworks have prompted policy initiatives, structural barriers — such as centralized governance, economic priorities, and resistance to participatory reform — limit their practical impact, hindering meaningful land decolonization. This paper examines historical contexts, analyzes Vietnam's law reform, and assesses the role of international advocacy, before concluding with actionable recommendations.

HISTORICAL CONTEXT OF LAND RIGHTS IN VIETNAM

Understanding Vietnam's historical land rights is crucial to analyzing its current challenges and the influence of international human rights norms. Historical shifts in land governance — rooted in colonial policies, post-colonial reforms, and state-driven economic strategies — continue to shape the legal and cultural frameworks governing

land in Vietnam today.

In pre-colonial Vietnam, land was managed communally through local customs, particularly among highland ethnic minority groups with spiritual ties to ancestral lands (Nguyen, "Land Policies"). This balance was disrupted during French colonial rule in the nineteenth century, when colonizers imposed centralized land administration to maximize resource extraction. The introduction of private ownership, land appropriations for plantations, and heavy taxes dispossessed rural and Indigenous communities, eroding customary practices and exacerbating social inequalities (Osborne et al.). A landholding elite, loyal to the colonial administration, further marginalized the peasantry and entrenched disparities that persisted into subsequent regimes (Pham and Luu 39).

After Independence in 1954, post-colonial reforms aimed to address colonial inequalities but often neglected ethnic minorities' customs. Northern land redistribution programs and post-1975 collectivization declared land state property under the 1980 Constitution, alienating Indigenous communities whose practices did not align with collectivist models (Raymond 45–50). The Đổi Mới (Renovation) reforms of 1986 introduced a market-oriented approach, with land-use rights later established in the 1993 and 2003 Land Laws (Nguyen, "Land Law"). However, these laws retained state ownership and failed to recognize communal ownership, leaving ethnic minorities disconnected from their ancestral lands (Do and Iyer 3–4). This historical trajectory highlights the persistent struggle to reconcile state laws with customary practices, a critical barrier to Vietnam's land decolonization process.

VIETNAM'S COMMITMENTS TO INTERNATIONAL HUMAN RIGHTS NORMS: OBLIGATIONS AND SHORTFALLS

Vietnam's engagement with international human rights frameworks, such as the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) and the International Covenant on Civil and Political Rights (ICCPR), establishes important obligations regarding customary land rights. UNDRIP provides globally recognized standards affirming Indigenous Peoples' rights to their ancestral lands (United Nations), while the ICCPR, ratified by Vietnam in 1982, imposes binding obligations (OHCHR). Specifically, Article 27 of the ICCPR, as interpreted by the Human Rights Committee, protects minorities' cultural practices, including land and resource rights integral to their way of life (United Nations Human Rights Committee pars. 1, 7).

However, as Nguyen, a Vietnamese legal scholar, argues, these international commitments often reflect symbolic gestures rather than substantive action ("Land Law"). In analyzing Vietnam's incorporation of international human rights standards into domestic law, Nguyen notes a persistent gap between formal legal alignment and effective implementation, particularly where centralized governance and state priorities prevail ("Land Law"). This disconnect is evident in land governance policies, such as the Forest Land Allocation (FLA) program, which criminalizes traditional practices, like swidden cultivation, and reframes Indigenous land use as incompatible with state development objectives (Bayrak et al. 39). Under the FLA program, forestlands — including traditional swidden areas — are reassigned, often to individual households, without meaningful consultation or consent from affected communities (Bayrak et al. 41–44), in violation of UNDRIP's principle of Free, Prior, and Informed Consent (FPIC) (United Nations arts. 26, 32).

The consequences of these UNDRIP violations are evident in Ban Tat village, where the replacement of communal land systems with individually assigned plots

disregarded Indigenous land management practices and created significant hardships (Van Mai and To 172). Households in Ban Tat experienced recurrent seasonal food shortages following land reallocation, as reassigned plots could not sustain traditional agricultural cycles (Van Mai and To 174). Villagers were forced to shorten fallow periods — a critical practice for restoring soil fertility — resulting in degraded land and diminished livelihoods (Van Mai and To 175). Vietnam implemented such policies without meaningful consultation or participation, undermining its commitments to UNDRIP, which emphasizes the protection of Indigenous traditions and equitable land-use practices.

These actions reflect systemic flaws in Vietnam's land governance, rooted in its prioritization of centralized control over customary practices, as codified in the 2013 Land Law (National Assembly of the Socialist Republic of Vietnam art. 4, 17). By requiring formalized Land Use Rights Certificates (LURCs), the 2013 law formalizes land tenure in ways that prioritize individual and organizational ownership over collective and communal land traditions, thereby alienating Indigenous practices (Ironside 8–10). By failing to recognize these Indigenous rights, Vietnam's policies fundamentally contradict UNDRIP's principles of preserving Indigenous land traditions and the ICCPR's emphasis on inclusive governance. For example, the 2013 Land Law's allowance for land seizures under ambiguous terms such as "socio-economic development" has been used to reallocate forestlands in Kon Tum province to private enterprises, disregarding local communities' spiritual and cultural ties to the land (Ellett and Phan 247–249). These policies perpetuate legacies of state control established during Vietnam's collectivization efforts of the 1950s and 1970s, in which centralized governance marginalized communal land systems in favor of national economic priorities.

POSITIVE INFLUENCE OF INTERNATIONAL HUMAN RIGHTS NORMS ON VIETNAM'S LAND POLICIES AND INITIATIVES

Despite systemic challenges, international human rights frameworks and global advocacy have positively influenced Vietnam's land policies at both the national and grassroots levels, aligning governance with global norms while empowering local initiatives to protect customary land rights.

Global organizations have been instrumental in advocating for Vietnam's alignment with international human rights norms. For example, the Mekong Region Land Governance (MRLG) project, which focuses on land tenure security, equitable access, and improved governance, has been a key contributor to Vietnam's land reforms (Communications, MRLG). Alongside the World Bank's Land Governance Assessment Framework (LGAF), MRLG provided recommendations reflected in the 2024 Land Law (Communications, MRLG). These recommendations emphasized transparency, democratic decision-making, and the recognition of customary land rights. The amended law explicitly incorporates these principles, safeguarding the rights of smallholder farmers, ethnic minorities, and women while ensuring their participation in land policy processes.

Similarly, at the local level, the United Nations Development Programme (UNDP) has promoted inclusive development in Vietnam's ethnic minority regions, emphasizing participation, accountability, and non-discrimination (VietnamPlus). For example, UNDP initiatives with Dao women have increased incomes through cooperative selling, enhancing their economic influence over land-use decisions (UNDP Asia-Pacific). These efforts also preserve traditional knowledge of medicinal plants and

promote sustainable forest management, strengthening the Dao Peoples' connection to ancestral lands. Commune-level cooperatives further align with customary land rights by reducing reliance on slash-and-burn agriculture, addressing poverty, and fostering sustainable livelihoods (Sowerwine 249–258).

CHALLENGES AND LIMITATIONS OF INTERNATIONAL HUMAN RIGHTS NORMS IN VIETNAM

Vietnam's integration of international human rights norms remains limited due to structural resistance and the suppression of civil society, which stifles grassroots advocacy and silences independent voices critical of land governance practices. A key obstacle is the state's emphasis on sovereignty, which leads to selective adoption of international norms. This selective implementation perpetuates inequities by systematically silencing activists and grassroots organizations who work to challenge inequitable land policies.

The suppression of civil society restricts grassroots advocacy and silences independent voices that could otherwise support reforms. Vietnam has imprisoned individuals for exercising basic civil rights, fostering a climate of fear that discourages dissent. This environment undermines the participatory governance principles central to international human rights frameworks and necessary for any reforms, including land governance reforms. A striking example is Can Thi Theu, a prominent land rights activist, and her son Trinh Ba Tu, who actively criticized illegal government land grabs in Duong Noi and Dong Tam ("Vietnam: Free Democracy Activist Mother, Sons"). They documented land disputes, advocated for fair compensation, and demanded the return of confiscated lands. In response, the government arrested Can Thu Theu and Trinh Ba Tu and sentenced them to lengthy prison terms under Article 117 of Vietnam's Penal Code, which criminalizes "anti-state propaganda" ("Land Rights Defenders Can Thi Theu and Trinh Ba Tu Sentenced"). Their criminalization highlights the state's deliberate efforts to suppress activism, enforce centralized control, and disregard international principles of freedom of expression and engagement.

The influence of NGOs in Vietnam is also significantly limited by systemic barriers, as centralized governance and restrictive policies hinder their efforts to promote human rights and equitable land management. For example, the Centre for Sustainable Rural Development (SRD), involved in Vietnam's Reducing Emissions from Deforestation and Forest Degradation (REDD+) initiatives, has introduced community-based forest management models to empower local communities (Pham et al. 5–8). However, their work is often undermined by centralized decision-making, which restricts their ability to push for comprehensive policy reforms. This example highlights how structural constraints hinder grassroots initiatives and underscores the critical yet restricted role NGOs play in advancing equitable land governance. The long-term effectiveness of these efforts remains uncertain without meaningful changes to the governance framework.

CONCLUSION

Vietnam's engagement with international human rights norms has set important benchmarks for reforming its approach to customary land rights. Instruments such as UNDRIP and the ICCPR, along with global advocacy, have spurred policy initiatives. However, the suppression of civil society and the state's emphasis on economic growth and centralized control continue to limit the full realization of these reforms,

perpetuating structural barriers and leaving Indigenous communities marginalized.

To address these persistent gaps, Vietnam must shift from symbolic commitments to meaningful action. Establishing independent monitoring bodies with representation from international observers, civil society organizations, and Indigenous leaders could enhance accountability, ensure compliance with international obligations, and counter the suppression of independent voices (Indigenous Navigator Consortium 5–7). Additionally, fostering participatory governance through strategies such as creating local councils with binding authority over land disputes, and involving Indigenous representatives in decision-making bodies, could decentralize control, empower communities to shape land-use policies, and ensure that land governance reflects the needs and rights of marginalized groups (Ironside 30).

While initiatives such as land redistribution, supported by global organizations, demonstrate the potential for progress, these successes remain limited in scope without structural reforms that address the root causes of inequities. Future research comparing Vietnam's efforts with those of neighboring countries like Cambodia and Laos could provide valuable insights into best practices for integrating customary land rights and advancing decolonization, particularly by examining how these countries have navigated similar post-colonial challenges and balanced state control with Indigenous land governance (Mellac and Castellanet 23–25). Although Vietnam has made strides in aligning with international standards, sustained implementation and comprehensive reforms are critical to achieving equitable land governance and ensuring the full realization of Vietnam's international commitments.

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THE DREYFUS AFFAIR'S IMPACT ON FRENCH SOCIETY

Exposure, Amplification, and Creation of Societal Divisions

SIYA DUGGAL

The Dreyfus Affair, also known as The Affair, began in 1894 when Captain Alfred Dreyfus was accused of leaking military secrets to Germany after a French spy found a *bordereau* – i.e., memorandum – in the German Embassy's trash can (Conklin, Fishman, and Zaretsky 2015, 106). Although the bordereau was neither signed nor did it match Dreyfus's handwriting, Dreyfus was accused because he was Jewish and came from a family in Alsace, a region that had been ceded to Germany in 1871 following the Franco-Prussian War (106–107). Dreyfus was pronounced guilty in December 1894 and sentenced to life imprisonment on Devil's Island, a French penal colony in Guiana (107). After large-scale societal mobilization, he was pardoned in September 1899 (114). France witnessed many regime changes in the century preceding the Dreyfus Affair; thus, during the 1890s *fin-de-siècle*, i.e., end-of-century, period, the French political sphere was characterized by many tensions. As Dreyfus's case entered public discourse in such a climate, the ideological and political divisions in French society surfaced.

This paper argues that the Dreyfus Affair exposed and amplified pre-existing French societal divisions while also giving rise to new divides, such as those between political intellectuals and proponents of laicity (i.e., the strict separation of the state and religion). The Affair exposed the divides between France's political left and right, illustrating how Leftist Republicans supported the Third Republic while the right-wing nationalist monarchists despised it (109–110). The Affair also demonstrated the differing perspectives of the left and right on the army and conceptions of the French nation. Furthermore, Dreyfus's case exposed underlying anti-Semitism to the limelight. Simultaneously, the Affair amplified the divisions between the Church and the State, which ultimately caused their permanent separation. Lastly, the Dreyfus Affair gave rise to French intellectuals, namely Émile Zola and thereby created a new form of political opposition.

EXPOSING DIVISIONS BETWEEN THE POLITICAL LEFT AND RIGHT

Under the Third Republic, French society featured radical views on both ends of the political spectrum, and the Affair showcased these divisions. Dreyfus's supporters —the Dreyfusards— included Leftist secular Republicans; meanwhile, the anti-Dreyfusards encompassed right-wing nationalists and monarchists (109–110). The two sides' approaches during the Affair exposed the left and right's differing perceptions of the French nation. The Dreyfusards' leftist approach was rooted in Enlightenment and Revolutionary values (Popkin 2020, 171). They took pride in the Republic's egalitarianism and viewed citizens living in France as French nationals (Silverman 1994,

30). In contrast, the right's model of France was rooted in ethnicity; thus, the anti-Dreyfusards asserted that French nationals must be French by blood and origin (30). Charles Maurras, an anti-Dreyfusard writer, depicted these differing perceptions as "legal" and "real" France (Conklin, Fishman, and Zaretsky, 110). He argued that Republican France was "legal France" as the 1789 Revolution created a "nation of laws," but "real" France rests on "a people linked, by ancestry, to a particular territory" (110). Anti-Dreyfusard nationalists also supported the restoration of the monarchy, favoured the Bonapartist regime, and "insisted upon natural social hierarchies" (110).

Such ideological differences were also reflected in how the Dreyfusards and the anti-Dreyfusards regarded the army. French society viewed its army as "a critical source of national pride" (107). However, the Dreyfusards placed a higher value on individual rights; they believed that "no damage to the army's reputation could justify imprisoning an innocent man" (109). They asserted that Dreyfus's unfair court-martial dishonoured the Republic and was "unacceptable in the nineteenth century" (108). Meanwhile, the right-leaning anti-Dreyfusards held the army in higher regard and believed that the liberal principles of the Third Republic were corrupting France (Conklin, Fishman, and Zaretsky, 107; Popkin, 171). The anti-Dreyfusards opposed sacrificing the state or army's honour for that of Alfred Dreyfus (Conklin, Fishman, and Zaretsky, 107). Instead, they argued that by posing a threat to the the army, Dreyfus and his supporters posed a threat to the nation (110). This view matched the anti-Dreyfusard understanding of France as a nation composed of social hierarchies and citizens who are French by origin. In their hierarchy, the state and army superseded the individual, and Dreyfus was an outsider since his homeland — Alsace — was at the time German territory. When a new suspect, Colonel Esterhazy, emerged, the anti-Dreyfusards continued supporting Dreyfus's conviction even though Esterhazy had gambling debts and was a greater potential security risk than Dreyfus (Popkin, 172). The anti-Dreyfusards opposed reopening the case, arguing that it would abolish public faith in the army and courts, thereby undermining French defence (172). While the case was eventually retried and incriminating evidence against Esterhazy was found, he was declared not guilty (172). Esterhazy's acquittal and Dreyfus's sustained conviction sparked unrest among the Dreyfusards, who saw it as an upheaval of Republican values. The distinctions between the Dreyfusard and anti-Dreyfusard perspectives of France exposed the political divides between the Third Republic's supporters and dissenters.

THE INCREASE IN REPUBLICAN POWER AND AGGRAVATION OF LEFT-RIGHT POLITICAL DIVIDES

The Dreyfus Affair was viewed as a victory for individual rights because, despite combined opposition from the army, Church, court system, and most politicians, "private citizens who had taken up Dreyfus's cause had launched the first modern crusade for human rights and ultimately prevailed" (Popkin, 173). The Dreyfusards' eventual win through the 1899 pardon revealed that the majority of French society preferred the egalitarian model of France over the ethnic one preached by anti-Dreyfusards (Silverman, 30). Thus, while the Dreyfus Affair exposed divisions between the left and right, the Republicans's success also revealed the left-leaning nature of French society at the time.

The left's success in the Affair yielded a strengthened Republic because Dreyfus's innocence reinforced the power of left-wing political parties. Movements emerged in metropolitan France that defended republican and democratic institutions. Furthermore, a common front formed on the left, where republicans and socialists

banded together against the anti-Dreyfus agitators (Popkin, 175). The new cabinet, led by Waldeck-Rousseau, illustrated how the political left's power increased in the wake of Dreyfus's innocence (Hauksson-Tresch 2021, 141). The Waldeck-Rousseau government combatted "anti-republican forces that … surfaced during the Dreyfus Affair" by repressing right-wing agitation, purging military hierarchies, and removing officers who were "willing to go to extremes to defend the Dreyfus verdict" (Popkin 175; Hauksson-Tresch, 141). This state-sanctioned repression increased the divides between the Third Republic's supporters and dissenters.

EXPOSING AND AMPLIFYING FRANCE'S ANTI-SEMITISM

The Dreyfus Affair also spotlighted French society's underlying anti-Semitism. It highlighted how, in *fin-de-siècle* France, anti-Semitism had transitioned from being rooted in religious differences and propagated by the Church to becoming an element of French nationalism. Within the polarized climate of the Affair, anti-Semitism became deeply intertwined with the right's ethnic and nationalist conception of the French nation. Instead of being considered outsiders because they were not Christians, France's Jewish minority came to be viewed as outsiders by ancestry and as a biological threat to the French nation's purity (Conklin, Fishman, and Zaretsky, 111). This new kind of prejudice was demonstrated in Eduard Drumont's 1886 best-seller *La France Juive* (Popkin, 171), where he alleged that Jews were using their influence in banking and the press to promote an explosive capitalism that was "poisoning … French culture" (171). The Catholic Press echoed Drumont's ideas as it blamed Jews for the Republic's anti-clerical laws (171).

During the Dreyfus Affair, anti-Semitism reached "an intensity never before experienced in France" when Dreyfus's fellow officers accused him of treason due to his Jewish identity because, under the right-wing model of the French nation, Dreyfus was "not one of them" (Begley 2017, 6–7). Dreyfus's critics viewed him as an alien because they believed his Jewish identity would never allow him to truly conform to French culture (Begley, 7; Popkin, 171). Thus, anti-Dreyfusards believed that Dreyfus's conviction would spare the French army the stain of treason being "committed by a French officer assigned to it" (Begley, 7). The anti-Semitic press applauded Dreyfus's conviction, and anti-Semites employed Dreyfus's treason as support for their argument "that the liberal and republican principles of liberty and equality were leading the country to disaster" (Popkin, 172). Anti-Semitism was also exhibited in the opposition to reopening Dreyfus's case after Esterhazy emerged as a suspect. While protecting the army's honour was one of the reasons for their opposition, anti-Dreyfusards also attempted to discredit claims of Dreyfus's innocence by asserting that such claims came from Jews and non-Catholics (172). These ultranationalists viewed the army as France's honour and ultimate safeguard; thus, they defended Dreyfus's conviction with the argument that claims of Dreyfus's innocence were inferior to the "French truth," a term coined by nationalist writer Maurice Barrès, which meant "what is most useful to the nation" (172). In the anti-Dreyfusards' eyes, protecting France's honour and security — both of which they believed Jews threatened — was more important than a non-Frenchman's innocence. Thus, the anti-Dreyfusards' alienation of Dreyfus during the Affair amplified French anti-Semitism.

This rising hatred toward French Jews was illustrated by the increased anti-Semitic demonstrations and publications during the Affair. At the height of Dreyfus's case in 1898, "there were anti-Semitic demonstrations in at least seventy French cities" (171–172). The most violent protest occurred amidst the settlers in French Algeria, as

they resented the implementation of the *Crémieux Law* of 1871, which granted French citizenship to Algeria's Jewish population (172). These settlers did not view Jews as "real" French citizens, pursuant to the right's ethno-nationalist model of the French state, and consequently, anti-Semitic protests erupted in Algeria. Furthermore, during the Affair, numerous anti-Dreyfusard publications portrayed Dreyfus as a traitor and featured anti-Semitic themes, thereby demonstrating the rising hatred against France's Jewish population (Hauksson-Tresch 2021, 129).

THE SEPARATION OF THE CHURCH AND STATE

Before the Affair, France's Church-State divisions were deep-seated, as both parties viewed each other as threats due to their opposing foundational values (Conklin, Fishman, and Zaretsky, 118). The Church was an ancient institution rooted in hierarchy and faith, while the revolutionary Republic embraced the ideals of liberty, equality, and fraternity (118). The Dreyfus Affair deepened the divide between the Republic and the Catholic Church because Church leaders supported the Republican Dreyfusards' opponents. The Church was linked to anti-Dreyfusard nationalists, supported the army, and opposed reopening Dreyfus's case (118). Additionally, *La Croix*, the newspaper of the Assumptionist Order — a Catholic congregation — was a vital channel of anti-Semitic and anti-Dreyfus propaganda (Popkin, 175). Given that the Affair had strengthened the Republic by uniting the left against a common enemy, the government was able to employ its increased power to distance the State from the Church. In 1901, the Republic passed a new law on associations that "tightened controls on … Catholic religious congregations" despite establishing a flexible framework for other non-profit groups (175). Subsequently, in 1904, the government broke relations with the Vatican, followed by the Assembly voting to nullify the 1801 *Concordat*, which had governed Church-State relations since the Napoleonic era (175). In doing so, the Republic officially separated the Church and State, and laicity remains a fundamental principle of French society (Hauksson-Tresch, 141). Thus, by amplifying Church-State tensions, the Dreyfus Affair created a permanent divide between the two entities.

THE EMERGENCE OF THE FRENCH PUBLIC INTELLECTUAL

One of the most notable aspects of the Dreyfus Affair was the emergence of the French intellectual, defined as someone who "held a position of power and authority in the political and cultural establishment, and thus defined norms and values for the rest of society" (Conklin, Fishman, and Zaretsky, 115). These intellectuals played a vital role in the Affair because they inspired societal mobilization by publishing their opinions.

Émile Zola was a preeminent example of this rise of intellectuals. When Esterhazy was acquitted despite evidence proving that he was an officer and spy of the German Empire, Zola intervened by publishing his famous news article "*J'Accuse!*" in January 1898 (Hauksson-Tresch, 129). In "*J'Accuse!*," Zola criticized the army, government, and court for their conduct in Esterhazy's trial. Zola accused them of carrying out a court-martial that was "a supreme insult to all truth and justice" and sullying France's image (1898). Zola also used graphics to convey his message. The article's title was printed in letters usually reserved for print posters and featured double capitals on the J and A to ensure it could be seen from afar (Hauksson-Tresch, 139). Zola's article included a list of accusations, naming officials and their crimes (1898). These accusations were formatted such that they captured readers' attention as each assertion was indented and began with "*J'Accuse*," i.e., I accuse (140). Zola's article "was

the cornerstone of … mediatic activity at the time," generating massive public mobilization in support of Dreyfus (Hauksson-Tresch, 141; Popkin, 173). While Zola was charged with libel and fled to Britain, the profound impact of "*J'Accuse!*" led to the President pardoning Dreyfus in 1899 and the Court rehabilitating him in 1906 (Hauksson-Tresch, 129).

Zola was arguably the most impactful intellectual who emerged in the Dreyfus Affair, but he was not the first nor the only intellectual. Professional historians were key intellectuals participating in the Dreyfus Affair, partly because of their prominent position in French society, but also because they were professionally trained to analyze handwriting (Creyghton 2018, 280). Since the *bordereau* was the primary evidence alongside other forged written documents, handwriting analysis was a key issue in the case (280). French historian Gabriel Monod was the first academic and one of the first intellectuals to publicize his conviction that Dreyfus was innocent (279–280). On November 5, 1897, Monod sent an open letter to newspapers announcing his opinion and explaining that it "was based on carefully undertaken research into the dossier" (280). Notably, intellectuals were not limited to the Dreyfusards. There were also anti-Dreyfusard intellectuals, namely Maurice Barrès. Barrès used "intellectual as a term of scorn," yet as a politician, novelist, and journalist, he himself was an intellectual (Conklin, Fishman, and Zaretsky, 115). Such right-leaning intellectuals used their platforms to reveal the elements they perceived as "rotten in the Republic" (116). Namely, Barrès argued that the Republic's positivist education was uprooting young Frenchmen "from their customs and communities" (116).

The rise of the intellectual also involved the emergence of "the politically committed intellectual" (Popkin, 173). This type of intellectual encompassed Frenchmen who were inspired by intellectuals like Zola and Barrès to join organizations that supported their own political values and who were willing to risk themselves to protect their moral principles (173). Dreyfusard political intellectuals joined the League for the Defence of the Rights of Man; anti-Dreyfusards supported the League of Patriots, the *Ligue de la Patrie française*, and *Action française* (173). Both sides employed mass rallies and press propaganda to promote their causes; this increased political activity reflected how Zola's article broadened the Dreyfus Affair from "a campaign against an act of injustice to a struggle over the nature of French society" (173).

The emergence of the French political intellectual during the Dreyfus Affair also involved increased female political activity. During the Affair, specifically between December 1897 and February 1898, Zola received over 2000 letters, of which 280 were from women (Humphries 2005, 434). Analysis of the letters sent to Zola throughout his lifetime revealed that women made up three to seven percent of the total correspondents; however, during the Dreyfus Affair, women authored 13% of the letters sent to Zola, which confirmed that "the Affair politically activated a significant number of women" (434). Alongside their male compatriots, women also asserted Dreyfus's innocence or denounced Zola's opinions "in their letters and articles published in Parisian newspapers, notably in the feminist journal *La Fronde*" (434). These opinions only represent an elite selection of women known as *reporteresses* (i.e., female journalists) or those directly involved in the Affair, i.e., "the wives or mistresses of the men concerned" (435). Nonetheless, the increased political participation of women supports the claim that the Dreyfus Affair amplified political activity and created a new division in French society as it established the French public intellectual. The rise of the public intellectual exposed France's existing Left-Right political divisions, as intellectuals differed in the political model they favoured. The emergence of the public intellectual

also created a new division between society and the state, as not all members of society supported the intellectuals.

CONCLUSION

On balance, the Dreyfus Affair exposed, amplified, and created divisions in *fin-de-siècle* French society. It exposed and amplified the divisions between France's political left and right by cementing their differing conceptions of the French nation; the Dreyfusards supported the Republican values of liberty, equality, and fraternity, while the anti-Dreyfusards promoted a hierarchical, ethnically unified, monarchist version of France. With the revelation of Dreyfus's innocence, the Affair ultimately strengthened left-leaning parties and allowed them to repress their opposition. Thereby, the Affair furthered divisions between the Third Republic's leftist supporters and right-leaning dissenters. Moreover, the Dreyfus Affair demonstrated how France's anti-Semitism had transitioned from being a religious divide to also being rooted in race, while also amplifying Church-State divisions. By unifying the political left, the Affair equipped the Republic with the power it required to separate the Church and State, creating a division that remains vital to France's image as a secular nation to this day. Lastly, the Affair produced the French intellectual through the published opinions of notable figure like Zola, Monod, and Barrès. This emergence of the French intellectual inspired increased public political activity among men and women, thereby creating new political divides in French society. As a *fin-de-siècle* moment, the Dreyfus Affair featured pre-existing ninteeth-century divisions between Republicans and monarchists, and it laid the foundations for the divisions – i.e., racial prejudice, laicity, and intellectual political opposition – that would characterize the twentieth-century.

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SOCIAL SCIENCES

THE BISON AND THE RAILROAD

Analyzing Infrastructure and Ideology's Role in Colonial Dynamics on the Great Plains Borderlands

ATLAS CHANGULANI

The so-called Wild West Era of the nineteenth-century occupies a key place in culture, folklore, and popular conceptions of US history. The bison and the railroad remain iconic symbols of the frontier, featured in countless stories of gunslinging cowboys against horse-mounted Indians. Yet behind these narratives of swashbuckling adventures is a history of both brutal colonization and Indigenous resistance in the Great Plains. This history too features the bison and the railroad as key sites of colonial struggles for dominance and as symbols of the contrasting worldviews of Indigenous nations and the imperial state.

In this essay, I explore US tactics of forced-starvation through ecocide and the military-corporate driven imposition of colonial infrastructures onto Indigenous lands, as employed in the Great Plains in the mid-1800s, and contextualise them within ideologies of capital accumulation and white supremacy, which frame nature as a resource to exploit and define civilization by a society's willingness to do the same. I aim to convey how colonial dominance is forged by infrastructures that proliferate violence through ideologies of resource extractivism, and how anticolonial struggles necessitate not only resistance to such infrastructures but to the exploitative worldviews they manifest — struggles that are founded in enduring relations of reciprocity between Indigenous populations and the land the U.S settler state claims to own.

I begin by exploring how colonial actors, prominently the military, employed bison ecocide as a colonial tactic, followed by how railway construction mutually sustained a corporate-military confluence that established material imperialist control over the Plains. Subsequently, I analyze the way these imperial mechanisms are embedded in understandings of nature, civilization, and race driven by white supremacy and logics of capital production, using sources from military networks as well as popular art as illustrative examples. Finally, I contrast colonial worldviews with Indigenous modes of relationality, specifically those of the Lakota, arguing that these persisting relations continue to inform resistance against the ongoing US settler-colonial project.

BISON ECOCIDE AS A TOOL OF COLONIAL DISPOSSESSION:

Forced starvation has been a widely employed strategy of imperial domination, paradigmatically manifest in U.S colonisation of the Great Plains through a multi-decade effort to exterminate the bison. The scope of this annihilation is staggering: over a century, the bison population plummeted from tens of millions to mere hundreds (Cunfer, 2016, pp. 1–29). While bison had coexisted with Indigenous peoples for fifteen-thousand years in various dynamic relationships (Cunfer, 2016, pp. 1–29), merely a century of settler-colonial aggression in the Plains was enough to cause an ecocide that

would destabilize Indigenous livelihoods for many years to come, joining the many acts of colonial violence amidst the countless that form the foundation of the United States.

The near-annihilation of the bison was perpetrated by a variety of causal factors. The bison fur market expanded rapidly throughout the mid-nineteenth century, and hunting bison for sport gained increasing popularity, putting additional pressure on the population (Cunfer, 2016, pp. 1–29). However, it wasn't merely reckless hunting that led to the species' near-collapse: after the Civil War, the US implemented a deliberate policy of buffalo extermination in pursuit of westward expansion (Smits, 1994, pp. 313–338). This was executed through state-chartered corporations, most notably the Union Pacific Railroad company (Karuka, 2019, pp. 74–94), as well as the state military.

Smits (1994) lays out an analysis of primary sources to provide evidence illustrating both the extent of the US Army's involvement in bison extermination as well as the intent. One such source, an article from the Armed Forces Journal dated June 26 1869, reports General William Sherman's proposition that a campaign seeking the destruction of the bison would prove an expedient solution to the "Indian Problem" that threatened the expansion of empire. Defeating the Lakota nation through conventional military means had proven exceedingly difficult (Smits, 1994, pp. 313–338); this article suggests instead the deployment of a strategy of scorched-earth brutality already proven to work against the Confederates, involving not merely the destruction on the opponent's military capacities but also of civilian infrastructure necessary to sustain life. The article notes that in contrast to the Confederacy, the nomadic Plains nations lacked conventional infrastructural targets to strike: the only way to attack Indigenous 'infrastructure' was to make it impossible for them to sustain themselves on their land. The most effective way to do so was annihilating the buffalo, their primary food source. The resulting starvation would force them onto state reservations, rendering them further vulnerable to the whims of imperial domination.

However, omitted from this source is the critical role of settler-colonial infrastructure projects in facilitating the mass extermination of the bison. Beyond direct military engagement, bison populations were depleted through the enormous ecological transformation brought about by the transcontinental railroad, which was both enabled and utilized by the military in establishing control over sovereign Indigenous land. The destruction of Indigenous modes of sustenance was inextricably connected with the expansion of colonial infrastructure; both processes enabled the other in a vicious cycle perpetrated by the same force: the war-finance nexus.

THE TRANSCONTINENTAL RAILROAD AND THE WAR-FINANCE NEXUS:

The destruction of the buffalo in the Great Plains was facilitated by the construction of the Transatlantic Railroad in a variety of ways. The railway enabled an enormous expansion of buffalo hunting by easing the transport of both hunters and carcasses and fuelling an industrialized market in hides; moreover, the laying of tracks through the middle of the plains divided herds and fundamentally transformed their habitat, making it further vulnerable to ecological and colonial forces (Cowen, 2020, pp. 475–476). Yet the Transatlantic Railroad was itself an infrastructure of colonial infringement, and in tandem with buffalo-slaughter, paved the way for dispossession in the Plains (Cowen, 2020, pp. 473–475).

Karuka (2019) argues that imperialism proceeded on the Great Plains through an interrelationship of military expansion and corporate finance termed the war-finance nexus (pp. 74–94). The building of railroads by state-chartered corporations

Figure 1: Palmer, FF. (1868) *Across the Continent. "Westward the Course of Empire Takes its Way"* [Print]. Yale University Art Gallery. New Haven, USA. https://artgallery.yale.edu/collections/objects/47239

enabled the consolidation of military power over new territories, which, in turn, sustained the necessary military force for further railroad expansion — a self-reinforcing vicious cycle through which U.S settler-colonial domination became materially manifest. Railways facilitated the transport of troops, supplies, and munitions, enabled the construction of military forts and settler towns, and allowed the army to attack Indigenous villages directly. Simultaneously, the military secured the tracks and settler towns from sabotage, enabled their expansion and ensured investor profit, and provided industry access to resources from stolen land.

Karuka (2019) also notes how, in violation of multiple treaties, the Pacific Railroad Act granted railway corporations lands legally and materially under full Indigenous sovereignty, granting them fictitious property rights that had to be manifested *through* the process of track-building — a system remarkably similar to financial credit. Here, Karuka reveals, the US is not a territory but rather a set of threats, asserting dominance and dominion materially inscribed across the landscape through the construction of railroads (pp. 74–94).

THE IDEOLOGIES OF EMPIRE:

The mechanisms underpinning 19th-century US imperialism and the tactics it used to manifest control in the Great Plains are embedded within a view of nature, civilization,

and race shaped fundamentally by white supremacy and capital accumulation. Such perspectives held that nature was separate from humans and had value only through exploitation, thus defining civilization by its capacity for extraction and casting mutualistic, non-hierarchic Indigenous land kinship and relationality as barbaric and primitive, and assuming that the white race by virtue of its supposed advancement had the unquestioned right to conquer Indigenous land.

These ideas are reflected in the Armed Forces Journal article (1869) discussed previously: it was taken for granted that the US had the right to colonize lands under Indigenous sovereignty, to displace Indigenous peoples to reservations where they could be confined, forced to abandon nomadic livelihoods, and thus elevated from "savagery". All that is under consideration is the method for doing so, and the idea of decimating an entire species and wreaking havoc on the ecosystem to impose starvation seems to have raised no qualms among these "civilized" gentlemen.

These worldviews were widely held among not only the military, but also settler 'civilians', and became deeply embedded in the settler-colonial imagination. The railway was key to US expansionism also as a symbol of ideology — we see this clearly in F. F. Palmer's 1868 print "Across the Continent" (Figure 1). The railroad is central to this print, demarcating a bustling settler town and a vast natural expanse only sparsely populated by Indigenous peoples. A train depicted near the bottom steadily makes its way westward, carrying symbolism impossible to ignore.

The rail here draws literal boundaries between settler and native, between a "civilized" white settlement built upon the domination of its environment and a "savage" Indigenous society living on "undeveloped" land. The train's advance into the western horizon shows the 'inevitable' march of settler civilization — a horizon notably depicted as empty, almost as if waiting to be populated by settlers carried by the tracks. This image vividly illustrates ideas of manifest destiny and terra nullius, while making clear the centrality of the railway in 19th-century conceptions of empire building. The railway, as depicted here, represents the colonial myth of progress and the advancement of civilization through technologies enabling extraction; a United States stretching from sea to shining sea, its dominion uncontestable, one nation under God as it was always meant to be.

INDIGENOUS RELATIONS AND RESILIENCE:

In contrast to colonial frameworks premised on coercive control and exploitation for the benefit of settler upper classes, Indigenous modes of relationship are often structured upon principles of reciprocity. To the Lakota, nature was not "other" but inextricable from their communities, seen not as a resource but as kin (Posthumus, 2016, pp. 278–310). Lakota relationships to land centered expansiveness, not expansion: expansiveness that proved to be the strongest obstacle to US expansion in the Plains (Karuka, 2019, pp. 74–94).

The bison in particular was not merely a food source but also a defining part of Lakota identity, a centerpiece of social life and spirituality (Posthumus, 2016, pp. 278–310). Attempts to eradicate the buffalo were not merely depriving them of a resource but attacking their very social fabric — and were met not merely with a material resistance the US struggled with subduing for decades, but equally importantly with cultural fortitude enabled by and built around the bison.

The centrality of the buffalo in Lakotan ontologies survived even the near-extinction of the species. Despite the loss of the animal, forced displacement onto reservations, and the destruction of many traditions, buffalo remained the framework by

which the Lakota viewed the world, and the expansiveness this relation embodied persevered despite all odds (Posthumus, 2016, pp. 278–310). So did the animal itself — and so did the nation.

Thwarting every colonial attempt to sever this relationship, bison continue to thrive among indigenous communities despite the enormity of the violence inflicted on both. Similarly undeterred, the Lakota have continued to exert their sovereignty against the state at Alcatraz, at Standing Rock, and through everyday resistance and anti-colonial praxis. Where the railroad symbolizes colonial domination, the bison arguably embodies indigenous resilience.

CONCLUSION:

Centuries onward, the divine destiny the US claims over stolen Indigenous land has yet to be made manifest. Colonial sovereignty stands on a fundamentally precarious foundation; one that must be enforced through constant violence yet remains threatened by the presence of Indigenous people and their enduring relationships to this land. The US has been a force of unparalleled destruction across Occupied Turtle Island, decimating thousands of communities in a supposed civilizing mission carried by ecocide-enabled forced starvation, infrastructure imposed for corporate greed and military expansion, and countless other means of colonial violence. Yet sovereignty built on tactics based in exploitation, on lands held onto by white supremacist fictions of ownership rights and considered worthy only through their exploitation, is unsustainable no matter how powerful it becomes. Indigenous frameworks of reciprocity and kinship, however, persist despite every attempt to destroy them, enabling resistance to colonial infrastructures and ideology alike as fundamental frameworks underlying the fight for decolonization.

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STRAWBERRY FIELDS FOREVER

The Detachment of Strawberry Consumers and Harvesters

SOFIA TARNOPOLSKY

Driscoll's, one of the world's leading berry distributors, sources its non-organic (also labelled as conventional) strawberries from various warm climates. These include locations in California (Oxnard, Salinas, Santa Maria, and Watsonville), Central Mexico, and Florida (Driscoll's, n.d.). In this analysis, I will concentrate on the conventional strawberries cultivated in Mexico. Driscoll's boasts that each berry is hand-harvested and that after purchasing your berries, it is likely that the only other person who has touched them outside of the box is the harvester (Driscoll's, n.d.). In Southern Ontario, consumers acquire strawberries as a simple grocery purchase, detached from the long and complex supply chain that brings them from Mexican fields to Canadian tables. I will argue that consumers and workers are detached from any relationship with one another, as well as both being detached from the transportation of the strawberries from Mexico to Canada. Consumers are further detached from the labour of the strawberries' production because they have only a transactional relationship with the strawberries. The workers' rights and the lack of knowledge on the part of the consumers characterize this detachment because they are drastically separated contexts.

Driscoll's conventional strawberries are cultivated across warm climates in North and South America and grown primarily in California and Mexico. In 2019, Mexico was ranked third in global strawberry production after harvesting 861,000 tons of strawberries (Oğuz, Oğuz, and Kafkas, 2022, pp. 1-2). Driscoll claims to use natural breeding methods that create a patented variety of strawberries while relying on cross-pollination techniques that do not use genetic modifications or irradiation; the berries are naturally resistant to disease and pests (Driscoll's, n.d.). The company begins by growing its strawberries in nurseries where the seedlings are later harvested and shipped to coolers. The plants remain in hibernation before being planted. Driscoll's emphasizes that its farmers' goals are to "shape, rather than control, the biological diversity of their fields, with a minimum amount of agricultural inputs" (Driscoll's, n.d.). When Driscoll's strawberries in Mexico are harvested, 75-80% of those are shipped the day they are picked (Fischer-Daly, 2022, 9).

While their expansion in Mexico has boosted local economies and employment, it has also initiated environmental debates, particularly concerning water resource management and sustainable agricultural practices (Wu et al., 2018). The farmers are trained to modify their behaviour according to the local ecosystem rather than manipulating it further (Driscoll's, n.d.). However, in Northern Baja, Mexico, some strawberry farmers are permitted to use groundwater at a rate that exceeds its natural replenishment despite severe droughts (Barringer, 2018). Over 95% of the water in the San Quintín Valley is used for irrigation for cultivating strawberries and other Driscoll's berries (Barringer, 2018). In a place where the economy is grounded on water and

workers' production, there is clean water for strawberries, but not for all workers (Fischer-Daly, 2022, 1). Regardless of Driscoll's emphasis on sustainability, strawberry production in some Mexican farms relies on the exacerbation of local water supply, which further exploits the local environment in the name of the economy.

In 2015, a strike defined the detachment present in Driscoll's strawberry production, as consumers do not question the environmental and physical impact of the water used to produce the strawberries they purchase. Workers in the San Quintín Valley went on strike during peak strawberry harvest season in 2015 due to low wages, poor working conditions, and labour rights violations — many of these workers were from farms that supplied Driscoll's with strawberries through its Mexican partner Berrymex (Fischer-Daly, 2022, p. 6). Workers enacted this strike in a request for an increase in wages, benefits, holidays, and overtime pay; an end to sexual harassment; and an established dialogue between employers and the state government (Garrapa, 2019). Additionally, they demanded better living conditions in the San Quintín Valley area; this included improved and developed public health facilities and the development of running water, electricity, paved roads, and a drainage system (Garrapa, 2019). Following the workers' strike, *Familias Unidas por la Justicia* (Families United for Justice) travelled through the western coast of the United States to promote boycotts of Driscoll's global consumption. These boycotts were unsuccessful as immigration laws blocked the workers from travelling to the primary sales locations in the United States, where others have developed and facilitated boycotts (Fischer-Daly, 2022, 7). Despite their efforts, immigration laws and corporate barriers prevented workers from taking their fight directly to the main markets, exposing the extensive systemic and structural issues that keep labour exploitation in place.

Driscoll's controls the production, importation, and distribution of strawberries and other berries on a global scale, with distribution centers in Australia, Canada, Europe, New Zealand, and the United States (Driscoll's, n.d.). On its Mexican farms, the harvesting and inspection process defines this control (Driscoll's, n.d.). After strawberries are harvested, they are inspected for quality and then placed on pallets to be cooled to 0 degrees Celsius. Once cooled, they are wrapped to preserve freshness and then transported by truck to stores (Driscoll's, n.d.).

When consumers purchase a local commodity, it carries more symbolism, whereas purchasing a clamshell of Driscoll's strawberries is purely transactional. The availability of strawberries in Southern Ontario reflects an intricate dynamic between local produce and Driscoll's influences on consumer purchasing behaviours. In 2024, Driscoll's partnered with farmers in British Columbia and Quebec to cultivate their California-developed strawberries in Canada. This partnership was developed to produce higher-quality berries in Canada that are able to adapt to climate change (Charlebois, 2024). Despite the benefits of this cross-border development, it can potentially dominate the local markets and obscure local strawberry production, which further emphasizes the global berry monopoly that Driscoll's has created (Charlebois, 2024). In their 2015 study, "Understanding consumer choices for Ontario produce," Dukeshire et al. argue that consumers purchase locally sourced produce — in this context strawberries — to support community farmers as well as promoting environmental stability. The study suggests that despite positive attitudes towards purchasing local produce, there is a gap between symbolic intentions and material practices. Dukershire et al. note that consumers experience barriers such as distance to local markets, price, seasonal availability, and difficulty finding local produce (2014, p. 4). Despite consumers' desire to support local strawberries and other produce, structural barriers are in place under the aforementioned global berry monopoly. This further

illustrates the detachment consumers have from the harvesters because there is no equitable access to locally sourced produce that bridges the gap between the producers and consumers.

Consumers and workers are detached from the transportation of strawberries from Mexico to Canada, whereas consumers are further detached from strawberries because their relationship is purely transactional. Consumers are generally unaware of the laborious aspects of harvesting strawberries and transporting them to grocery stores in Southern Ontario. This includes a lack of knowledge of workers' rights that further distances the two groups. Structural barriers reinforce this detachment as Driscoll's has created a global berry monopoly that overshadows local strawberry production in Southern Ontario. When consumers purchase local produce, there is a deeper symbolism of supporting companies that have a connection to the consumers' communities. In contrast, Driscoll's strawberry consumers in Southern Ontario have a transactional relationship because the strawberries are grown thousands of miles from their communities. Driscoll's reinforces the detachment from consumers and producers because strawberries grown in Mexico are transported to Canada and the United States where consumers have a transactional relationship. These issues of detachment are fortified by the structural barriers that highlight the global issues of labour exploitation and consumers' ethical choices in a globalized strawberry production system.

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COLLECTIVE DESIRE

The General Will and Psychoanalytic Theory

DEAN TESSARO

This article proposes a novel connection between the Rousseauian concept of the "general will" (as it is presented in the Political Economy) and Lacanian psychoanalytic theory. After denoting the psychoanalytic base which underscores the superposition of the "general" and "particular" wills, the particular will of the individual is examined through the lens of the Freudian id, ego, and superego. These "agencies" are then examined in their superseded forms as the Lacanian "registers" which form the Borromean knot, wherein the objet a is located. Finally, via the forms of the Father and "law" employed in both Lacanian psychoanalysis and the Political Economy, a linkage is formed demonstrating how the general will manifests in each register to produce the societal objet a.

The writings of Jean-Jacques Rousseau are rarely considered within the context of the philosophical-psychoanalytic tradition despite the heavy emphasis he places on development, education, and affect throughout. Moreover, where Rousseau does receive psychoanalytical attention, it often takes the form of a psychoanalysis of his own character; when (psychoanalytical) literary critique is applied to his works, it more often focuses on those deemed "less-political"[1] (*Émile*, *Confessions*, *Reveries*, etc.).[2] Any devout Freudian who approaches the *Discourse on Political Economy*[3] would likely be surprised by this, as the work is, on its face, rich with potential for the application of the Oedipus complex — such as Rousseau's heavy emphasis on the state's "fatherhood" over its citizens.[4] However, as espoused by later psychoanalytical thinkers (Lacan in particular, as well as, say, Deleuze & Guattari), to place the Oedipus complex — as conceived in the psychosexual terminology of its Freudian root) — at the centre of

[1] I am hesitant to say "non-political" here, as these works exist within a deeply political context and intrinsically possess political meaning. The point being here is that when these works are subject to psychoanalysis, the focus is primarily upon their "non-political" (again, so to speak) aspects.

[2] See e.g., Jacques Derrida, "Typewriter Ribbon: Limited Ink," in *Without Alibi*, trans. Peggy Kamuf (Stanford University Press, 2002), https://doi.org/10.1515/9781503619890; Julia Kristeva, *Passions of Our Time* (Columbia University Press, 2025), 181–99, https://doi.org/10.7312/kris21899; Laurence Viglieno, "Les structures dramatiques obsédantes dans le théâtre de jeunesse de Rousseau: essai de lecture psychocritique," in *Rousseau et le spectacle*, ed. Jacques Berchtold et al. (Armand Colin, 2014), https://doi.org/10.3917/arco.htold.2014.01.0075; Mark R. Anspach, "Freud, Judge of Sigmund: Narcissism and the Varieties of Self-Love in Rousseau," trans. JPD Systems, *Revue du MAUSS* 37, no. 1 (2011): 243–52, https://doi.org/10.3917/rdm.037.0243; Elizabeth Rose Wingrove, *Rousseau's Republican Romance* (Princeton University Press, 2000), https://doi.org/10.1515/9781400823543.

[3] Referred to hereinafter as the Political Economy: Jean-Jacques Rousseau, *A Discourse on Political Economy*, ed. and trans. G. D. H. Cole (J. M. Dent & Sons, 1913; repr., ETH Zurich, 2008), https://www.files.ethz.ch/isn/125495/5020_Rousseau_A_Discourse_on_Political_Economy.pdf.

[4] Rousseau, Political Economy, 1–2, 12–14.

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psychoanalysis is to miss the forest for the trees, so to speak.[5] In a similar sense, to focus a psychoanalytical exploration of the *Political Economy* on the Oedipal dynamics of governance would likely cause one to miss a concept far more deserving of such pursuits: the general will.

This concept, vital to Rousseau's *On the Social Contract*, has been subject to diverse hermeneutical exploration due to his often vague and abstract description of it; though the *Political Economy* predates the *Social Contract* (and is thus often considered "an immature work"[6]), the condensed iteration of the general will provided therein presents a useful opportunity for a delineation of its meaning via psychoanalytical interpretation. Rousseau's conceptualization of will has a direct connection to psychoanalysis: although "will" as a noun is primarily translated from *volonté* (volition) in the *Political Economy*, when used as a verb it is instead translated from *vouloir*,[7] which may also mean "to want" or "to *desire*"[8] — the latter form even used in the translation of the *Political Economy*, wherein "qu'il ne doit pas *vouloir* détruire en eux les passions"[9] becomes "that he ought not *to desire* to destroy their passions."[10] Desire is also central to psychoanalytical theory, and, in particular, the work of French psychoanalyst Jacques Lacan, who posed "the Other's question" — "*chè vuoi?*"[11] (What do you want?) — as central to its understanding. I will thus advance an approach to understanding the general will as a form of Lacanian desire, beginning with an analysis of how will is developed through the psyche's dialectical mediations and subsequently extrapolated to the development and reproduction of the law via the triadic orders of Lacan's Borromean knot.

THE GENERAL AND PARTICULAR WILLS

The society of the *Political Economy* is described by Rousseau in terms of a body politic, a machine composed of many parts which are unified by the so-called "general will."[12] This incorporeal will of the whole of a social group exists in dialectical contrast to the "particular will" — the will belonging to a subset of the general society, be that a lone individual or a subset of the collective united via common interest. These two forms of will exist in superposition, wherein a given will is simultaneously particular to a larger group but general to a smaller group within it (and whether it is general or particular thus depends on the position from which it is observed) — for example, a political party may possess a will that is general to its members, but particular to the state.[13]

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[5] Jacques Lacan, *The Other Side of Psychoanalysis*, trans. Russell Grigg, *The Seminar of Jacques Lacan, Book XVII* (W.W Norton & Company, 2007), 99–101. Gilles Deleuze and Félix Guattari, *Anti-Oedipus: Capitalism and Schizophrenia*, trans. Robert J. Hurley et al., Penguin Classics (1977; Penguin Books, 2009), 51–56.

[6] Clifford Orwin, "Rousseau on the Problem of Invisible Government: The Discours sur l'économie politique," in *Educating the Prince: Essays in Honor of Harvey Mansfield*, ed. Mark Blitz and William Kristol (Rowman & Littlefield, 2000), 101.

[7] For example, Rousseau writes "ne doutons pas qu'ils n'apprennent ainsi à se chérir mutuellement comme des frères, à ne vouloir jamais que ce que veut la société," (italics added); the uses of vouloir herein are translated to English as "will." See Jean-Jacques Rousseau, *Le citoyen, ou Discours sur l'économie politique* (Genève, 1765), 45–46, BnF Gallica, https://gallica.bnf.fr/ark:/12148/bpt6k96023109; cf. Rousseau, Political Economy, 12.

[8] Italics for emphasis.

[9] Rousseau, *Discours Sur l'économie politique*, 42 (italics added).

[10] Rousseau, *Political Economy*, 12 (italics added).

[11] Jacques Lacan, *Écrits: The First Complete Edition in English*, trans. Bruce Fink, with Héloïse Fink and Russell Grigg (W.W. Norton, 2006), 690 (italics in original). NB: while Lacan poses the question in the presented Italian, the verb volere (conjugated here as vuoi) directly translates to the French vouloir.

[12] Rousseau, *Political Economy*, 3.

[13] Rousseau, *Political Economy*, 3–4.

This establishes two elements of the will which are central to the psychoanalytical comparison: firstly, it defines the general will as essentially relational, insofar as it is produced via dialectic between its constitutive particular wills. In other terms, there cannot exist a particular will of the self where there does not exist a particular will of the other; in the latter's absence, an upper bound of generalization is established wherein the former becomes general. Even if there is another particular will existent beyond the bounds of a given will's perception — say, for example, an unknown alien society whose general will conflicts with the general will of all human society — the absence of relation (or nonexistence of a social contract) between the two means these wills have no shared body politic to execute their general will. For this reason, Rousseau asserts, the general will of the world is "always the law of nature."[14] Inversely, this dilemma of perception also establishes a lower bound of particularization at the level of the individual. In the depths of the psyche which produce the individual's will (that which is general to the individual but particular in its relation to the wills of other individuals) lies what Lacan calls the Real, that which completely resists any attempt at symbolization and which is "absolutely without fissure."[15] It is from this point that the psychoanalytical base of the general will emerges, and thus from where my analysis begins.

THE SOCIETAL PSYCHE

Despite Lacan's quasi-rejection of the Oedipus complex, his psychoanalytical project (which he called a "return to Freud"[16]) is quintessentially built upon the Freudian psyche, particularly in its division into three "agencies": the *id*, *superego*, and *ego*.[17] The id (*das Es*; the "It") is constituted of an individual's fundamental desires to fulfill their biological and psychological needs; the superego (*das Über-Ich*; the "Over-I") is their internalization of social norms, mores, laws, and the like, manifest in the form of the "Ego-Ideal" (the ideal self); and the ego (*das Ich*; the "I") mediates between the two, synthesizing the individual's active desires which are subsequently manifested in their actions (i.e., their externally-projected identity and *will*).[18] The Rousseauian state of nature, wherein man is subject only to his particular will, might be described as the state of the unmoderated *id*;[19] it is life lived purely according to the pleasure principle.[20] Upon

[14] Rousseau, *Political Economy*, 3.

[15] Jacques Lacan, *The Ego in Freud's Theory and in the Technique of Psychoanalysis*, ed. Jacques-Alain Miller, trans. Sylvana Tomaselli, with John Forrester, *The Seminar of Jacques Lacan, Book II* (W. W. Norton, 1988), 97–98. See also Jacques Lacan, *The Four Fundamental Concepts of Psychoanalysis*, ed. Jacques-Alain Miller and Alan Sheridan, *The Seminar of Jacques Lacan, Book XI* (W.W. Norton, 1998), 280–81.

[16] Jacques Lacan, "The Freudian Thing, or the Meaning of the Return to Freud in Psychoanalysis," ch. 17 in *Écrits*.

[17] Janet Sayers, Sigmund Freud: *The Basics* (Routledge, 2020), 142–46, https://doi.org/10.4324/9780429323447. NB: while the agencies are typically presented in the order "id, ego, superego," I opt here to follow the order in which Lacan presents his version (addressed shortly hereafter); see Jacques Lacan, "The Seminar of Jacques Lacan XXII: R.S.I.," trans. Cormac Gallagher, Jacques Lacan in Ireland, 2010, archived August 29, 2016 at https://web.archive.org/web/20160829195935/http://www.lacaninireland.com/web/wp-content/uploads/2010/06/RSI-Complete-With-Diagrams.pdf.

[18] Sigmund Freud, *The Ego and the Id*, ed. James Strachey, trans. Joan Riviere (W.W. Norton, 1962), 13–18, 24–29. See also Jean Laplanche and Jean-Bertrand Pontalis, *The Language of Psychoanalysis*, trans. Donald Nicholson-Smith (Karnac Books, 2018), 15, 130–42, 197–99, 435–38, https://doi.org/10.4324/9780429482243.

[19] Especially insofar as Freud's use of the term may be traced back to Nietzsche, who used it for "whatever in our nature is impersonal and, so to speak, subject to natural law." Freud, Ego and the Id, 13n3. Cf. A. H. Chapman and Mirian Chapman-Santana, "The Influence of Nietzsche on Freud's Ideas," *British Journal of Psychiatry* 166, no. 2 (1995): 253, https://doi.org/10.1192/bjp.166.2.251.

[20] The "pleasure principle" is the constant strive for pleasure which underlies the desires of the id; see Sigmund Freud, *On Metapsychology: The Theory of Psychoanalysis*, ed. Angela Richards, trans. James Strachey, The Penguin Freud Library, Volume II (Penguin, 1991), 36.

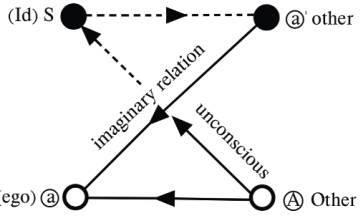

Figure 1: Schema L, the first of Lacan's many diagrams; S, herein, represents the subject (rather than the Symbolic, as in Figure 2).[27]

his entry into society (i.e., to the social contract), the superego — the law — is internalized (as "duty") via the general will, that "celestial voice which dictates to each citizen the precepts of public reason, and teaches him to act according to the rules of his own judgment, and not to behave inconsistently with himself."[21] The obligations subsequently imposed upon the individual are dialectically mediated against their personal desires in the id — the particular will — through the ego. Thus, the individual is able to defer the fulfillment of immediate desires (in violation of the social contract) in accordance with their long-term goals (the maintenance of one's life and liberty) — in Freudian terms, the sublimation of the pleasure principle into the reality principle.[22]

One of the predominant criticisms levied against Freudian psychoanalysis is its reliance on "biologically-determined" mechanisms of the psyche, with some psychoanalysts asserting that these mechanisms are instead culturally-conditioned.[23] Moreover, Freud's focus is excessively contained within the individual; it is for this reason that the analysis here shifts to the socio-relational frameworks of Lacan, who supersedes the Freudian "agencies" with a refined set of "elementary registers" (or "orders").[24] The id becomes the Subject of the aforementioned Real order, the "logical obstacle of what, in the Symbolic, declares itself to be impossible;"[25] the superego becomes the *Autre* (or the "big [capitalized] Other") of the Symbolic order, the internalized influences of society conditioned by structural networks of signification that "[orient] our entire existence;"[26] and the ego becomes the *petit autre* ("little other") of the Imaginary order, the egoistic internal self (*a*) and the externally-perceived specular image of the self (*a*′) as it is presented to others (i.e., that whom one sees in the mirror, metaphorically).[27] Rather than existing in a dualist orientation of synthesis (like that of the Freudian unconscious), the three orders form a quasi-dialectical Borromean knot (see Figure 2): an interlocutory triad wherein one cannot exist without the others, which has at its centre the *objet* (*petit*) *a*(*utre*)[29] — what might be approximated as the

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[21] Rousseau, *Political Economy*, 5.

[22] Freud, *On Metapsychology*, 36–42.

[23] Stephen Frosh, *The Politics of Psychoanalysis: An Introduction to Freudian and Post-Freudian Theory*, 2nd ed. (Bloomsbury Academic, 1999), 96–97. See also Lacan, Écrits, 40–41.

[24] See e.g., Sayers, *Sigmund Freud: The Basics*, 146.

[25] Lacan, *The Other Side of Psychoanalysis*, 123.

[26] Todd McGowan, *The Cambridge Introduction to Jacques Lacan*, Cambridge Introductions to Literature (Cambridge University Press, 2025), 49, also 48–55, https://doi.org/10.1017/9781009300742.005. See also Jacques Lacan, *Desire and Its Interpretation*, ed. Jacques-Alain Miller, trans. Bruce Fink, *The Seminar of Jacques Lacan, Book VI* (Polity Press, 1988), 10–17.

[27] Lacan, *Ego in Freud's Theory*, 236, 241–45. See also *Lacan, Desire and Its Interpretation*, 19; McGowan, *Cambridge Introduction to Jacques Lacan*, 55–60. Figure 1 is a reproduction of schema L as it appears in Seminar II (*Ego in Freud's Theory*, 243); it is provided here for reference, but a full examination of it is otherwise beyond the scope of this paper.

[28] Reproduced from Lacan, "R.S.I.," 13.

[29] Lacan, "R.S.I.," 56–58. McGowan, *Cambridge Introduction to Jacques Lacan*, 64–66. NB: According to frequent Lacan translator Alan Sheridan, Lacan insisted this term be kept in the original French upon translation of his works in order to retain its algebraic symbolism; see Alan Sheridan, "Translator's Note," in *Écrits: A Selection*, by Jacques Lacan, trans. Alan Sheridan (Routledge Classics, 2001), xiv, https://doi.org/10.4324/9780203995839. (NB: this version of the Écrits is exclusively cited here; all other citations to the Écrits herein refer only to the Fink translation.)

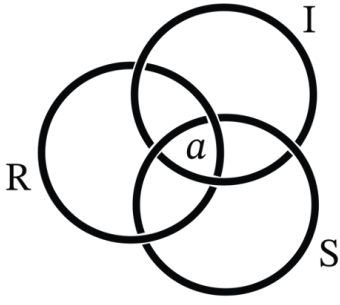

Figure 2: Lacan's Borromean knot, wherein R is the Real, I is the Imaginary, S is the Symbolic, and a is the objet a.[28]

object cause of desire (not desire itself, but the drive for it, so to speak) — and, to Lacan, "law originates in desire."[30]

THE BORROMEAN KNOT

On the subject of the law — which gains its force from the general will[31] — Rousseau begins the *Political Economy* with the observation that "the functions of the father of a family and those of the chief magistrate ought to make for the same object."[32] This is echoed in Lacanian psychoanalysis via the "Name-of-the-Father," the position of the Symbolic Father-as-lawgiver — the first point of interaction between the Subject and the *Autre*, which acts as a "master signifier" from which all other signification (for signification is necessarily relational) is derived.[33] The Symbolic Father[34] is differentiated from the Real Father (the true relations one has with the Father) and the Imaginary Father (the *imago* of the Father).[35] It is the Christian Trinity (from which the term "Name-of-the-Father" stems), wherein the Father is the Symbolic, the Son is the Imaginary, and the Holy Ghost is the Real, the three together forming God.[36] Rousseau, too, makes this distinction, as he argues that one is charged with learning to live as a citizen at the moment of birth; where the father exercises authority of the child's education in the state of nature in the name of natural law, he is discharged of this natural duty by the state except where he acts as a citizen in the name of the state law (i.e., channeling the general will as the Symbolic Name-of-the-Father, whilst retaining the roles of the Real & Imaginary Fathers).[37]

The first explicit mention of a "general will" in the *Political Economy* is preceded by a statement vital to the extension of psychoanalysis unto the abstract Rousseauian sovereign: "the body politic, therefore, is also a moral being possessed of a will."[38] So too does this will take the form of the Trinitarian (Borromean) Father: it is Real in its effects[39] and existence in the abstract (which also evinces the historical difficulty of explaining it); Symbolic as it is manifest in the law; Imaginary in its egoistic *a* as justice & sovereignty and its specular *a*' as the organs of the government; and at the centre of these, it is the *objet a* of a society in its provisioning of justice & liberty via the

[30] Lacan, *Écrits*, 689.
[31] Rousseau, *Political Economy*, 6.
[32] Rousseau, *Political Economy*, 2.
[33] Lacan, *Écrits*, 465–66, 688–89. See also McGowan, *Cambridge Introduction to Jacques Lacan*, 93–95.
[34] NB: Lacan's use of "Father" is not referring to a literal father, but rather a metaphorical term for one's guardian.
[35] Lacan, *Four Fundamental Concepts*, 281–82.
[36] Lacan specifically references the Trinitarian nature of the Borromean knot in his 1975 lecture delivered at MIT; see Jacques Lacan, "MIT Lecture on Topology," trans. Jack W. Stone and Russell Grigg, *The Lacanian Review* 12 (Spring 2022): 87–95.
[37] Rousseau, *Political Economy*, 12.
[38] Rousseau, *Political Economy*, 3.
[39] Cf. Rousseau, *Political Economy*, 4, wherein he makes a similar comment on the general wills of social groups.

protection of the law — or, for each individual, the desire for protection from the *Autre* — forming the collective answer to the aforementioned "Other's question": "*chè vuoi?*"[40] It is for this same reason that, although the general will itself is always just insofar as it "tends always to the preservation and welfare of the whole and of every part,"[41] it may be "seduced" by private interests contrary to its own. The *objet a*, which is that fundamentally true and just nature of the general will, may be led to false mechanisms of achieving the root desire — but the nature of that desire is unchanging.

CONCLUSION AND FUTURE RESEARCH

Lacan's work was foundational for the connection of psychoanalysis and political philosophy, laying the groundwork for much of what would become the post-structuralist movement throughout the latter half of the 20th century — yet his thought is rarely traced further than the works of Freud, Saussure, and Hegel.[42] I have sought to develop here a novel Lacanian analysis of the general will, illustrating not only the ways in which the Lacanian orders and *objet a* (constituting the Borromean knot) serve as useful analytical tools for dissecting such a notoriously difficult-to-understand concept, but moreover the insight they provide into the reasoning for this difficulty and the impossibility of its absolute comprehension as a whole. From this, there lies ample opportunity for the connection of Lacanian and Rousseauian thought (as well as, more broadly, psychoanalytic and Enlightenment thought); future research might explore, in particular, the specular *a'* of the "citizen" designed by Rousseau (briefly touched upon here in discussion of the relation between the state and the father). At bottom, the centrality of desire — and the fundamentally relational nature thereof — across both thinkers' work bears continued salience through the modern day, as it strikes to the very core of what defines the social contract: the existence of the *Autre*.

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[40] Lacan, *Écrits*, 690 (italics in original). See discussion on page 2.

[41] Rousseau, *Political Economy*, 3.

[42] See e.g., Jan Marta, "Lacan and Post-Structuralism," *The American Journal of Psychoanalysis* 47, no. 1 (1987): 51–57, https://doi.org/10.1007/BF01252332.

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THE END OF ENDLESS GROWTH

Rethinking Technology, Economy, and Identity

ELIZABETH ASSIMES

How does one build a sustainable future? How do we build a sustainable future? In this paper, I consider sustainability's overarching definition as a complete system that enables humans to live within natural boundaries while creating social justice and promoting human well-being. Sustainability requires three essential elements, which include 1) respecting planetary boundaries, 2) using regenerative methods to restore natural systems, and 3) transforming economic and political structures to serve collective prosperity above immediate financial gains. Moreover, it demands the maintenance and intersection of environmental health, economic fairness, and social stability. Sustainability requires people to adopt new perspectives that redirect their focus from controlling nature and the accumulation of personal wealth to interconnectedness and mutual accountability. This takes many forms, including Armstrong presenting how Indigenous perspectives teach us to view the land as a living community which sustains identity, culture, and ethical responsibility in *The Land Is Us* (2008, p. 28–31). Another instance includes Robin Attfield demonstrating the necessity of extensive ethical systems which recognize our obligations to present and future populations, recognizing that environmental issues stem from limited human-centered perspectives which require comprehensive systemic solutions (2003, p. 1-6).

This paper argues that to achieve sustainability, we need to effect three interconnected transitions: a technological revolution of biomimicry and regenerative design; economic and political reforms comprising the internalization of ecological costs via mechanisms such as carbon pricing; and a paradigmatic transition from neoliberal individualism towards collective responsibility. These transitions are, however, confronted with institutionalized corporate interests, systemic growth imperatives, and consumption-based capitalist cultural mindsets. Finally, the direction of a sustainable human civilization will be determined not only by innovative technology and policy but by our ability to redefine what it is to prosper both together and within environmental limits.

TECHNOLOGICAL FACTOR: BIOMIMICRY AND REGENERATIVE DESIGN

Biomimicry and regenerative design are transformative technological innovations that could significantly advance sustainability by emulating nature's efficiency and resilience. These approaches replicate biological systems: self-healing concrete using bacterial processes and wind turbines using humpback whale fin designs to produce waste-free energy-efficient solutions are two examples (M. Hathaway, personal communication, June 9, 2025). Another is the implementation of permaculture systems replicating forest

ecosystems to regenerate soil and biodiversity while producing food (M. Hathaway, personal communication, June 9, 2025). According to Speth (2006), such "wholesale transformation in technologies" is essential to separate economic operations from environmental destruction and transition beyond sustainability toward active regeneration (p. 140).

The economic barriers to implementation persist because our current growth-dependent system remains entrenched. Hinton & Goodman (2010) explain how capitalist systems choose short-term profits over long-term sustainability because the UK's "Changing Patterns" policy actively works to exclude reduced consumption (p. 248-250). This system produces counterproductive rewards that support industrial agricultural monocultures instead of regenerative farming practices. Existing market structures, together with current subsidies, work against circular systems (M. Hathaway, personal communication, May 12, 2025). According to Speth (2006), full-cost pricing (p. 140-141) and policy reforms (p. 146) should be used to overcome these barriers, but Hinton & Goodman state that dismantling the "growth-first mindset" is necessary to prevent transformative innovations from becoming limited solutions (p. 249, 258), emphasizing that no clear solution has emerged.

ECONOMIC & POLITICAL FACTOR: CARBON PRICING

Sustainability requires the adoption of complete carbon pricing systems together with rigorous corporate accountability standards. The financial incentives for emission reduction emerge from carbon pricing systems that operate through taxes or cap-and-trade mechanisms (M. Hathaway, personal communication, May 28, 2025). The Canadian carbon tax program demonstrates success in pushing industries toward cleaner technologies by increasing its rate to $170/tonne by 2030 and implementing rebates for household protection (M. Hathaway, personal communication, May 28, 2025). According to Wahl (2016), equity measures need to accompany such policies because "we cannot create regenerative cultures without creating more equitable cultures" to ensure transition benefits reach all socioeconomic groups (p. 251).

Political opposition against carbon pricing emerges from economic concerns and cultural values that encourage short-term gains. The fossil fuel industry uses lobbying efforts to block carbon pricing (M. Hathaway, personal communication, May 28, 2025) while voters frequently oppose economic policies that they view as threatening despite rebate programs. According to Wahl (2016), our existing competitive depleting win-lose economy mindset requires a fundamental shift toward collaborative regenerative win-win thinking (p. 252). Speth (2006) explains that building public support requires educational efforts to expose greenwashing practices (p. 141), while Hathaway's lecture proposes that collective individuals can have dual advantages in impact and effect, but not without limitations – without corporate (and secondarily, government) compliancy (M. Hathaway, personal communication, June 4, 2025). The implementation of strong carbon policies faces the risk of dilution or repeal because of the unaddressed political and cultural obstacles, which Wahl (2016) calls "evolutionary activism" (p. 252).

PARADIGM FACTOR: REJECTING NEOLIBERAL INDIVIDUALISM

Another essential change for sustainability requires moving away from neoliberal individualism because it incorrectly presents ecological crises as personal issues while adopting collective systemic action. The transition between lectures 9 and 10

demonstrates the necessity of moving past superficial actions to address the fundamental causes of environmental deterioration which stem from corporate dominance and governmental stagnation (M. Hathaway, personal communication, June 2 & June 4, 2025). Harper (2019) demonstrates how environmentalism emerged as a public response to industrial pollution and governmental regulatory failures, which led to the creation of Earth Day (p. 297–299). According to Daly (2007), the economy functions as a dissipative subsystem of a finite ecosystem which cannot sustain endless growth without triggering ecological destruction (p. 9–11). The economic system becomes both unsustainable and uneconomic when growth surpasses the ecosystem's ability to process waste and restore resources.

The political-economic challenge to transitioning from individualism to collective responsibility stems from neoliberal environmentalism's capture by corporate interests (M. Hathaway, personal communication, June 2, 2025). And we must ask ourselves, why? The corporate world uses green consumerism initiatives such as eco-labels and carbon offsets to maintain their profit structures instead of making system-wide changes. Harper (2019) explains how Earth Day and other grassroots movements experienced partial co-option by established actors who worked to maintain the existing order (p. 299). The achievement of this goal requires limiting corporate power through measures that include blocking fossil fuel lobbying, establishing supply-chain openness, and developing democratic processes for environmental management (M. Hathaway, personal communication, June 2, 2025). The continued dominance of entrenched interests prevents shared stewardship values from flourishing because systems that benefit from individualism and continuous expansion work against these values, and, more frankly, the bottom line's and shareholders' pockets.

POSITIONALITY

Sustainability requires powerful policy changes, technological advancements, and behavioral modifications in our system participation. Currently, education stands as my most effective method of contribution (and gain) because I select to study sustainability courses that match my personal interests. As a business major with entrepreneurial interests, sustainability led me to study these questions through academic and personal research. I created an independent study about sustainable practices in luxury fashion to examine how brands should transition from fast fashion toward long-lasting investment pieces while transforming both manufacturing processes and consumer value systems. The experience helped me better understand how systemic transformations relate to individual conduct, supply chain morality, and brand management approaches. Moreover, it forced me to develop my ability to construct better solutions regarding sustainability within its current operational system. My thought processes are now more centered on sustainability whenever I create business ideas or work with clients because I ask myself about product origins, beneficiary identification, and operation regenerative potential.

Moreover, while my dedication to sustainability shapes my academic approach to solving business problems at the corporate level, it also shapes how I view business creation entirely. The goal should be to establish organizations which focus on enduring value creation for communities, ecosystems, and future populations, instead of accepting the misleading profit versus sustainability dichotomy.

Sustainability requires both discipline and a long-term vision, which I strive to embody in both my academic work and professional responsibilities. Sustainability functions on the basis of having the correct mental approach, practical ability to execute,

and vision to leave a place better than you found it, and I intend to use these core takeaways in every professional position to create regenerative business systems instead of depleting resources.

CONCLUSION

In essence, sufficiently achieving 'sustainability' requires more than accretive adjustment. Rather, it mandates transformation across three major sections of human contribution – technology, economy, and cultural identity. Both biomimicry and regenerative design offer potential paths forward by decoupling human activity from ecological destruction while also challenging the current widespread capitalist structure that rewards overly extractive industrial practices. Corporate accountability, through mechanisms such as carbon pricing, have the potential to realign monetary incentives to align with long-term planetary benefits; however, their effectiveness hinges on dismantling the political influence of fossil fuel interests through building genuine public support. Most importantly, neither technology nor economic policy will succeed without a fundamental paradigm shift away from neoliberal individualism. Rather, collective stewardship rests on the understanding that endless economic growth within a finite ecosystem is, in the short term, unsustainable and, in the long term, ultimately self-defeating.

Although listed separately, this essay demonstrated a few (of the many) ways technology, economy, and cultural identity are deeply interdependent. Technological innovation without economic reform becomes diminutive; carbon policy without cultural change invites protest; and shifts in values without structural support remain superficial wishes rather than reality. In the current context, growth is the priority, but I argue that only when all three subsections of transformation work in concert can this trajectory shift from malignant to regenerative. Transformation is not a question of if, but rather how and when. We must deliberately choose whether to lead that transformation or be forced into it by the collapse of an unsustainable system.

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MAPPING SICKNESS

How Peel Region's Health System Fails Immigrants Facing Chronic Illness

ARMITI ZARBAKHSH

The Peel Region is a municipality consisting of the Town of Caledon, the City of Brampton, and the City of Mississauga (Region of Peel, 2021). It is home to 1.5 million residents, 51.8% of whom are immigrants (Region of Peel, 2019; Region of Peel, 2016). Peel contains the highest proportion of immigrants in Ontario, with 18% of Ontario's immigrants residing there. A 26% immigrant population increase occurred between 2006 and 2016 (Region of Peel, 2016). Immigrant populations often experience what is known as the healthy immigrant effect, where individuals arrive with better overall health than the native-born population, but this advantage gradually diminishes over time after settling in the new country (Newcomer Mental Health and Wellness Through a Settlement Sector Lens, 2023). This paper explores four emergent health issues shaped by structural inequities that identify public systems, rather than individual choices, as the primary drivers of poor health outcomes.

METHODS

The secondary research for this paper was conducted using government reports, academic journals, and the official Peel Region website. An initial Google search was done to identify relevant health issues for immigrants in this region. Next, keywords related to the health issues and region were inserted into the University of Toronto's LibrarySearch search engine tool to find pertinent research. Examples of keywords used include "cancer screening," "mental health," "diabetes," "obesity," "Peel," "Ontario," "Canada," "Toronto," and "immigrant." Peer-reviewed studies and official reports were preferred. Each source's limitations were also reviewed to identify how they would affect the interpretation of results. To ensure data relevancy, the sources' publication dates are no earlier than 2010.

EMERGENT HEALTH ISSUES

Poor Mental Health

Mental health is an emergent crisis for immigrants in Peel. While one in five Peel immigrants report mental illness or addiction annually, "only 1 in 3 will access services" (Peel Newcomer Strategy Group, 2023, 2019). At the intrapersonal level, migration-related stressors and language barriers hinder access to care. Recent immigrants rank employment and finances as primary stress sources, with this ranking intensifying over time (Imbarlina-Ramos, 2020). About 4% of Peel's population speaks neither of Canada's official languages; without accessible services, patients are "limited in their ability to express their concerns, describe symptoms, and negotiate treatment" (Robert

& Gilkinson, 2012; Region of Peel, 2021).

Cultural dimensions significantly impact mental health care. While Western cultures typically emphasize individualistic approaches, Eastern cultures typically prioritize collectivistic frameworks (Felstad, 2020). These perspectives shape how symptoms are interpreted and treatments are approached, as well as how stakeholders participate in care decisions (Kirmayer et al., 2011). Low cultural competence from healthcare providers exacerbates mental health problems (Peel Newcomer Strategy Group, 2023), while systemic underfunding of mental health services in the region represents the fundamental policy failure perpetuating Peel's mental health crisis (Region of Peel, 2021). Peel's crisis exemplifies how provincial funding gaps reduce service capacity, placing unsustainable strain on existing systems (Region of Peel, 2019).

Low Cancer Screening Rates

Peel immigrants are significantly less likely than locals to seek life-saving cancer screening (Lofters et al., 2013). At the intrapersonal level, many immigrants have low health literacy and encounter hazardous health misinformation (Cao et al., 2023). At the institutional level, there is a shortage of culturally responsive screening resources and primary care physicians capable of addressing misinformation and referring patients for screening (Lee-Foon et al., 2024).

At the community level, social norms substantially shape screening behaviours. The largest demographic of new immigrants in Brampton is from India, where the national screening rate is only 2% (Bhugra, 2024; Lee-Foon et al., 2024). Cervical cancer has become the second leading cause of death in India despite being treatable when detected through early screening (Bhugra, 2024). For many Indian immigrants, seeking regular cancer screening is simply not a norm, making them unlikely to engage in screening after relocating to Canada (Lee-Foon et al., 2024). Additionally, income disparities correlate with lower screening likelihood (Cao et al., 2023). Many Peel immigrants are located in neighbourhoods with the highest material deprivation and lowest screening rates (Ontario Health, 2024). At the policy level, geographic barriers to screening, including remote health facilities, inaccessible public transit, and insufficient screening infrastructure, compound these disparities (Lee-Foon et al., 2024).

Rising Obesity Rates

Rising obesity rates among Peel's immigrants represent a significant public health concern. By 2021, 53.6% of adults were overweight or obese, driven by screen use, poor diet, physical inactivity, economic barriers, and large portions (Region of Peel – Public Health, 2019; City of Mississauga, 2021). At the intrapersonal level, many Peel immigrants prioritize survival needs — rent, employment, and remittances — over healthy food choices and physical activity (Dean & Elliott, 2011; Karbasy et. al, 2019). Thirty-seven percent of youth exceed two hours of screen-based entertainment daily, which contributes to reduced physical activity time (Region of Peel – Public Health, 2017).

At the institutional level, the Ontario School Food and Beverage Policy mandates nutritional standards for school-sold items, yet it fails to attain its objective of promoting healthy eating when students access fast food off school property (Valaitis, 2016; Vine et al., 2014). Within-school meals are often perceived as expensive, driving students toward unhealthy cheaper alternatives (Vine et al., 2014). At the community level, food deserts, areas with few grocery stores but many convenience stores, limit

access to fresh food (Ghosh-Dastidar et al., 2014). Urban planning decisions influenced by corporate lobbying from the junk food industry have contributed to convenience store saturation and food desert formation (Dean & Elliott, 2011). While infrastructure for active recreation programming exists, it often caters to Eurocentric sports, reflecting policy misalignment with Peel's diversity (Dean & Elliott, 2011).

Rising Type 2 Diabetes Mellitus Incidence

Type 2 diabetes mellitus (T2DM) represents an emerging priority issue within Peel's immigrant population. While many chronic diseases decline, diabetes incidence rises (Region of Peel – Public Health, 2019), suggesting shortcomings in individual health behaviours and public health infrastructure. Ethnicity is a key contributor, and immigrants of South Asian and Caribbean ancestry face the highest burden (Lipscombe et al., 2024). About 50% of Peel's population is overweight or obese, a significant risk factor for diabetes (Region of Peel – Public Health, 2019; Lipscombe et al., 2024). Abdominal obesity particularly affects South Asian immigrants, who do not necessarily have high obesity rates but tend to accumulate abdominal fat (Lipscombe et al., 2024).

Household income and socioeconomic status influence diabetes prevalence and healthcare-seeking behaviour (Fazli et al., 2024; Hyman et al., 2017; Hyman et al., 2012). On an interpersonal level, provider-patient relationship quality impacts immigrants' adherence to disease self-management strategies (Hyman et al., 2017). Immigrants are less likely to consult medical specialists or alternative healthcare practitioners (Hyman et al., 2012).

Neighbourhood environments critically shape T2DM risk. Immigrants tend to self-select neighbourhoods based on cultural or linguistic similarity, sometimes congregating in areas with lower walkability (Lamb et al., 2020). Living in neighbourhoods with the lowest walkability scores increases prediabetes risk by 15–20% (Fazli et al., 2020). Without policies targeting social determinants of diabetes risk — including food insecurity, housing affordability, and transportation accessibility — T2DM will continue disproportionately affecting low-income immigrant populations and their ability to access healthcare services (Lipscombe et al., 2024).

SWOT ANALYSIS: STRENGTHS, WEAKNESSES, OPPORTUNITIES, AND THREATS

Strengths

Peel possesses robust data collection infrastructure, including demographic and economic data within the Region of Peel Data Portal, enabling disparity identification (Region of Peel, 2025). Moreover, 54.7% of Peel residents have attained post-secondary education, surpassing the Greater Toronto Area average (Region of Peel, 2025). This contributes to higher health literacy and more health successes, including a relatively low smoking rate of 10.9% (Region of Peel, 2025). Economically, 225,090 independent businesses owned and operated by immigrants have demonstrated community resilience (Region of Peel – Public Health, 2012). The Peel Region Social Capital Study found strong family and friend connections, with 91.1% reporting at least one family member or friend they can rely on (United Way Greater Toronto, 2021).

Weaknesses

Despite extensive research on Peel's built environment and health, policy implementation remains severely limited. Focusing solely on individual behaviours is insufficient: structural barriers including economic instability, weak social infrastructure, and systemic discrimination sustain health disparities (Krieger, 2014). The presence of areas with poor walkability and food deserts as well as the lack of health services that are culturally and linguistically representative constitute evidence of policy failure (Ontario Health, 2024; Region of Peel – Public Health, 2019; Lipscombe et al., 2024). While newcomer information centres provide support, they rarely imbue their clients with the civic knowledge and advocacy skills needed for community change (Region of Peel – Public Health, 2012). Governments may have political and economic incentives to under-report immigrant health disparities (e.g., avoiding financial burdens associated with policy reform) while sampling biases, language-based exclusions, and selective data framing obscure disparities further (Brown et al., 2019).

Opportunities

Multi-level community-based interventions prove crucial for sustainable health promotion (Chappell et al., 2006). Health organizations can partner with community organizations and cultural institutions, including faith-based groups supportive of newcomers, to implement targeted chronic disease prevention programs (Region of Peel – Public Health, 2012). Empowering community representatives through tailored support, such as the provision of resources in local languages, enhances health literacy (Region of Peel – Public Health, 2012). COVID-19 vaccination clinics in trusted community locations like schools and places of worship achieved high uptake while maintaining cultural sensitivity (North American Observatory on Health Systems and Policies, 2023).

Threats

A major threat is rising income inequality in Ontario, which leads to increased precarious work, rising housing costs, and escalating cost of living hindering immigrant social mobility (Diversity Institute, 2019; Raphael et al., 2020). Many immigrants — especially refugees — remain precariously employed without opportunities to utilize previous education or skills, threatening belonging and financial security (Diversity Institute, 2019; Raphael et al., 2020). Growing racism and xenophobia, particularly toward South Asians, perpetuates health disparities: hate crimes against South Asians increased 143% between 2019 and 2022 (Liddar & Pallapothu, 2024). Historical discrimination shapes current structural inequities, and increasing racism could reinforce systemic barriers, limiting immigrants' comfortable access to health-conducive amenities like clinics and parks (Krieger, 2014; Raphael et al., 2020).

PRIORITY ISSUE: TYPE 2 DIABETES MELLITUS

Emergent health issues in Peel's immigrant population (namely poor mental health, rising obesity rates, low cancer screening, and rising T2DM incidence) are interconnected through structural inequities: systemic primary care underfunding, racialized urban planning, and corporate-driven food environment designing (Dean & Elliott, 2011; Karbasy et. al, 2019; Lipscombe et al., 2024). T2DM merits priority not

solely due to its prevalence but also because of its association with high-cost-incurring complications such as heart disease, kidney failure, and neuropathy (American Diabetes Association Professional Practice Committee, 2024). With 40% of Peel's diabetes patients developing cardiovascular complications, healthcare systems already burdened by mental health crises and late-stage cancer face further strain (Rosella et al., 2023). This cascade effect is amplified by intersecting marginalized identities (relating to race, language, and immigrant status), as linguistic barriers and culturally incompetent care delay diagnosis, accelerating preventable complications (American Diabetes Association Professional Practice Committee, 2024).

As Peel's population ages and grows, T2DM incidence will only increase (Lipscombe et al., 2024). Chronic diseases are not isolated phenomena but products of deliberate policy neglect demanding interconnected solutions (Brown et al., 2019; Krieger, 2014). Targeting diabetes' structural roots entails eliminating key risk factors, including poor diet and sedentary lifestyles, which contribute to multiple chronic illnesses (American Diabetes Association Professional Practice Committee, 2024). Prioritizing T2DM interventions involves addressing systemic drivers of obesity, mental illness, and cancer, in addition to preventing costly complications. Doing so would transform Peel's approach to immigrant health, shifting the focus from individual-level to structural-level change (Dean & Elliott, 2011; American Diabetes Association Professional Practice Committee, 2024; Lipscombe et al., 2024).

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WHAT IS FREEDOM

A Comparative Analysis of the Works of Rousseau and the Great Law of Peace

VICTORIA HARLING

Throughout the study of political science, there has been a never-ending debate over the true meaning of political freedom and how to achieve it within a society. Both the *Great Law of Peace* and the works of Rousseau present an argument concerning what is the best form of government and freedom within their societies. Rousseau makes a clear distinction within his work between natural and moral liberty and believes that true freedom is when a person is the master of themselves. Whereas in the *Great Law of Peace,* freedom is based on values of peace and friendship between nations, leading to contentment. Despite being written in different eras, and Indigenous political theory and "classic" European thinkers often diverge especially when taking into consideration their distinct historical contexts, there are some similarities between the two texts and their ideas of freedom.

Rousseau's idea of freedom within a society depends on self-legislation within a sovereign made up of the people, which governs according to the general will. The *Great Law of Peace,* though differing from the works of Rousseau, offers a similar idea of freedom based on collective unity. Both texts have the goal of maintaining freedom through national/sovereign expression of the general will and the common good. However, the *Great Law of Peace* has a further emphasis on the unity of nations and consensus as the foundation of freedom, which challenges Rousseau's more individualistic idea.

Rousseau, within his writing *On the Social Contract,* critiques forms of government that restrict freedoms, as well as political authority that claims to be legitimate but in reality is based on restricted freedoms and inequality. A society can infringe on one's freedoms in many ways. The main ways that are identified within Part Two of the *Discourse of Inequality* are a society that hinders natural and/or moral liberties, when society and laws are created by the powerful, and the categories created by private property as sorting people into different economic classes (rich and poor). According to Rousseau, one of the largest threats to a person's freedom is when a society and its laws are based on the needs of the rich and powerful. As Rousseau argues, when “the origin of society and laws, which gave new fetters to the weak and new forces to the rich, irretrievably destroyed natural liberty” (Rousseau, 2011, p. 79). When society is based on an unequal power structure, Rousseau believes this limits freedom, as the people are no longer the masters of themselves. As they would be in the state of nature, they are at the whim of the powerful. This way of creating laws creates moral inequality, based on factors such as wealth, status, class, and power. Often those in power will present these laws as serving the common good of the people while ultimately deploying them towards self-interest and to oppress the people below them. Rousseau refers to these laws as a “fraudulent contract” (opposed to his social contract), in which

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these contracts trick the public into a society with the promise of protection; in reality, the society is only built to preserve the interests and authority of the powerful and subjects the rest of the population to "labor, servitude, and misery" (Rousseau, 2011, p. 79). Not only would the general public be losing their freedoms under a fraudulent contract, but the masters would be as well, since Rousseau states "[m]an is born free, and everywhere he is in chains. He who believes himself the master of others does not escape being more of a slave than they" (Rousseau, 2011, p. 156). Therefore, as a result of this illegitimate contract, all parties involved are not truly free. This form of fraudulent contract not only creates moral inequalities but also hinders a person's natural liberties. Natural liberty, according to Rousseau, is no longer the case when people are not the masters of themselves, as all laws and powers now serve the hierarchy of power created.

Now that it has been defined what is classified under a fraudulent contract, Rousseau presents the social contract as a solution to this problem, arguing that this allows people to keep their freedoms while still living under a sovereign. Rousseau believes that this social contract allows people to keep and enjoy the protections of their freedoms. As a person gives up the unstable, but unlimited freedom provided by the state of nature in exchange for civil liberty, they gain a more secure and protected form of freedom. Rousseau defines natural liberty as freedoms that are only limited by the "force of the individual involved" (Rousseau 2011, p. 167) and defines civil liberty as freedoms which are only "limited by the general will" and between possession (which is merely the effect of the force or the right of the first occupant) and proprietary ownership (which can only be based on a positive title) (Rousseau 2011, p. 167).

The way to preserve these liberties and ensure individual self-mastery when entering into the social contract is to collectively agree for the people to become sovereign. This loss of natural liberty will be balanced with the gain of civil liberties and property ownership. The way that the social contract can guarantee liberty is that everyone who agrees to the social contract must submit to the law created by the sovereign. In this formulation, the sovereign is composed of all citizens of the society and creates laws agreed to by the people to serve the common good and the general will. This thereby maintains freedom, as these are laws that the people have given to themselves (self-legislation), therefore making them the masters of themselves since they helped create the law, and by obeying the law, they are obeying their own will.

In practice, this means that the new legitimate social contract would cause the "total alienation of each associate together with all of his rights to the entire community" (Rousseau 2011, p. 164). This would make all citizens equal, and according to Rousseau's logic, then "since the condition is equal for everyone, no one has an interest in making it burdensome for the other" (Rousseau, 2011, p. 164). This will allow people to maintain freedoms without the moral inequities that are caused by fraudulent contracts, as the sovereign (which is made up of all citizens) only acts under the general will, and will serve the common good of everyone in the society instead of just serving the powerful. However, this is not the only reason that Rousseau gives to justify joining the sovereign, as it means becoming the master of one's self (meaning they are free), but he also claims that by joining the sovereign, a man will develop "justice for instinct in his behaviour and give his actions a moral quality they previously lacked" (Rousseau, 2011, p. 167). Meaning that citizens under the social contract are not just free because they are a part of the sovereign, but also due to their development of justice, meaning the protection of freedom.

The *Great Law of Peace* shares the idea of unity within the Haudenosaunee Confederacy, resonant with the works of Rousseau. The Confederate Council has a

larger focus on peace and friendship, rather than the desire to be the master of one's self. The *Great Law of Peace* shares a story of the peacekeeper named De-ka-nah-wi-deh, who had the goal of creating peace and harmony between the six nations to allow for a new era of friendship and peace instead of conflict. De-ka-nah-wi-deh assured the nations that joined the confederate council that "good tidings of Peace and Friendship have come to the people, and you will find that all strife is removed from your settlement" (Committee of the [Six Nations] Chiefs, 1912, p. 200). The *Great Law of Peace* can establish this through the Confederate Council, which is made up of the leaders from each of the nations involved in the council. With the nations now unified, they come up with communal rules and regulations that all nations must follow. To decide within the Confederate Council, instead of a majority vote, there must be consensus. This helps prevent domination of power by one nation and reinforces the idea of unity and friendship within the council. These rules share the sentiment of keeping peace and friendship among the nations with "principles set forth in the message of good tidings of Peace and Power, and in dealing with the affairs of our people of the various Provinces, thus we shall secure to them contentment and happiness" (Committee of the [Six Nations] Chiefs, 1912, p. 226). De-ka-nah-wi-deh believes that the way to protect the peace and freedoms of the people is to unify the different nations and, by basing laws on peace and the common good of all nations involved, that it will allow for "contentment and happiness" for many generations. Similar to Rousseau, both of the ideal ways to run a society are based on the unity of the sovereign and laws/institutions built to support the common good. The peace and unity allow for civilian freedom as each leader is allowed to voice their ideas for their community within the council, thus allowing for freedom to stem from political participation and consensus between leaders.

The entire structure of The *Great Law of Peace* and the Confederate Council is based on unity and the combining of the power of the separate nations into a common union. This union allows for the values of De-ka-nah-wi-deh and achieves unity as the council is said to share "one body, one head, and one heart" (Committee of the [Six Nations] Chiefs, 1912, p. 227). This means that no matter what conflict the union faces, they will all act in the best interest of the union to maintain peace and friendship. To better show this unity, De-ka-nah-wi-deh proclaims that the "[l]ords of the Confederate Nations shall plant a tree Ska-renh-heh-se-go-wah, (meaning a great tall and mighty tree)" (Committee of the [Six Nations] Chiefs, 1912, p. 226).

The tree spoken about in The *Great Law of Peace* is not just a physical symbol of the confederacy but also carries critical symbolic meaning. Within the text, the tree is described as tall and mighty, also representing the strength of the community. In addition, when the nations are bound together, they are stronger and will prosper. This is symbolized in the tree as when a tree is nurtured, it offers protection to smaller creatures, just like the confederation will act in the protection of their people. Furthermore, the council will prosper with the support of each other, leading to growth, just as when a tree is nurtured it will grow. Another item that can be used as a form of symbolism to represent the unity of the council is the arrows. Within the text, each nation is represented by an arrow and all the arrows are tied together. This created a bundle that "no one can bend or break " (Committee of the [Six Nations] Chiefs, 1912, p. 227). This arrow bundle symbolizes that all the people and leaders are bound together by the council, and where one arrow might be seen as weak, when bound together, they are stronger and can face a conflict. Using the symbols of the tree and the arrows, it shows that the values being represented by De-ka-nah-wi-deh are meant to ensure the happiness and protection of each of the nations and their citizens through the

establishment of fair laws and institutions. This system is meant to last for generations. This is seen through the creation of a circle made up of the members of the council who are bound together by "forming a circle so strong that if a tree should fall upon it, it could neither shake nor break it, so that our people and grandchildren shall remain in the circle in security, peace and happiness" (Committee of the [Six Nations] Chiefs, 1912, p. 226). The circle represents the binding and security that the council provides to each nation, allowing them to operate freely without the fear of conflict.

Though these texts were written in wildly different contexts and traditions, as one is based on Indigenous knowledge and one in a European context, these works share striking similarities. Both authors make it clear that the main goal of maintaining freedom and order within a society, as well as both wish to achieve happiness and cater to the public good. The *Great Law of Peace* desired peace and friendship, and Rousseau, through the sovereign acting on general will, hoped to move towards the common good. Another similarity is the clear preference for unity and a collective sovereign. Within the works of Rousseau, the perfect standard of moral and political freedom comes from laws catering to the general good and a collective sovereign. The *Great Law of Peace* combines individual powers into one collective power that seeks property, peace and security for all involved. This would be classified as working towards the common good, yet differing in that the sovereign is not made up of all the civilians. Though according to Rousseau, to maintain freedom, the sovereign must make laws based on the common good and the well-being of the whole. This is a similar value shared within The *Great Law of Peace,* as the council acts for the happiness of their people, thus meaning the laws are for the public good.

Ultimately, I believe that the design of the Haudenosaunee Confederacy secures for its citizens the standard of moral and political freedom that Rousseau believes is possible. Both systems aim to provide security, protection of freedom, happiness, and act towards the general will, as well as the common good. Though Rousseau's model is based more on an individualistic sovereign compared to the Confederate council, I believe that the consensus model presented through the council acts for the public good, and both texts share the importance of unity within the sovereign(s), and even though in both models a person is asked to give up their unlimited amounts of freedom under the state of nature, both forms of political society offer protection of the common good and property in exchange, which I believe is enough that Rousseau would believe the confederate secures an adequate standard of moral and political freedom.

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CONSCRIPTION INTO MUTUAL DESTRUCTION

Wiindigo Infrastructures and a Symbiotic Logic of Oppression

LAUREN ZACHARIAS

"for as long as my people's memory
stretches back; i, we, us
have always been in relation to
these waters and this land"
—K Dawn Martin, 2017

INTRODUCTION: COMMODIFICATION, POLLUTION, EXTRACTION, RESTRICTION

Through a legacy of genocidal efforts and a continuing project of colonial power enforcement, the struggle of Indigenous communities in Canada persists. In this long project of colonialism, more-than-human kin have been implicated in the oppression of their Indigenous kinfolk, and have themselves been oppressed. Water, for example, is exploited and oppressed in its own right, just as Indigenous communities are oppressed in their own right, and, in a weaponization of relationality, water is implicated in the oppression of Indigenous peoples, as are Indigenous peoples implicated in the oppression of water. This is the severance of life worlds that capitalism and colonialism thrive on. The Wiindigo is an Indigenous cautionary tale of gluttony — an anthropomorphized creature that consumes and destroys in a violent pursuit of excess. Colonially-established infrastructure is thought to embody the spirit of this legend; a systematic devaluation of lives, both human and not, occurs at the hand of the Wiindigo. Framing water as a life-giver reveals how the Wiindigo's destructive infrastructure implicates water and human kin alike in its exploitation.

WIINDIGO INFRASTRUCTURES: CAPITALISM, COLONIALISM, AND WATER EXPLOITATION

Winona LaDuke and Deborah Cowen examine capitalist and colonial infrastructure in connection to Indigenous lore of the Wiindigo, a monstrous characterization of greed shown through an insatiable cannibalistic hunger, manifested as a "predatory economy rooted in extraction and exploitation" (LaDuke & Cowen, pg. 252). The point of Wiindigo infrastructure is to extract, to consume, to displace, to destroy — the Wiindigo harbours chaos and destruction, and it does so "not in the system's failure, but in its smooth operation" (LaDuke & Cowen, pg. 253). This colonial denigration is embedded at every level of institution (LaDuke & Cowen, pg. 244) — highlighting Wiindigo

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infrastructure as the focus for resistance initiatives.

The life-sustaining properties of water are revered in Indigenous ontologies for what it does and what it represents. Indigenous peoples conceive of water as a living body, a dynamic relational agent and importantly a "relative to whom humans are linked through a web of extended kin relationships" (Wilson, 2019, pg. 102). As capable of sustaining and giving human life, water is central to reciprocal care between itself and Indigenous peoples, as well as being connected to womanhood and reproduction. Applying capitalism to this ontology, commodification emerges as an *inherent* disrespect. Water undergoes violence at the hands of capitalist exploitation by means of its commodification. Pollution, for example, is the result of extractive practices that disrespect water (Wilson, 2018). The capitalist tendency to think of water as purely technical, as a resource available for human consumption and nothing more, is a process by which the water is denied its dignity as a life-giver (Wilson, 2018, pg. 518). Wiindigo infrastructures that commodify water achieve the severing of Indigenous-water relations and perpetuate the continued systematic oppression of both. As a result, the Wiindigo works effectively by "not only doing violence *to* Indigenous people, but also *through* Indigenous people" (LaDuke & Cowen, pg. 253, emphasis in original). I will examine this through a framework of symbiotic logic: the conscription of kin into mutual destruction.

SYMBIOTIC LOGIC

As water and Indigenous communities are individually oppressed, they are also conscripted into mutual destruction. These two kin are simultaneously implicated as weaponized tools of colonial oppressive projects in three major dimensions: accessibility, gender, and consumption. Importantly, these three considerations all arise from commodification's *inherent* exploitation, which we have come to understand as 'Wiindigo infrastructure.'

How is water weaponized against its kin?

Accessibility. Indigenous communities on reservations experience profoundly disproportionate water insecurity (Black & McBean, 2017, pg. 248). Water exploitation and systematic pollution are used to disenfranchise and harm Indigenous people. The pollution severs the life-giving relation, which is further complexified and weaponized through unstable accessibility. By rendering water unsafe, restricted, and contentious, the commodification of water harms both water and its kin. Not having easy access to clean water endangers people's lives, and in this way, water is manipulated into a form of violence against its kin.

In what Gagnon describes as "ecocolonization" (pg. 276), Wiindigo infrastructures distance Indigenous people from ancestral traditions with the land. Communities that have historically relied on the land are deprived of this relation. Water is mobilized as an unwilling actor in this process in which diets and cultures that have revolved around local fish and water sources are unable to continue, practices of hunting and harvesting and cooking die out, and community growth is stunted in the face of erasure (Gagnon, 2023) (Wilson, 2018).

Gendered severing. Kahnekanoron - Water is Life is a 2017 award-winning poem in which Ontarian poet K Dawn Martin makes a connection between womanhood and water as carriers of life. The parallel between the human need for water to sustain life and women as keepers of life shapes her poetic analysis of settler-colonialism as

restricting life itself and severing earthly kinship. In a statement about the poem, Martin states:

> As a woman, I've been taught that we are the water carriers and there is a responsibility in that. We as women have the ability to bring in new life into this world — so does our Mother the Earth. Water truly connects all of creation and what happens to the waters happens to us as a human race (2017).

Thus, in exploiting water, women suffer in relation. Martin illustrates this in her poem with the words: "if they trespass onto our lands / they trespass on our bodies." Here Martin does not employ simile or metaphor, instead she is stating a fact of her ontology: that Indigenous kinship means that the transgression of one *is* the transgression of the other. Not only does it cause further violence among kin through dispossession and ecocolonization, but the very moment of violence is two-fold: in the pain of their water kin's exploitation, women too feel pain and are exploited.

How are Indigenous peoples weaponized against water?

Consumption. Capitalism offers little to no choices for ethical consumption. Part of the colonial project has been the enforcement of the capitalist mode of production, making all its constituents consumers, and making all consumption unethical. In this way, all peoples are recruited as bearers of harm on the Earth and as violators of the land. This implicates Indigenous people as part of this systematic ecological destruction. To engage with society and with life is to engage with extractive practices; the Wiindigo logic is forced upon kinship networks through consumption. Engaging in capitalist extraction and its resulting pollution and relational severing is impossible to avoid in the settler colonial context, and thus the project mobilizes kin against kin.

CONCLUSION

The Wiindigo works through the settler-colonial infrastructure as a representation of how reciprocal ontologies are suppressed. Commodification is the utter objectification of Indigenous communities and their more-than-human kin. This suppression destabilizes life in ways that limit opportunities for prosperity and limits cultural values so as to achieve Indigenous erasure. In polluting, commodifying, extracting, and restricting, water is mobilized in violence against Indigenous peoples as they are implicated in violence against water. This oppression is particularly damaging in the long term, and LaDuke and Cowen implore resistance to dismantle the infrastructure that perpetuates and substantiates this oppression. They suggest an increase in railway and its electrification, a divestment in fossil fuels, and cite community engagement and activism and important catalysts for resistance against Wiindigo infrastructure. By doing so, they promote the protection of Indigenous land, and a dismantling of the colonial project as a meaningful avenue for revolutionary thought and action.

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RECONSIDERING NON-PROFITS

Tocqueville as a Normative Standard

MAIA CASSIE

In his seminal book Democracy in America, Alexis de Tocqueville (1840) famously asserted that "nothing, in [his] view, more deserves attention than the intellectual and moral associations in America" (p. 517). He saw associations — and by extension, as scholars now argue, non-profits (Dodge & Ospina, 2016) — as valuable specifically because they generate social bonds and good citizenship. Since Tocqueville first wrote this praise, over a million non-profits have sprung up in the United States (National Center for Charitable Statistics, 2020). Yet despite this growth, today's non-profits have deviated from the benefits Tocqueville describes, often prioritizing achieving external outcomes at the expense of cultivating prosocial citizens. After outlining how Tocqueville describes associations and how non-profits differ today, I will argue that it is this very disjunction that makes his writing useful; it allows us to extend and repurpose his insights as a normative standard for non-profits seeking to better fulfill their civic purpose. His account provides more than a rationale for encouraging associations — it can be used as a framework for improving modern non-profits, by recentring their missions on bettering citizens and sustaining community.

Tocqueville was intrigued and impressed by Americans' prioritization of voluntary associations. Specifically, he emphasized that associations are uniquely capable of teaching virtue, community, and "habits of acting together" (Tocqueville, 1840, p. 514). Associations are critical insofar as they function as spaces wherein "feelings and ideas are renewed, the heart enlarged, and the understanding developed" (p. 515). By teaching citizens how to collaborate and value one another within a democracy, associations offer a remedy to individualism; the interpersonal contact that they provide helps to cultivate civic-minded members who care about the world (van der Meer & van Ingen, 2009). For Tocqueville, these benefits are automatically produced by associations; people "unite" and "thenceforth they are no longer isolated individuals" (p. 516). Today, however, as the non-profit sector is shaped by factors Tocqueville did not anticipate — such as increases in scale, bureaucracy, and philanthropic influence — such ideals are less inevitable and increasingly obstructed.

Indeed, the aforementioned benefits are rarely seen today amid the growing formalization of non-profits (Shirinashihama, 2018). As Theda Skocpol traces in her 2003 book Diminished Democracy, American non-profits have been steadily moving away from being participatory, volunteer-driven structures and toward being professional, staff-run groups — "from membership to management," to quote the book's subtitle. Modern non-profits tend to focus on producing measurable deliverables rather than serving as Tocquevillian sites of heart enlargement (King & Griffin, 2019). A major aspect of associations is connections between members, and this is undermined when non-profits relegate volunteers to disconnected, menial roles (Taylor & de Laat,

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2013). Though some argue this trend toward professionalization is beneficial (it allows more funds to be raised, for example; Shirinashihama, 2018), it undoubtedly prevents non-profits from helping members become less individualistic citizens in the way that Tocqueville praised. As Skocpol (2003) writes, this shift toward managerialism threatens non-profits' ability to build a "national community of fellow democratic citizens" (p. 292). While both the "doing for" and "doing with" of non-profits may be valuable, it is this latter purpose — teaching values to citizens — which makes associations so crucial in Tocqueville's view, and it is this purpose that non-profits are straying away from.

Tocqueville's writing on associations may not accurately describe today's non-profits, but it nonetheless remains relevant as a civic benchmark to aim for. Scholars have previously documented a recent general decrease of civic engagement, but Tocqueville — in combination with modern-day critics of non-profit professionalization — helps us diagnose a decline in quality rather than just quantity. Interest in associations may be waning, but, perhaps more importantly, even many active non-profits are no longer capable of teaching the "art of association" (Tocqueville, 1840, p. 517). In Tocqueville's account, the mere existence of associations seems sufficient to foster community and civic-mindedness; today, however, promoting prosocial values only appears possible if associations function in explicitly member-focused ways (Dodge & Ospina, 2016). When we understand his writings not just as a call for the continued prevalence of non-profits but as a set of priorities for associations to pursue, Tocqueville encourages us to see how associations should be spaces for individuals to be transformed for the better and connected to their communities — not just employed as instruments of external change. The outcome-focused professionalization of non-profits obscures their vital goal of shaping and improving participants, leaving them unable to combat individualism and teach collaboration.

This analysis suggests that Tocqueville's picture of American associations in the 19th century offers a normative standard for non-profits to strive for today. Though modern non-profits look quite different from the associations he describes, this is all the more reason to return to his enduring insights; his description of associations can be read as a suggestion for the inward-facing work non-profits should prioritize in order to curb individualism. Tocqueville's perspective, therefore, reshapes how we evaluate, study, and participate in non-profits. Read through this lens, he reminds us that the strength of civil society — and of democracy — rests not just on the prevalence or external success of non-profits but also on their ability to cultivate communities of civic-minded citizens. He shows us that democracy and community flourish when associations are capable of "refreshing the circulation of feelings and ideas" (Tocqueville, 1840, p. 516), a role that non-profits must intentionally reclaim today.

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SCIENCES ♥

PREDICTIVE PROCESSING AND CULTURAL SHAPING

A Neurocognitive Account of Infant Helping

MIKE HOWARD

Why do infants help? Classic debates about "nature versus nurture" have framed prosocial development as a question of whether young children are innately altruistic or shaped primarily by socialization. Recent work in developmental psychology, cross-cultural research, and cognitive neuroscience suggests a more integrated picture. In this conceptual review, I argue that predictive processing provides a useful mechanistic framework for understanding early instrumental helping. On this view, infants construct internal models of others' goal-directed actions: representations of how actions are likely to unfold and what outcomes they are meant to achieve. When observed events deviate from these expectations, a prediction error is generated. Infants may act to reduce this prediction error by intervening in ways that bring the unfolding situation back in line with their internal model. Helping, in this sense, often emerges not from fully formed altruistic concern, but from attempts to resolve mismatches between expected and observed action outcomes. I then consider how cultural ecologies and household practices shape the trajectories built on this neural substrate. Cross-cultural studies of costly helping and socialization goals show that societies differ in whether children factor cost into helping decisions, and whether helping is scaffolded through empathy, obligation, or shared distress. At the local level, caregivers' everyday practices, particularly opportunities to help and task scaffolding, further calibrate how children come to see themselves as helpers. Together, predictive processing and cultural shaping offer a framework in which early prosocial tendencies are neither purely innate nor purely taught but are canalized differently across environments.

Keywords: infant prosocial development, predictive processing, cross-cultural psychology, scaffolding, costly helping

Across cultural contexts, infants begin to engage in helping and sharing early in development. They pick up dropped objects, open doors for adults, and respond to others in distress. Researchers have interpreted these early-emerging behaviors as evidence for an innate basis for prosociality, yet the vast cross-cultural differences in the forms that helping takes across the world suggest there is more to the picture.[1–3] Rather than asking whether helping is "inborn" or "learned", a more productive question is what neural and cognitive mechanisms support early helping, and how are these processes shaped into distinct trajectories across cultural and household environments?

I propose predictive processing as a unifying mechanistic account of the earliest, largely instrumental forms of infant helping. Through this view, infants act to minimize discrepancies between expected and observed states of the world, including

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the actions, goals, and outcomes of other people. Helping emerges when assuming another's goal minimizes prediction error more efficiently than passively observing or ignoring it. I then argue that these core mechanisms do not dictate a single, universal form of prosociality. These computations unfold within caregiver-infant dyads. Within these dyads, prediction-based action becomes socially organized and embedded in cultural norms. While the underlying inferential architecture is broadly shared, it does not produce a single universal form of prosociality. Cultural ecologies and everyday caregiving practices calibrate prediction-based helping by shaping how children weigh costs, represent others' goals, and come to see themselves as participants in shared action. In this way, environments influence not only the degree of helping but its qualitative form.

The paper proceeds in three parts. First, I outline predictive processing as a mechanistic account of early helping. Second, I examine cross-cultural variation in costly helping and socialization goals to show how shared neural machinery can yield divergent developmental outcomes. Third, I consider household scaffolding and everyday opportunities to help as micro-level mechanisms through which children construct enduring "helper" identities.

PREDICTIVE PROCESSING AS A MECHANISTIC CORE OF INFANT HELPING

Predictive processing models perception and action as fundamentally inferential. Within this framework, the brain is understood as a "prediction machine" that generates hypotheses about sensory input and then updates those hypotheses to minimize prediction error: the mismatch between expected and actual input.[4,5] Organisms can reduce error either by revising their internal model or by acting on the world so that it better matches their predictions. This general architecture has been applied to motor control, perception, and learning; here, I extend it to early prosocial behavior.

Nagai (2019) proposed a predictive learning model of cognitive development in which behaviors that look like helping can arise from attempts to minimize estimated error in others' goal-directed actions. When an infant expects that a reaching action will culminate in grasping an object, observing an adult repeatedly fail to obtain the object creates persistent prediction error. One way to resolve that error is to take on the adult's goal as one's own and complete the action: for example, by handing them the desired object. In an illustrative demonstration, an error-minimizing robot modeled on predictive learning came to "help" an experimenter retrieve an object when the experimenter's failed reaching violated its learned expectations.[6]

This account dovetails with goal-alignment hypotheses of early helping, which propose that infants help to the extent that they can infer others' goals and adopt them as their own.[7] Such goal inference does not require mature empathic concern or an explicit desire to improve another's welfare; it requires only that infants represent others' actions as organized by underlying goals. Infants attribute goal structure to simple action sequences early in development,[8] and alignment between observed and self-produced actions strengthens their representation of others' goals.[9] These findings indicate that infants possess and refine representations of goal-directed action that allow them to detect when outcomes deviate from expectation and to anticipate how actions should unfold. Sensitivity to goal structure becomes more robust over the first two years of life,[8,10] consistent with evidence that predictive anticipation of action outcomes improves with age.[11,12] From a predictive-processing perspective, such developmental improvements may expand the range of situations in which infants detect goal

discrepancies and intervene to reduce them. At the same time, engaging in helping interactions may itself refine infants' predictive models of others' actions, suggesting a potentially reciprocal developmental process.

Shared neural systems may support this process. Mirror-like mechanisms allow infants to map others' actions onto their own motor representations, effectively simulating another's behavior as if it were their own.[6] If an observed action stalls, the infant's internal simulation also produces an error signal. Acting to complete the stalled goal, such as picking up the dropped toy and handing it back, reduces this error. Early helping, then, can be seen not as a discrete module for altruism, but as an emergent property of general-purpose learning systems that seek coherence between predicted and actual outcomes in a social world.

This mechanistic account helps explain two developmental patterns. First, instrumental helping, such as handing an out-of-reach object, emerges earlier and more robustly than empathy-based comforting or sharing, which require more sophisticated representations of others' emotional states and preferences.[7] Second, early helping may occur even in the absence of explicit self–other differentiation or articulated moral norms. What matters initially is the ability to track actions and goals, generate predictions, and act to reduce error when others' actions deviate from expectations.

Predictive processing therefore provides a plausible neural and cognitive substrate for early helping. But the framework itself is agnostic about *what* goals infants prioritize, *when* they are willing to incur costs, and *how* they interpret the meaning of helping. Those aspects are shaped by development within specific cultural and familial contexts.

FROM SHARED NEUROBIOLOGY TO CULTURAL DIVERGENCE

If predictive processing supplies a broadly shared mechanism, why does helping look so different across societies? Cross-cultural research suggests that while basic capacities for action understanding and prosocial responding appear early and broadly, cultures diverge in how these capacities are elaborated, valued, and practiced.[1,3]

Kärtner (2018) reviews evidence that foundational components of prosocial development — such as the ability to understand simple goals, respond to others' distress, and engage in instrumental helping — are present in the second year of life across diverse settings. However, he argues that these capacities do not unfold along a single, genetically fixed trajectory. Instead, caregivers structure infants' everyday activities in ways that embed helping within local expectations about autonomy, obedience, and relatedness. Over time, these structures shape not only how often children help, but also their motivations and the cognitive routes by which they get there.[3]

One particularly revealing comparison comes from a study of toddlers in Delhi and Berlin.[13] In Berlin, mirror self-recognition, a marker of explicit self–other differentiation, was associated with prosocial behavior, consistent with a model in which children help because they recognize another's subjective state as distinct and respond with empathic concern. In Delhi, by contrast, mirror self-recognition was not related to helping. Instead, prosocial behavior seemed to arise from what the authors term "situational helping" in which toddlers take on others' emotional states through contagion and act to reduce a shared distress state. These findings suggest that developmental context may shape which cognitive tools are recruited to promote helping: in autonomy-oriented settings, explicit self/other differentiation and perspective-taking may scaffold prosocial action, whereas in relationally oriented settings, affective contagion and embodied co-experience may play a more central role.

In predictive-processing terms, children in both contexts may be minimizing error, but the representational format differs: Berlin toddlers may rely more on explicit representations of another's mental state, whereas Delhi toddlers rely more on embodied sharing of distress.

These differences are not random. They track cultural socialization goals. In contexts emphasizing autonomy and psychological independence, such as middle-class urban Germany, caregivers often encourage perspective taking and emphasize the child's internal states.[13] In contexts that prioritize relational obligations and obedience, such as many families in Delhi, caregivers may instead stress behavioral conformity and shared emotional climates. As a result, the same neural susceptibilities to social contagion and prediction error are harnessed into distinct developmental pathways: one that foregrounds understanding another mind and another that foregrounds participating in a shared state.

The key point is that cultural environments do not merely modulate the *amount* of helping. They shape the computational "solutions" children use to minimize interpersonal prediction error, whether by simulating others' goals explicitly, absorbing their affective states, or internalizing norms about what helpers do in a given situation.

Cost is a powerful lens on prosocial behavior. While non-costly helping (for example, handing over an extra object) is relatively common and shows similar age-related increases across societies, "costly helping" — giving up something of one's own or incurring risk — varies more widely.[14,15]

Corbit et al. (2020) examined costly and non-costly helping in 16- to 36-month-old children across Canada (n = 35), India (n = 34), and Peru (n = 31), contexts differing in ownership experience and resource abundance (total N = 100). In two conditions, children helped an experimenter either by relinquishing one of their own valued items (costly) or by returning an item that belonged to the experimenter (non-costly). Non-costly helping increased with age across all three societies. Costly helping, however, diverged: it increased in Canada, remained stable in Peru, and decreased in India, a pattern supported by a significant society × age interaction in the fitted model ($\chi^2 = 13.14$, $p = .001$), with confidence intervals around the fitted trajectories shown in Fig. 1, and it was mirrored in analyses of the number of communicative cues required before helping occurred. The authors interpret these cross-societal differences as consistent with variation in children's ownership experience and resource abundance, suggesting that while low-cost helping develops similarly across contexts, sensitivity to cost is shaped by sociocultural environments.[14]

A larger cohort study by House et al. (2013) examined prosocial choices in 326 children (ages 3–14) across six societies and found a similar cost-dependent pattern: when prosociality was non-costly, children's prosocial responses increased with age with relatively little cross-societal variation; however, when prosociality was costly, trajectories diverged across societies as children moved through middle childhood, shifting toward the average adult pattern in their own community, becoming increasingly generous or selective. Model comparison supported this contrast: for non-costly prosociality, the best-fitting model collapsed across societies (DIC weight = 0.94), whereas for costly prosociality, the best-fitting model required society-specific developmental trajectories (DIC weight = 1.00). Together, these findings converge on a consistent pattern: early, low-cost prosocial responding shows cross-cultural similarity, whereas costly helping diverges across societies and tracks locally normative behavior.[15]

Predictive processing offers one way to integrate these findings. If infants' early, low-cost helping reflects a generic tendency to reduce prediction error in social interactions, then the *cost function* applied to these actions must be learned. Through

repeated experiences, children update their priors about when giving up a resource is expected, rewarded, or risky. In contexts with high material scarcity or strong norms around ownership, predictions may favor self-protection; attempts to help at personal expense may lead to social or material loss, reinforcing a narrower "helping policy." In wealthier or more individualistic contexts, children may learn that sharing and costly helping are rewarded with praise or relational benefits, making costly helping an efficient route to minimizing long-term social prediction error.

The same underlying machinery of tracking others' goals, anticipating outcomes, and evaluating discrepancies can therefore support very different helping strategies, depending on how cost and norm information are integrated into children's generative models of social interaction.

HOUSEHOLD PRACTICES AND THE CONSTRUCTION OF "HELPER" SELVES

Cultural influences are not transmitted in the abstract; they are instantiated in the mundane routines of households. Within any given society, caregivers differ in how they invite, structure, and interpret children's helping. These local practices can create substantial variation in prosocial behavior even among families who share a broader cultural context.

Hammond and Carpendale (2015) focus on scaffolding as a key mechanism. They define scaffolding as the way parents reshape tasks that are initially beyond the child's ability into manageable components the child can understand and participate in. In their study, toddlers were given opportunities to help with everyday chores (e.g., tidying, putting items away) while researchers observed mothers' behaviors. Children whose mothers provided more effective scaffolding, such as breaking tasks into simple steps, physically guiding the child's actions, and framing the activity as shared, helped more often and more quickly, even after controlling for sociability.[16]

Unlike isolated praise, scaffolding does more than provide feedback after the fact. It creates opportunities to act, making "helping" a familiar, practiced solution when a task arises. In predictive-processing terms, repeated, scaffolded participation allows children to build rich generative models in which "parent + child + chore" is a coherent, low-error pattern of joint action. Over time, these models support a sense of themselves as someone who *can* and *does* help. When similar situations arise, the prediction that "I will join in and help" is already in place, and acting to fulfill it reduces error both at the level of task completion and at the level of self-concept.

Other work underscores how parental socialization goals and practices co-vary with children's helping. Giner Torréns and Kärtner (2017) found that Delhi mothers reported providing more opportunities for toddlers to help at home and used more punitive strategies when children failed to comply with helping requests, whereas Münster mothers offered fewer such opportunities and treated helping more as a voluntary expression of autonomy.[17] These differences tracked frequency of helping in experimental tasks. Again, what children learn is not simply *that* helping is possible, but *how* it is embedded in relationships: as obedience, as collaboration, or as individual choice.

These household-level practices can either amplify or dampen the impact of broader cultural norms. Two families in the same city may give their children very different "data" about when helping is expected, rewarding, or risky. Over thousands of interactions, these local signals shape the priors that children bring to novel situations, influencing how much precision they assign to another's need — for example, whether

it is construed as an invitation to collaborate, a normative expectation, or something easily deprioritized.

IMPLICATIONS AND FUTURE DIRECTIONS

Bringing predictive processing into dialogue with cross-cultural and developmental research allows us to move beyond debates about whether helping is "innate" or "learned." Early prosocial behavior can be understood as the product of domain-general learning systems that operate in socially structured environments. Infants come equipped with neural architectures that are highly sensitive to prediction error, social contingency, and action-outcome regularities.

These architectures make it likely that, in many settings, infants will begin to act in ways that look helpful when others' goals are thwarted.

However, the *forms* and *meanings* of helping that emerge from these mechanisms are not fixed. Cultural ecologies shape which computational routes to reducing social prediction error are favored: empathic perspective taking, distress contagion, norm adherence, or obligation. Household practices, especially scaffolding and opportunities to contribute, further sculpt how children calibrate cost, understand their own role in joint activities, and construct stable "helper" identities.

This framework has several implications. First, interventions aimed at increasing prosocial behavior should be cautious about assuming universal pathways. For example, punitive strategies may correlate positively with helping in one context and negatively in another,[17] not because punishment is inherently good or bad, but because it is embedded in different relational and normative landscapes. Second, predictive-processing accounts suggest that changing the *structure* of children's experiences — what situations they encounter, what regularities hold, and how often they see helping succeed — may be as important as appealing to explicit moral norms.

Finally, integrating mechanistic models with cross-cultural data can sharpen developmental theory. Predictive processing invites concrete questions: How do children weigh social prediction errors relative to other sources of uncertainty? How are cost and norm information encoded in generative models of interaction? How do socialization practices surrounding helping shape the experience-dependent tuning of neural systems that encode social prediction error and precision, and to what extent are cross-cultural differences in helping mediated by this developmental recalibration? Addressing such questions would deepen our understanding of how shared neural building blocks give rise to the rich diversity of human prosociality.

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REVIEW: TIO2-BASED PHOTOCATALYTIC DEGRADATION OF METHYLENE BLUE

SIRUI (ANDY) ZHU

Dye pollution from industrial wastewater poses significant environmental challenges due to its toxicity and persistence. Photocatalytic degradation using titanium dioxide (TiO2) has emerged as an effective method for treating dye-contaminated water. This literature review explores the mechanisms of TiO2-based photocatalytic degradation of methylene blue (MB), a common dye pollutant, and examines the influence of various parameters such as light wavelength, pH, dissolved oxygen concentration, initial dye concentration, and TiO2 concentration on degradation efficiency. Additionally, the review discusses advancements in TiO2 doping techniques to enhance photocatalytic performance and highlights the need for further research on the effects of inorganic salts commonly found in real wastewater on photocatalytic degradation processes.

Synthetic dyes are widely used in various industries, including textiles, paper, plastics, and food. Over 100,000 types of dyes exist, and 7×10^5 tons are produced annually. Of this, 36,000 tons are consumed by the textile industry each year. During the dyeing process, up to 20% of the total world production of dyes is lost and released in the sewage.[1] The dyes released contribute to a rise in chemical oxygen demand and biological oxygen demand of the water, which can be detrimental to aquatic life. Furthermore, many dyes and their breakdown products are toxic, carcinogenic, and mutagenic.[2] Thus, it is crucial to treat dye-containing wastewater before releasing it into the environment.

Various methods have been developed to treat dye-containing wastewater, including physical, chemical, and biological methods. Of the mentioned methods, biological methods are the most economical. However, they are kinetically slow, and many dyes are not biodegradable. Physical techniques, such as adsorption, precipitation, reverse osmosis, and coagulation, are also not effective in completely removing dyes from wastewater. Chemical methods, such as chlorination, ozonation, and advanced oxidation processes (AOPs), are more effective in degrading dyes. However, chlorination can lead to the formation of toxic chlorinated organic compounds, and ozonation is expensive and requires high energy input.[1]

AOPs, first proposed in the 1980s, use powerful hydroxyl radicals to degrade persistent organic pollutants. AOPs include ozone-based processes, Fenton-based processes, and photocatalysis. These can be classified as homogeneous and heterogeneous processes. For homogeneous processes, reactions occur in a single phase (e.g., Fenton process, UV/H_2O_2); for heterogeneous processes, reactions involve solid catalysts (e.g., TiO_2 photocatalysis, heterogeneous Fenton). The absorption of photons

by a semiconductor triggers the photocatalytic reaction at its surface. TiO_2 has been widely investigated as a heterogeneous photocatalyst due to its high stability, low cost, and non-toxicity.[1]

The photocatalysis mechanism begins with photon absorption, exciting electrons from the valence to the conduction band, creating electron-hole pairs. Redox reactions occur at the surface, where holes oxidize water or hydroxide ions to produce hydroxyl radicals, while electrons reduce oxygen to form superoxide anions $O_2^{\bullet-}$. These reactive species then react with organic pollutants, mineralizing them into carbon dioxide, water, and inorganic ions. This mechanism can be summarized by the following reactions:[1,3]

$$TiO_2 + h\nu \rightarrow h^+_{VB} + e^-_{CB} \quad (1)$$

$$(O_2)_{ads} + e^-_{CB} \rightarrow O_2^{\bullet-} \quad (2)$$

$$(H^+ + OH^-)_{ads} + h^+_{VB} \rightarrow H^+ + OH^\bullet \quad (3)$$

$$O_2^{\bullet-} + H^+ \rightarrow HO_2^\bullet \quad (4)$$

$$2HO_2^{\bullet-} \rightarrow H_2O_2 + O_2 \quad (5)$$

$$H_2O_2 + e^- \rightarrow OH^\bullet + OH^- \quad (6)$$

$$R + OH^\bullet \rightarrow R'^\bullet + H_2O \quad (7)$$

$$R + h^+_{VB} \rightarrow R^{+\bullet} \rightarrow R \text{ degradation.} \quad (8)$$

where $h\nu$ is the photon energy, h^+_{VB} is the hole in the valence band, and e^-_{CB} is the electron in the conduction band. The organic pollutant (R) can be directly oxidized by holes or indirectly by hydroxyl radicals, leading to its degradation.

DEGRADATION KINETICS

Methylene blue (MB) is commonly used as a model pollutant to evaluate the photocatalytic activity of TiO2. MB concentration is determined using a UV-Vis spectrophotometer at 660 nm, and the Beer-Lambert law describes the relationship,

$$A=\varepsilon bC \quad (9)$$

where A is the absorbance, ε is the molar absorptivity, b is the path length of the cuvette, and C is the concentration of MB.

At equilibrium, the catalyst fractional site covered by MB, θ_{MB}, can be defined (at constant temperature) by the Langmuir adsorption isotherm. This is given by Equation 10,

$$\theta MB=K ads C eq1+K ads C eq \quad (10)$$

where K_{ads} is the adsorption equilibrium constant, and C_{eq} is the equilibrium concentration of MB in solution. The Langmuir adsorption constant Kads is defined by Equation 11,

$$K ads=k ads k des \quad (11)$$

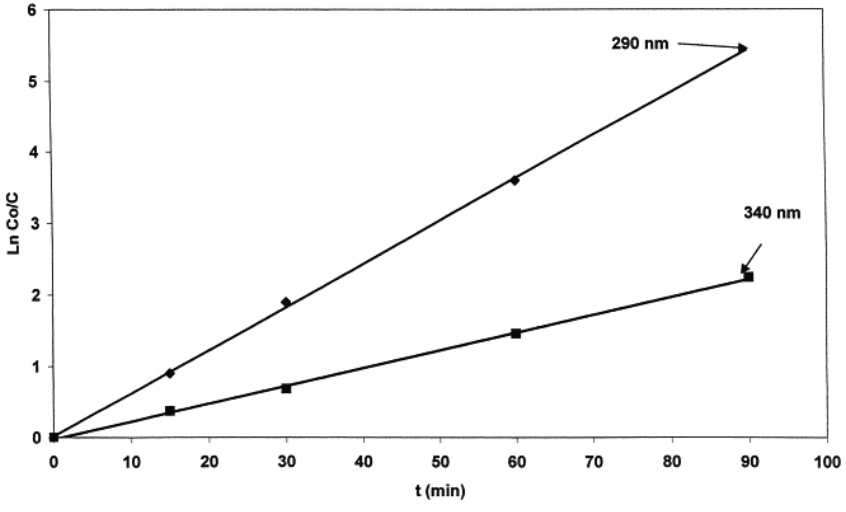

Figure 1: Plot of $\ln(C_0/C)$ versus time for MB degradation under different UV wavelengths, λ=290 nm and λ=340 nm.5

where *k*ads and *k*des are the adsorption and desorption rate constants, respectively.

The degradation of MB is widely accepted to follow the Langmuir-Hinshelwood kinetic model, which accounts for both adsorption and surface reaction steps. The rate is given by Equation 12,

$$r\mathrm{MB}=-\mathrm{d}C\mathrm{d}t=k\mathrm{MB}\theta\mathrm{MB}=k\mathrm{MB}K\mathrm{LH}C1+K\mathrm{LH}C, \quad (12)$$

where r_{MB} is the degradation rate of MB, k_{MB} is the reaction rate constant, θ_{MB} is the surface coverage of MB on TiO_2, K_{LH} is the experimentally determined Langmuir adsorption equilibrium constant, and C is the concentration of MB in solution. Note that K_{ads} (theoretical) may differ from K_{LH} (experimental) due to differences in experimental conditions and assumptions.

This model describes how the reaction rate increases with concentration at low coverage but approaches a maximum as the photocatalyst surface becomes saturated. For dilute solutions where $K_{LH}C \ll 1$, the Langmuir-Hinshelwood equation simplifies to pseudo-first-order kinetics,[4]

$$r\mathrm{MB}\approx k\mathrm{MB}K\mathrm{LH}C=k\mathrm{app},C, \quad (13)$$

where $k_{app}=k_{MB}K_{LH}$ is the apparent rate constant, dependent on light intensity, dissolved oxygen concentration, pH, and TiO_2 concentration. The integrated form yields

$$\ln(C0C)=k\mathrm{app}t. \quad (14)$$

A plot of $\ln(C_0/C)$ versus time is linear, with slope equal to k_{app}. However, at higher initial dye concentrations, the full Langmuir-Hinshelwood model better captures the saturation effects, allowing for more accurate kinetic analysis across a wider range of conditions.[5]

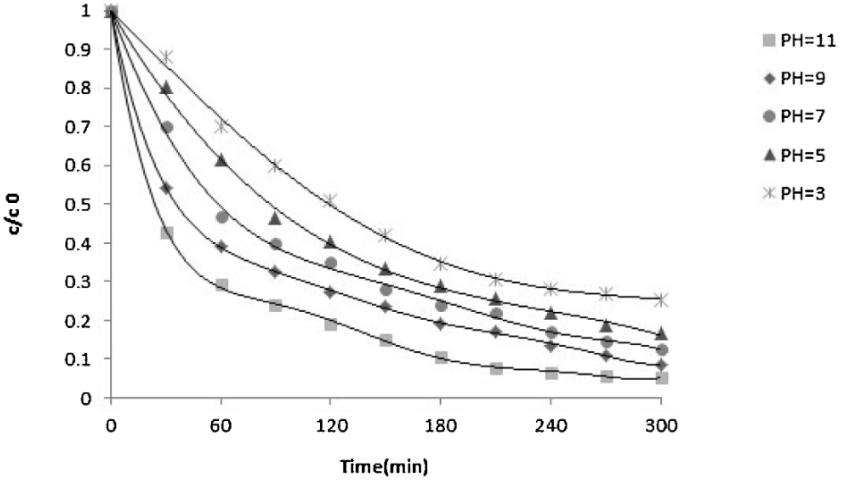

Figure 2: Degradation of MB at pH 3-11. Showing higher degradation rates at higher pH values.[6]

EFFECT OF VARIOUS PARAMETERS ON DEGRADATION KINETICS

From Einstein's equation and Planck's equation, the energy of a photon is given by Equation 15,

$$E=h\nu=hc\lambda, \tag{15}$$

where h is Planck's constant, c is the speed of light, and λ is the wavelength. Shorter wavelengths correspond to higher energy photons.

Houas et al. found that shorter wavelengths increase the degradation rate of MB because they provide more energy to excite electrons from the valence band to the conduction band of TiO_2, generating more electron-hole pairs and thus more reactive species. As shown in Figure 1, MB degradation was faster under shorter wavelengths, with apparent rate constants of 0.06 min^{-1} at λ=290 nm and 0.025 min–1 at λ=340 nm determined from the slopes of the first-order kinetic plots. The higher rate constant at shorter wavelengths results from greater UV intensity, which generates more electron-hole pairs and reactive species.[5]

In addition to wavelength, the kinetics of methylene blue degradation also depends on solution pH. Hoffmann et al. found that at pH values higher than the point of zero charge (pzc) of TiO_2 (pH_{pzc} = 6.25), the surface of TiO_2 is negatively charged, which enhances the adsorption of the positively charged methylene blue, leading to higher degradation rates. Conversely, at pH lower than the pH_{pzc}, the surface of TiO_2 is positively charged, which repels the methylene blue, resulting in lower degradation rates.[3]

Figure 2 shows the degradation of MB at different pH values. The degradation rate increases with increasing pH, with the highest rate observed at pH 11. This is due to the increased adsorption of MB on the negatively charged TiO_2 surface at higher pH values. Furthermore, the initial dissolved oxygen concentration also affects the

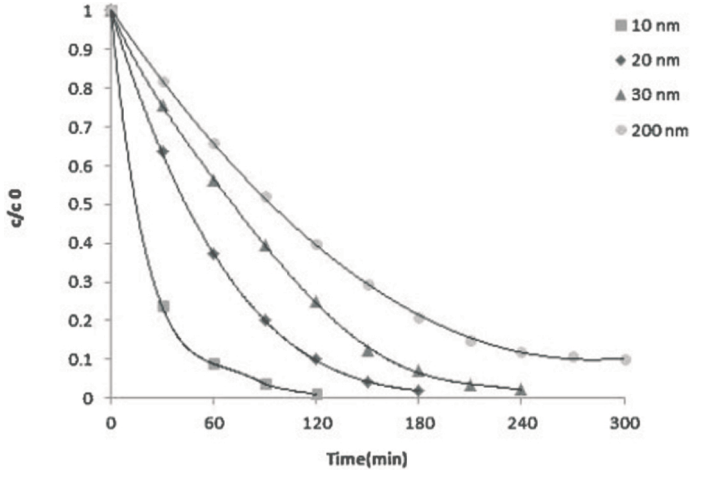

Figure 3: TiO2 size and MB degradation efficiency relationship, with particle sizes ranging from 10–200 nm.[6]

degradation rate. Higher dissolved oxygen concentrations lead to higher degradation rates, as oxygen acts as an electron acceptor to receive electron transfer from the excited TiO_2 valence band, reducing the recombination of electron-hole pairs and generating more reactive species.[7]

Lee et al. found that the degradation rate of diazo dye Reactive Green 19 increased with increasing dissolved oxygen concentration. The rate is highest when air was supplied at 4200mLmin^{-1}. Beyond this concentration, the rate decreased slightly, possibly due to the saturation of oxygen on the TiO_2 surface, hindering light penetration.[8] A similar trend is expected for MB degradation with increasing dissolved oxygen concentration.

The initial MB concentration also affects the degradation rate. At low initial concentrations, increasing the concentration increases the rate almost proportionally, as more dye molecules are available to react with the generated reactive species. However, at high initial concentrations, the rate increase is less pronounced, approaching a maximum, as the surface of TiO_2 becomes saturated with dye molecules, limiting the availability of active sites for the photocatalytic reaction. The general rate equation that models the effect of initial concentration on kinetics is given by Equation 16,

$$-r\text{dye}=k'aC\text{dye}1+k'bC\text{dye}, \quad (16)$$

where k'_a and k'_b are constants related to the adsorption equilibrium and reaction rate, respectively, and C_{dye} is the initial dye concentration.[7]

The decomposition rate can also be affected by the TiO_2 concentration. As the TiO_2 concentration increases, the degradation rate also increases, as more active sites are available for the photocatalytic reaction. However, beyond a certain concentration, the rate decreases slightly, as light penetration is hindered by the increased opacity of the solution, reducing the light penetration.[1,2,7]

The particle size of TiO2 also plays a role in the degradation rate. Dariani et al. found that the reduction of TiO2 particle size caused a reduction of electron-hole recombination and the enhancement of surface area, leading to higher efficiency.6 As shown in Figure 3, smaller particle sizes lead to higher degradation efficiencies. For example, TiO_2 with a particle size of 10 nm achieved a degradation efficiency of 95% within 60 minutes, while TiO_2 with a particle size of 200 nm only achieved a degradation efficiency of 60% within the same time frame.

DEGRADATION PATHWAYS

Degradation of MB leads to the conversion of carbon present in the dye to gaseous CO_2, and the nitrogen and sulfur present into inorganic ions such as NO_3^- and SO_4^{2-}.[9]

Figure 4 shows the proposed degradation pathway of MB under photocatalytic conditions. LC-MS and ESI-MS analyses identified key degradation intermediates: Azure C (m/z 242.9), thionine (m/z 228), and benzene sulfonic acid (m/z 159). The absence of Leuco-methylene blue indicates that MB undergoes oxidation rather than reduction. The pathway proceeds through *N*-dealkylation to form azure intermediates, followed by aromatic ring cleavage and oxidation, ultimately mineralizing to CO_2, NO_3^-, and SO_4^{2-}.[9] *N*-dealkylation is an important step in the degradation of many dyes, including MB, where the methyl groups attached to the nitrogen atoms are removed, leading to the formation of intermediates such as azure C and thionine. This causes a hypsochromic effect, where the absorption maximum shifts to shorter wavelengths, and the colour of the solution becomes less intense. This is important during the monitoring of degradation, as the change in colour can be used to track the progress of the reaction.[10]

Improving Degradation Efficiency via Doping

TiO_2 has been doped with various elements, ranging from non-metals (e.g., N, C, S) to metals (e.g., Fe, Cu, Ag) and even rare-earth elements (e.g., Ce, La). Doping introduces impurity levels within the band gap of TiO_2, allowing for visible light absorption and improved charge separation.[11]

Of the various metal doping methods, Li-TiO_2, Mg-TiO_2, Sn-TiO_2, performed the best in terms of photocatalytic activity, with Li-TiO_2 being the most effective, having a band gap of 2.66 eV and achieving ~100% degradation of methyl orange in 30 min.[11,12]

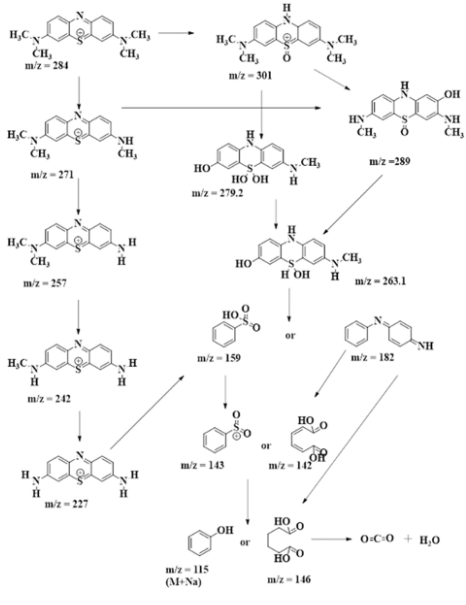

Figure 4: Proposed degradation pathway of MB under photocatalytic conditions.[9]

Among non-metals, nitrogen gains substantial attention because doping N atoms into the TiO_2 lattice leads to the generation of N 2*p* energy levels near the valence band, reducing the band gap and extending light absorption into the visible spectrum. N atoms also help prevent charge carrier recombination and form metastable centers due to their stability, low ionization potential, and atomic radius comparable to oxygen.[13] They also exhibit both upconversion and downconversion photoluminescence properties, allowing them to convert low-energy photons into higher-energy ones and high-energy photons into multiple lower-energy ones, thereby enhancing the photocatalytic activity of TiO_2 under visible light.[14] A combination of N-doping and graphene quantum dots has also been explored, which achieved an 85% increase in efficiency, showing a synergistic effect that further enhances the photocatalytic performance of TiO_2.[15]

In summary, doping TiO_2 with various elements, particularly nitrogen, significantly enhances its photocatalytic efficiency by extending light absorption into the visible spectrum and reducing charge carrier recombination. These advancements hold promise for more effective photocatalytic degradation of dyes like methylene blue under solar irradiation.

PHOTOCATALYTIC DEGRADATION IN NON-IDEAL CONDITIONS

While significant progress has been made in understanding and enhancing the photocatalytic degradation of dyes using TiO_2, most studies are conducted in idealized laboratory conditions with pure water and single dye systems. However, real industrial wastewater often contains various inorganic salts — most commonly Ca^{2+}, Cl^-, SO_4^{2-}, Na^+, and Mg^{2+} — which can influence photocatalytic efficiency by affecting ionic strength, surface charge, and the generation of reactive species.16 Despite their relevance, the effects of these inorganic salts on photocatalytic degradation pathways and kinetics remain underexplored. This is an important area for future research, as it will help bridge the gap between laboratory studies and real-world applications, and understanding these factors will enable the development of more effective and practical photocatalytic wastewater treatment technologies.

The introduction of salts at low ionic strengths may slightly enhance degradation efficiency by compressing the electrical double layer, thereby reducing the Debye length κ^{-1}. This allows for more effective interactions between the dye molecules and the photocatalyst surface. This relationship is described by Equation 17,

$$\kappa-1=\sqrt{\varepsilon\varepsilon 0kBT2e2NAI}, \tag{17}$$

which implies that

$$\kappa-1\propto 1/\sqrt{I}. \tag{18}$$

Here, e is the elementary charge, N_A is Avogadro's number, I is the ionic strength, ε is the dielectric constant of the medium, ε_0 is the permittivity of free space, k_B is the Boltzmann constant, and T is the temperature in Kelvin.[17]

At higher ionic strengths, particularly with divalent cations (Ca^{2+}, Mg^{2+}), a decrease in efficiency is expected due to particle aggregation.[8] Additionally, anions such as Cl^- may hinder surface reduction reactions due to their scavenging effects, which are concentration-dependent, potentially reducing photocatalytic activity.[18]

Another consideration is the presence of natural organic matter or other dye species in real wastewater, which can compete with dye molecules for adsorption sites

on the photocatalyst surface and scavenge reactive species, thereby reducing degradation efficiency.[16]

Future studies should focus on systematically investigating the effects of various inorganic salts and organic compounds on photocatalytic degradation kinetics and pathways to develop more robust and effective treatment strategies for real-world applications.

CONCLUSION

Photocatalytic degradation of methylene blue using TiO_2 is influenced by various parameters, including light wavelength, pH, dissolved oxygen concentration, initial dye concentration, and TiO_2 concentration. Shorter wavelengths, higher pH values, and increased dissolved oxygen concentrations enhance degradation rates. Doping TiO_2 with elements like nitrogen further improves photocatalytic efficiency by extending light absorption into the visible spectrum and reducing charge carrier recombination. However, most studies are conducted under idealized conditions, and the effects of inorganic salts commonly found in real wastewater on photocatalytic degradation remain underexplored. Future research should address these gaps to develop effective wastewater treatment technologies.[8]

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METAL PARTICLES FROM BRAKE WEAR

Sources, Chemistry, and Impacts

SIMING XIANG

Brake wear is a major source of airborne metal particles (e.g., Fe, Cu, Zn), which can be released under high-pressure and high-temperature conditions, emitting primarily PM10- and PM2.5-sized particles. Among them, iron (Fe) dominates in mass concentration and undergoes atmospheric transformations such as oxidation and aggregation. Critically, through Fenton-like reactions in aerosols, metal particles can catalyze the formation of reactive oxygen species (ROS). Both metal particles and ROS pose health threats: they can damage the human respiratory and cardiovascular systems. Despite their clear health implications, models for evaluating their total atmospheric effect remain incomplete, which also highlights the need for regulation.

Air pollution is one of the most pervasive and serious types of pollution that affects nearly all organisms globally. The UN Environmental Program (UNEP) reported that 8.1 million premature deaths annually are caused by air pollution, as hazardous chemicals can induce a number of diseases like cancer and stroke.[1] Particulate matter (PM) is a major contributor to air pollution. Classified by the diameter of particles, there are three main types of PM pollutants: coarse particles (2.5-10 μm), fine particles (0.1–2.5 μm), and ultrafine particles (< 0.1 μm).[2] Several studies clearly show that PM particle inhalation can result in cardiovascular disease, but the pathophysiological mechanism remains unclear.

PM pollution extends beyond industrial emissions; hazardous PM particles can be emitted through various pathways, such as construction and cooking. Furthermore, PM particles can also be released from road vehicles: exhaust emissions (gases from fuel combustion) account for 17% of total traffic-related PM, while non-exhaust emissions dominate the remainder.[3] In urban areas, non-exhaust sources — including tire, brake, and road wear — contribute over 50% of total PM emissions.[4,5] Among these, brake wear emerges as a critical topic that is focused on in this review. More than half of the PM10 non-exhaust emissions come from brake wear by mass.[5] In recent years, the pollution caused by exhaust gas emissions has gradually been regulated by both governments and the apparatuses that treat exhaust gas, such as using the photocatalyst in the pavement, applied in the architectural coatings to remove nitrogen oxides (NOx), and volatile organic compounds (VOCs).[6]

Braking systems convert wheel kinetic energy into heat via friction, inevitably generating metal particles. In disc brakes, pedal activation drives the piston and the caliper to press the pad against the rotor disc to stop wheel rotation.[6] Due to the drastic friction and massive heat released within one second (300–600 ˚C), brake wear particles

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will be generated from the pad and the rotor disc.[4] To withstand the higher force and temperature imposed, the rotor disc and the pad use various composite materials, including metal and non-metal materials.[7] Rotors are predominantly grey cast iron (Fe), so the Fe particles are the major pollutant.[4] The brake system also includes Zn, Cu, Ba, and Mn, and it can emit a wide range of these other metal particles.

Fine particles can participate in aerosol formation and agglomerates.[8] In addition, metal particles can be transformed into salt particles, which can catalyze the formation of hydroxyl radicals.[9] Both of the products from these two pathways can greatly affect human health. Reactive oxygen radicals are a significant factor in respiratory damage, as well as fine metal particles themselves, which have intensive toxicity when they enter the cardiovascular system. Despite the significant health hazards posed by the particles released from brake system wear, the mechanisms by which these specific compounds impact human health are still unclear.[2]

DISCUSSION

Source

Asbestos fibers were once used as the material for brake pads, but due to health concerns, modern brake pads are primarily made from four materials: non-asbestos organic (NAO), low-metallic combined with organic compounds, semi-metallic, and metallic.[10] Among these, low-metallic pads dominate passenger vehicles for balancing wear resistance and noise reduction. However, these four types of pads all contain metal compositions such as iron, copper, and aluminium.[10]

Emissions from these materials are highly correlated with the temperature of the brake. When braking at high speed, the brake disc and brake pads will heat up sharply. The temperature of the brake disc can rise to 300 °C when braking from a movement speed of 80 km/h.[11] Two critical particle emission processes can result: first, as the temperature rises on the pad, organic materials can be oxidized and release VOCs over 250 °C. Second, this condition can foster the formation of smaller metal particles because the higher temperatures degrade the volatile material in the brake disc and brake pads, allowing finer metal particles to be released.[11] Kukutschová simulated mid-size car braking and measured the metal particle production in the braking system. The research found that 35% iron and 7% copper are the main compositions, while other heavy metals such as Ti, Zn, Mg, and Pd are also found.[8]

63% of released metal particles fall within PM2.5–PM10. Iron particles are still the major contributor to emissions, whereas copper and zinc are less significant. This can be explained by their lower melting points, as copper and zinc particles will likely melt instead of emitting into the air.[11] As hot metal particles are released into the air, they will quickly be oxidized. For instance, iron particles can form Fe_2O_3 and FeO. As a result, metal particles usually exist in the air as oxidized and mineralized particles. Those metal oxides will attract and adhere to each other, leading to the formation of agglomerates.[11] Nanoparticles can be released from the agglomerates as they enter the human body. In addition to metal particles, a large number of tiny carbon particles are also formed and emitted from the braking system. These carbon particles can also contribute to PM, thereby harming human health.[11]

Chemical reactions

Widely used brake pads contain substantial organic compounds, with phenol

derivatives being the most abundant. Additionally, these pads also incorporate carboxylate acids, methyl esters, and other aromatic compounds.[12] When temperatures rise during braking, these organic compounds become more reactive, thereby releasing VOCs into the atmosphere.[11]

Although the brake pad materials contain fewer metals nowadays, the rotor discs are still mainly made of cast iron, copper, and other alloys. During braking, high temperatures cause these metal particles to be released. Meanwhile, oxidized iron compounds in brake wear particles undergo three atmospheric reaction mechanisms: proton-promoted, ligand-promoted, and reductive dissolution.[13] Through these processes, oxidized iron particles transform into various ferric (Fe^{3+}) and ferrous (Fe^{2+}) inorganic compounds. Additionally, they can also form chelation complexes with ligands such as dicarboxylic acids. In aerosol phases, these ionized iron forms efficiently catalyze the formation of hydroxyl radicals (·OH) and singlet oxygen (O) under hydrogen peroxide (H_2O_2) conditions,[14]

$$Fe^{3+} + H_2O_2 \rightarrow Fe^{2+} + HO_2 + H^+$$
$$Fe^{3+} + HO_2/2O \cdot \rightarrow Fe^{2+} + O_2 + H^+$$
$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH \cdot + OH^-$$
$$Fe^{2+} + O_2 \rightarrow Fe^{3+} + O \cdot + O \cdot .$$

In acidic environments, hydroxyl radicals can form even in the absence of hydrogen peroxide. This ion-driven process requires ultraviolet catalysis and an aquatic environment, which predominantly occurs in clouds and fog,[15]

$$Fe^{3+}{}_{(}H_2O)_6 + h\upsilon \rightarrow Fe^{2+}{}_{(}H_2O)_5 + OH + H^+$$
$$FeOH^{2+}{}_{(}H_2O)_5 + h\upsilon \rightarrow Fe^{2+}{}_{(}H_2O)_5 + OH$$

Ferryl ions (Fe(IV)) also exhibit catalytic activity in radical formation within cloud droplets. This reaction is highly pH-sensitive, with hydroxyl radical production occurring up to 50 times faster in highly acidic environments (pH 1–3), significantly enhancing oxidative processes in atmospheric aqueous phases,[16]

$$FeO^{2+} + H_2O \rightarrow Fe^{3+} + OH \cdot + OH^-$$
$$FeO^{2+} + OH + H^+ \rightarrow Fe^{3+} + H_2O_2$$
$$FeO^{2+} + H_2O_2 \rightarrow Fe^{3+} + HO_2 + OH^-$$
$$FeO^{2+} + HO_2 \rightarrow Fe^{3+} + O_2 + OH^- .$$

Other metal particles and their ionic forms in atmospheric droplets, such as Cu and Zn, can also engage in "Fenton-like" oxidative reactions, generating hydroxyl and oxygen radicals. However, their impact is less significant compared to iron ions, as these metals are present in much lower concentrations in the atmosphere,[17]

$$Cu(I) + O_2 \rightarrow Cu(II) + O \cdot + O \cdot$$
$$Cu(I) + H_2O_2 \rightarrow Cu(II) + OH \cdot + OH^-$$

HEALTH IMPACTS

Fine particles that can be easily inhaled into the human respiratory system, such as

PM10 and PM2.5, can cause serious bodily damage. Generally, smaller particles can enter the body more easily and tend to cause greater harm. Studies show that long term PM exposure is positively correlated with higher death rates from heart disease. Additionally, long-term exposure to PM is also connected to higher risks of atherosclerosis, strokes, and high blood pressure.[18]

As a component of PM, airborne metal particles can negatively impact the respiratory, cardiovascular, and immune systems, potentially leading to diseases such as arrhythmias and myocardial infarction. Metals like Fe, Cu, Ni, and Cr trigger oxidative stress. This stress comes from reactive oxygen species formed by metal particles.[19] ROS have strong oxidizing power and can damage important molecules like DNA. This is demonstrated by an increase in 8-oxo-7,8-dihydro-2'-deoxyguanosine (a marker of DNA damage) when DNA is harmed by ROS.[19] Higher levels of this chemical mark a rise in the risk of lung cancer. These metal particles also cause inflammation and platelet activation, leading to blood clots.[2] However, the exact mechanisms and how each pollutant specifically affects the body remain unclear due to limited research. Modeling the combined effects of multiple pollutants requires further development in the future.

Brake wear can also foster ozone formation. In brake system wear, organic materials in brake pads release VOCs. VOCs are essential for ground-level ozone production through photochemical reactions. Cars also emit large amounts of NOx; metal particles can help to create OH radicals. These chemicals have a severe impact: NOx can contribute to acid rain and ecosystem damage; VOCs and HOx can damage lungs and result in respiratory disease. Together, these factors cause massive ozone production on urban roads and nearby areas.

CONCLUSION

Braking system wear, as an inevitable consequence of vehicle operation, releases environmentally harmful metal particles, primarily Fe, Cu, and Zn. These metal particles are predominantly classified as PM10 and PM2.5 due to their small sizes. Generated under high-temperature and high-pressure conditions during braking, they undergo aggregation and oxidation, forming metal oxides in the air. Within atmospheric droplets, these particles ionize and catalyze the formation of hydroxyl radicals and ROS. These particles and their reaction products pose dual threats: they directly harm human health by triggering oxidative stress and inflammation while also catalyzing atmospheric reactions that worsen secondary pollution (e.g., ozone formation via VOC/NOx interactions).

However, several significant scientific uncertainties still make the brake-wear-derived metal pollution unclear. First, the models that track and quantify the variation of these pollutants and predict urban air quality still need further investigation. Interactions between metal particles and other PMs,[11] and the varying levels of pollution caused by different traffic environments still need to be considered in the models.[10] Second, durable brake pad and rotor disc materials that resist wear and minimize particulate emissions, still need to be developed.[11] In addition, capturing airborne metallic particles poses technical challenges, and controlling these particles is also a direction for future research. Finally, from the health impact perspective, the effects of different metal particles on the human body need to be refined.[18]

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SUCCESSIONAL STAGE OVERRIDES MICROTOPOGRAPHY IN STRUCTURING PLANT DIVERSITY IN A TEMPERATE COASTAL DUNE-FOREST ECOTONE

THALIA HE

Understanding the relative importance of successional stage and microtopography in shaping plant diversity is central to community ecology and conservation planning. In this study, we quantified herbaceous plant diversity across early-successional dune habitats and late successional forests in Pinery Provincial Park, Ontario, while assessing whether small-scale elevation differences (<5 m) further structured plant diversity. Using a stratified random sampling design, we established 50 quadrats (1 m × 1 m) across dune and forest hills, recording species composition, percentage cover, and key abiotic variables, including soil temperature and volumetric moisture. Forests exhibited significantly higher Shannon-Wiener diversity than dunes, consistent with predictions from classical successional theory. Elevation did not significantly influence diversity in either habitat ($P > 0.05$), whereas abiotic conditions differed markedly across successional stages. Dune environments were characterized by higher soil temperatures, lower moisture, and dominance by stress-tolerant specialist species, whereas forest understories supported shade-tolerant assemblages with greater compositional stability. These results demonstrate that the successional stage exerts a stronger influence than fine-scale elevation on herbaceous plant diversity in temperate dune-forest ecotones and highlight the importance of maintaining both early- and late-successional habitats for regional biodiversity.

Ecological succession is a fundamental process shaping biological communities, describing predictable temporal changes in species composition and ecosystem structure.[1] This conceptual framework was initially formalized through sand dune studies[1] and later expanded by Clements[2], who viewed succession as a deterministic process culminating in a stable climax community. Modern interpretations, particularly that of Odum[3], emphasize the roles of energy flow and nutrient cycling during ecosystem development. Successional theory predicts that early-stage communities, such as those on recently formed sand dunes, exhibit lower species diversity due to harsh environmental conditions and limited niche availability.[4] In contrast, late successional forests generally support higher biodiversity, driven by increased structural complexity, organic matter accumulation, and nuanced competitive interactions.[5]

Elevation gradients, even at small scales, may further influence successional patterns by generating variation in abiotic conditions and resource availability. While macro-scale altitudinal effects on species distributions are well documented,[6] the ecological significance of minor elevation differences (<10 m) within single habitat types remains poorly understood. Grytnes et al.[7] demonstrated that even small elevation differences can create distinct microhabitats in alpine systems. However, whether

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similar patterns occur in lowland temperate ecosystems requires further investigation.

Pinery Provincial Park, situated along Lake Huron's southeastern shore, provides an ideal setting to examine these interactions. The park features a well-defined dune-forest transition occurring over remarkably short distances, with Carolinian flora that includes both disturbance adapted dune species and shade-tolerant forest understory plants. This system allows for a direct comparison of plant diversity across successional stages while simultaneously assessing the role of micro-scale elevation.

In this study, we examined herbaceous plant diversity across early-successional dunes and late successional forests while simultaneously investigating the effects of micro-scale elevation gradients within each habitat, using the Shannon-Wiener index (H′) to quantify both species richness and evenness.[8] We test two hypotheses: (1) forest habitats support higher plant diversity than dunes due to greater structural complexity and resource heterogeneity, and (2) plant diversity varies systematically along microtopographic elevation gradients within each habitat, reflecting species sorting along environmental gradients. By integrating classical successional theory with contemporary perspectives on microtopography, this research aims to clarify the multi-scale drivers of biodiversity in temperate dune-forest ecotones.

METHODS

Study Area

Fieldwork was conducted in June 2024 within Pinery Provincial Park (43.28°N, -81.80°W), a protected area of approximately 25 km^2 encompassing Carolinian forest and coastal dune ecosystems along Lake Huron's southeastern shore.[9] The park's geomorphology is characterized by a series of parallel sand dunes gradually transitioning into mixed deciduous forest over distances of 200–500 m, forming clearly demarcated successional stages.[10]

Sampling Design and Layout

To assess variation in plant diversity across successional stages and microtopography, we employed a stratified random sampling design. Five dune and five forest hills with slopes of 10–20° were selected, with each hill separated by at least 10 m to maintain spatial independence. On each hill, we established a 5 m transect perpendicular to the slope contours, from the highest point (Q1) to the lowest point (Q5). Along each transect, five 1 × 1 m quadrats were placed for vegetation sampling, yielding 25 quadrats per habitat and a total of 50 quadrats across both successional stages.

Vegetation and Environmental Measurements

All vascular plant species under 40 cm in height within each quadrat were identified to species level using field expertise and verification via the iNaturalist platform, with unidentified individuals recorded as unknown. Percentage cover for each species was estimated using a modified Braun-Blanquet scale, providing standardized measures of presence and relative abundance while minimizing observer bias. Concurrently, soil temperature at 5 cm depth (digital thermometer, ±0.5°C) and volumetric soil moisture content (soil moisture meter, ±0.5%) were measured at each quadrat to characterize local abiotic conditions.

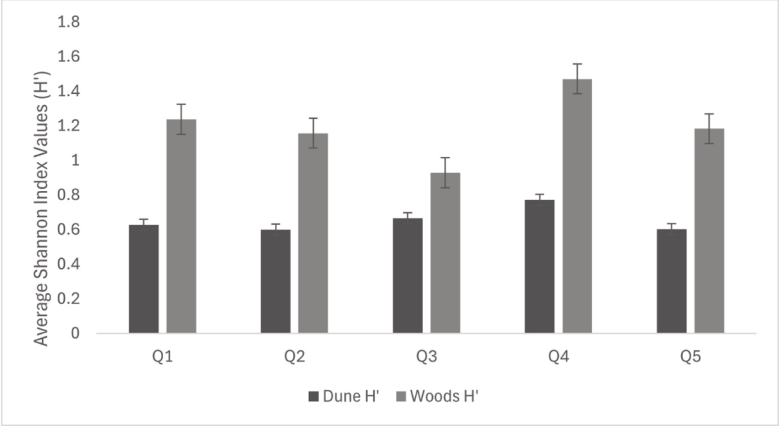

Figure 1: Herbaceous plant diversity in dune and forest habitats at Pinery Provincial Park. Mean Shannon-Wiener diversity index (H′ ± SE) from 1 × 1 m quadrats shows significantly higher diversity in forests than dunes (n = 25 per habitat; Welch's t-test: t = 5.75, df = 5, P = 0.0019).

Data Analysis

Plant diversity was quantified for each quadrat using the Shannon-Wiener index (H′), calculated as H′ = −Σ(pi × ln pi), where "pi" represents the proportional cover of species i. Differences in mean diversity between dune and forest habitats were assessed using Welch's t test to account for unequal variances. One-way ANOVA was used to test for elevation effects within each habitat, with Tukey's HSD post hoc tests applied when significant effects were detected. We used linear regression to test whether diversity varied with abiotic conditions. All statistical analyses were performed in Microsoft Excel using the Data Analysis ToolPak, with $\alpha = 0.05$ as the significance threshold. Results are reported as means ± standard error (SE), and visualizations were produced using Excel. Complete statistical outputs are provided in the appendices to ensure reproducibility.

RESULTS

Plant Diversity Across Successional Stages

Plant diversity differed significantly between successional stages, with forest quadrats showing substantially higher diversity than dune quadrats. The mean Shannon-Wiener diversity index (H′) in forest quadrats was 1.20 ± 0.087 (mean ± SE), nearly twice the value recorded in dune quadrats (0.65 ± 0.032). This difference was highly significant (Welch's t = 5.75, df = 5, P = 0.0019), providing strong support for our first hypothesis. Examination of species composition indicated that forest understories were dominated by shade-tolerant herbs and shrubs, including American witch hazel (*Hamamelis virginiana*), Canada mayflower (*Maianthemum canadense*), and poison ivy

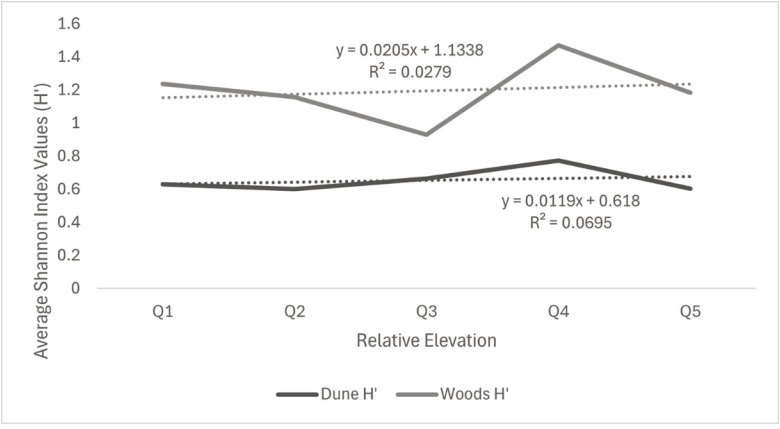

Figure 2: Relationship between elevation and herbaceous plant diversity in dune and forest habitats at Pinery Provincial Park. Shannon-Wiener diversity index (H′) across elevation categories (Q1–Q5) shows no significant relationship between elevation and plant diversity in either habitat, indicating that small microtopographic differences (<5 m) did not structure community diversity.

(*Toxicodendron radicans*), with occasional patches of woodfern (*Dryopteris* spp.). In contrast, dune vegetation was primarily composed of stress-tolerant species adapted to xeric conditions, such as marram grass (*Ammophila breviligulata*), sand cress (*Arabidopsis lyrata*), and field sagewort (*Artemisia campestris*), forming sparse, open communities with minimal vertical structure.

Species Composition and Ecological Strategies

Species composition analyses revealed distinct ecological strategies between habitats. Forest quadrats contained 23 species in total, with four species consistently present across quadrats, suggesting stable community assembly. Dune quadrats, by contrast, hosted only 13 species, dominated by grasses and mosses. These patterns are consistent with Grime's CSR framework[11]: forest communities were dominated by competitive and shade-tolerant species, whereas dune communities were dominated by stress-tolerant and ruderal specialists. Notably, apart from one grass species, no species overlapped between the two habitats, highlighting the uniqueness of each community.

Elevation Effects on Diversity

Contrary to our second hypothesis, plant diversity did not vary systematically with elevation within either habitat type. One-way ANOVA for forest quadrats revealed no significant effect of elevation on H′ values ($F = 1.25$, $P = 0.38$), with diversity remaining relatively constant across all five elevation levels (Q1–Q5). Similarly, elevation had no detectable influence on dune quadrats ($F = 0.90$, $P = 0.52$). Post hoc Tukey tests confirmed that no pairwise comparisons between elevation categories were significant in either habitat (all $P > 0.05$). These results suggest that the modest elevation changes

in our study system (<5 m) were insufficient to generate ecologically meaningful microhabitat variation.

Abiotic Conditions

Measurements of abiotic variables revealed pronounced differences between the two successional stages. Soil temperatures in dune habitats averaged 21.7 ± 0.4°C, significantly higher than forest soils (17.9 ± 0.5°C; $t = 6.12$, $P < 0.001$). Similarly, soil moisture content was considerably lower in dunes (1.26 ± 0.03% volumetric water content) compared with forests (2.11 ± 0.03%; $t = 7.84$, $P < 0.001$). These differences were consistent across elevation categories within each habitat, which may explain the lack of elevation effects on diversity. The dense forest canopy appeared to buffer understory conditions from temperature extremes and moisture loss, supporting higher species coexistence, whereas the open dune environment imposed greater environmental stress, filtering communities toward a small set of stress tolerant specialists.

DISCUSSION

Successional Stage Effects on Diversity

The higher plant diversity observed in forests than in dunes is consistent with classical successional theory and resource-based models of community assembly. Our findings align with Odum's[3] prediction that later successional stages develop greater biodiversity through increased niche differentiation and resource partitioning. The forest understory's structural complexity, with multiple vegetation layers and abundant decaying wood, likely provided diverse microhabitats that facilitated species coexistence. This interpretation is further supported by Huston[12], who demonstrated that moderate resource availability in intermediate and late successional stages maximizes diversity by mitigating competitive exclusion. In contrast, dune communities exhibited typical early-successional characteristics, with low diversity dominated by stress-tolerant species adapted to harsh abiotic conditions. Sparse vegetation and open canopy in dunes likely resulted in higher environmental stress, particularly from temperature extremes and low soil moisture, imposing strong abiotic filters that constrained species establishment and persistence.

Elevation and Microtopographic Effects

Contrary to our second hypothesis, plant diversity did not vary systematically with elevation within either habitat. This contrasts with studies of more topographically complex systems, such as those by Grytnes et al.,[7] who reported significant changes in diversity along altitudinal gradients in alpine ecosystems. The discrepancy likely reflects differences in the magnitude of environmental variation: alpine studies examined gradients spanning hundreds of meters, whereas our elevation differences were typically <5 m. Consistent abiotic measurements across elevation categories, combined with the buffering effect of forest canopies, likely minimized microhabitat variation in our system. Scherrer and Körner[13] found niche partitioning over elevation differences as small as 0.5 m in alpine zones. Clark et al.[14] likewise found that microtopographic gradients <5 m influence seedling establishment in tropical forests. Our null results suggest that lowland temperate herbaceous communities may require greater

topographic variation to exhibit measurable diversity changes.

Methodological Considerations

Several methodological factors may influence interpretation. First, focusing on plants <40 cm excluded taller understory species, which might respond differently to microtopography. Second, the relatively small spatial scale (25 quadrats per habitat) may have limited detection of subtle diversity patterns, although consistent abiotic measurements suggest the main trends are robust. Third, single-season sampling provides a snapshot rather than a temporal perspective, and multi-year monitoring could reveal seasonal or interannual variation in diversity patterns. Finally, although we measured temperature and moisture, other variables such as soil nutrients, especially nitrogen and phosphorus, and light availability may also help explain the observed diversity patterns.[15]

Implications for Climate Change

Our findings indicate that dune communities may be particularly vulnerable to climate change due to their narrow physiological tolerances and sensitivity to abiotic stress. Projected increases in temperature and lake-level fluctuations could exceed the tolerance limits of key dune stabilizers such as *Ammophila breviligulata*, potentially accelerating succession and altering community composition.[16] Long-term monitoring is recommended to track these dynamics.

Conservation and Management Implications

These results have important implications for managing dune-forest ecotones. The marked diversity differences between successional stages underscore the value of maintaining habitat heterogeneity within protected areas. While late-successional forests harbor higher species richness, early-successional dune habitats support unique specialist assemblages that contribute to regional gamma diversity. The apparent insensitivity of diversity to microtopography suggests that conservation strategies may prioritize broader habitat characteristics over fine scale terrain features. However, caution is warranted, as other taxa (e.g., arthropods, soil microbes) might respond differently to microtopographic variation. Future research could examine long-term successional trajectories and assess how climate change may alter dune-forest dynamics through shifts in disturbance regimes and species interactions. This would improve our understanding and conservation of these dynamic ecotones.

CONCLUSION

Our study demonstrates that the successional stage exerts a stronger influence than fine-scale microtopography on herbaceous plant diversity in temperate coastal dune-forest ecotones. Late-successional forests support higher species richness and compositional stability, while early-successional dunes harbor unique stress-tolerant specialists. Minor elevation differences (<5 m) did not significantly affect diversity, highlighting the dominant role of habitat type over microtopography in structuring plant communities. These findings underscore the importance of preserving both early- and late-successional habitats to maintain regional biodiversity and suggest that conservation strategies in lowland dune-forest systems may prioritize habitat-level characteristics

over fine-scale topographic variation. Long-term monitoring will be critical to understanding how climate change may shift the balance between these dynamic ecosystems.

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Appendix 1: *Complete Vegetation Raw Data From All Sampled Quadrats in Dune and Forest Environments at Pinery Provincial Park. Data include hill numbers and angles, elevation category (Q1–Q5), all recorded plant species with Braun–Blanquet cover-abundance values, and calculated Shannon–Wiener diversity indices (H′).*

Location: wilderness hill 1					
Angle: 10°					
	(top) %Cover of the Species (bottom)				
Species	Q1: 1m	Q2: 2m	Q3: 3m	Q4: 4m	Q5: 5m
Quercus velutina	0.2	0.5	4	2	0.2
Hamahelis virginiana	1	25		5	7
Maianthemum canadense	20	10	7	10	10
Fern A	1		1	1	
Bush A	15	1	5	5	
Grass A	1	2	1	2	1
Toxicodendron radicans				2	4
Opposite forb					9
temp (°C)	20	25	20	20	24
moisture (%)	1.5	2	1.8	2	2.1

Location: wilderness hill 2					
Angle: 13°					
	(top) %Cover of the Species (bottom)				
Species	Q1: 1m	Q2: 2m	Q3: 3m	Q4: 4m	Q5: 5m
Quercus velutina	1				0.5
Hamahelis virginiana	4				
Maianthemum canadense	8	8		2	4
Bush A		2	1		
Grass A	1	2	1		1
Toxicodendron radicans		1	1	1	0.5
Opposite forb	80	30	70	40	80
Polygonatum pubescens		2			
Geranium maculatum		1			
Prunus virginiana				5	
Sanguinaria canadensis				10	
Sarsafras (?)				5	
temp	19	21	22	18	20
moisture	2.1	2.2	1.5	2.5	2

Location: wilderness hill 3					
Angle: 12°					
	(top) %Cover of the Species (bottom)				
Species	Q1: 1m	Q2: 2m	Q3: 3m	Q4: 4m	Q5: 5m
Quercus velutina	0.1	3		1	2
Fern A	1			0.3	
Maianthemum canadense	4	7	10	10	20
Bush A	1			0.5	
Grass A	2	1	5	2	1
Toxicodendron radicans	2	1			
Bush B	3	1			
Polygonatum pubescens	1				
Prunus serotina		1			
Prunus virginiana	4				
Pinus resinosa			1		
Fern B			0.5		1
temp	15	13	12	15	19
moisture	2	1.9	2.1	2	1.9

Location: sand dune hill 1					
Angle: 17.5°					
	(top) %Cover of the Species (bottom)				
Species	Q1: 1m	Q2: 2m	Q3: 3m	Q4: 4m	Q5: 5m
moss A	90	95	90	100	80
Arabidopsis lyrata	1	0.1	0.1	0.1	0.2
forb A	2				
Maianthemum racemosum		1	2	1	0.5
Prunus virginiana			1.5		
grass A	5	8	5	6	15
temp (°C)	20	19	21	21	24
moisture (%)	1.2	1.2	1	1.3	1.5

Location: sand dune hill 2					
Angle: 20°					
	(top) %Cover of the Species (bottom)				
Species	Q1: 1m	Q2: 2m	Q3: 3m	Q4: 4m	Q5: 5m
Artemisia campestris	10	6	1	1	1
Arabidopsis lyrata	0.2	0.2	0.1	0.1	
grass A	41	32	33	20	18
Prunus pumila				10	8
temp	25	23	22	26	23
moisture	1	1	1	1	1

Location: sand dune hill 3					
Angle: 17°					
	(top) %Cover of the Species (bottom)				
Species	Q1: 1m	Q2: 2m	Q3: 3m	Q4: 4m	Q5: 5m
Shrub B heart shaped	3	6	3	8	1
Arctostaphylos uva-ursi	60	25	15	15	40
grass A	2	18	12	25	15
Forb B			1	0.5	
Shurb C		1.5			
temp	24	28	30	30	27
moisture	1.8	1.8	1.8	1.5	1

Location: wilderness hill 4					
Angle: 16°					
	(top) %Cover of the Species (bottom)				
Species	Q1: 1m	Q2: 2m	Q3: 3m	Q4: 4m	Q5: 5m
Quercus velutina	2	2	20	1	4
opposite forb	2	2		2	
Maianthemum canadense	2	2	3	4	4
fruticose lichen	1				
Grass A	2	4	5	6	4
Toxicodendron radicans	4	1	1	1	2
moss	2		3	0.5	
Hamamelis virginiana			40	5	
Prunus serotina				4	
Prunus virginiana	10	15		2	
Bigtooth aspen					3
Geranium maculatum					2
temp	19	15	14	13	12
moisture	2.3	2.4	2.6	2.3	2.4

Location: wilderness hill 5					
Angle: 10°					
	(top) %Cover of the Species (bottom)				
Species	Q1: 1m	Q2: 2m	Q3: 3m	Q4: 4m	Q5: 5m
Quercus velutina				5	3
opposite forb	70	70	90	40	
Maianthemum canadense	4	10	2	4	10
Fern A	2	10	5	2	15
Grass A	2	2	3	3	4
Toxicodendron radicans	2			3	1
Rose	2	1	2	2	1
Purple flower	1	0.5	1	0.5	2
unknown berry			15	6	
Prunus virginiana	3				20
Geranium maculatum		2	1	10	3
temp	20	21	20	15	16
moisture	3	2.2	2.2	2	1.8

Location: sand dune hill 4					
Angle: 12°					
	(top) %Cover of the Species (bottom)				
Species	Q1: 1m	Q2: 2m	Q3: 3m	Q4: 4m	Q5: 5m
Moss A	20	80	20	50	20
Arctostaphylos uva-ursi	10	3	7	7	7
grass A	2.3	7	20	7	10
Artemisia campestris	0.2	0.1			
Arabidopsis lyrata	0.1	0.1	0.1		0.1
forb A		0.2	0.1	0.5	1
Whitecedar			1	2	
temp	28	28	28	29	25
moisture	1.1	1.1	1.1	1.1	1.3

Location: sand dune hill 5					
Angle: 10°					
	(top) %Cover of the Species (bottom)				
Species	Q1: 1m	Q2: 2m	Q3: 3m	Q4: 4m	Q5: 5m
Arctostaphylos uva-ursi	10	5	5	15	
grass A	15.2	23	30	8	7
Artemisia campestris	1.5			1	
Shrub B	0.5		0.1		
forb A	1	2	2	1	
temp	30	25	35	30	31
moisture	1.8	1.1	1.3	1.2	1.2

Appendix 2: *Abiotic Measurements and Habitat Comparison Statistics. (A) Raw soil temperature (°C) and moisture content (%) data for all quadrats in both environments. (B) Results of Welch's unequal variance t-test comparing the two mean abiotic factors between dune and forest habitats.*

	Forest temp	Dune temp	Forest moisture	Dune moisture
Q1	18.6	21.166667	2.18	1.38
Q2	19	20.5	2.14	1.24
Q3	17.6	22.666667	2.04	1.24
Q4	16.2	22.666667	2.16	1.22
Q5	18.2	21.666667	2.04	1.2
Mean	17.92	21.733333	2.112	1.256
SE	0.4882622	0.4236088	0.030066593	0.031874755
temp t-test	0.0003904		moisture t-test	5.10505E-08
temp t-stat	6.12		moisture t-stat	7.84

Appendix 3: *Mean Shannon-Wiener Diversity Indices by Elevation Category. Mean Shannon-Wiener diversity indices (H′ ± SE) for each elevation category (Q1–Q5) in dune and forest environments.*

	Forest (H')	Dune (H')	t-test (P-value)	0.001956
Q1	1.237157873	0.62855175	t-statistic	5.75
Q2	1.156890809	0.60052177		
Q3	0.928793488	0.66469474		
Q4	1.47045441	0.77229578		
Q5	1.182727835	0.60205843		
	Standard error (SE)			
	0.086637472	0.03186928		
	Mean			
	1.195204883	0.65362449		

Appendix 4: *ANOVA Results Testing Elevation Effects on Plant Diversity. Full one-way ANOVA tables (F-ratio, degrees of freedom, and P-values) for forest and dune environments are analyzed separately.*

Forest ANOVA							
Source of Variation	SS	df	MS	F-value	P-value	F crit (α=0.05)	SS= Sum of Squares
Between Groups (Elevation)	0.15	4	0.0375	1.25	0.38	3.48	df = Degrees of Freedom
Within Groups (Error)	0.12	5	0.024				MS= Mean Square
Total	0.27	9					Fcrit = Critical F-value
Dune ANOVA							
Between Groups (Elevation)	SS	df	MS	F-value	P-value	Fcrit (α=0.05)	
Within Groups (Error)	0.022	4	0.0055	0.9	0.52	3.48	
Total	0.03	5	0.006				
	0.052	9					

EATING MY FEELINGS

Neural Mechanisms of Stress-Eating and Mindfulness Interventions

BILGE GUVEN

Chronic stress, often deemed a silent killer, is part of many people's lives in modern Western society and has an array of negative health effects, including on eating behaviour.[1] These effects are largely explained by dysregulation in the autonomic nervous system in charge of the physiological stress response.[2] Chronic stress-response activation leads to the dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, resulting in irregularities in stress-hormone production (e.g., cortisol), which have cascading effects on other hormone productions, such as leptin, ghrelin, and neuropeptide Y, which regulate perceived hunger and satiety. Chronic stress is also linked to disruptions in the medial prefrontal cortex (mPFC), responsible for higher cognitive functions like behavioural inhibition, attentional control, working memory and emotional regulation.[3,4] Thus, chronic stress has been linked to excess consumption of high-calorie foods, increased feelings of hunger, and emotional- and impulsive-eating behaviours through its impacts on the HPA axis and mPFC.[2,5] Similarly, obesity has been linked to neural alterations involved in its development and continuance, such as in functional connectivity (FC) of regions associated with reward, self-referential processing and emotional regulation (e.g., hypothalamus and reward networks).[6]

In addition to the consequent overeating, chronic stress facilitates increased fat storage and weight gain, which together can lead to obesity and other metabolic and cardiovascular diseases.[1,7,8] In order to reduce such outcomes, mindfulness-based interventions (MBI) have been utilized to target obesity-related eating behaviours, including binge- and emotional-eating, with promising results.[9] Mindfulness meditation training (MMT) is an emerging intervention in health psychology that has been shown to reduce the effects of chronic stress and increase well-being by enhancing interoceptive awareness and emotional regulation, and reducing sensitivity to stress.[10] MMT consists of intentionally directing attention internally and to surroundings, as well as being aware and present in the moment by eliminating distractors and judgments.[11] This practice has been suggested to regulate stress by altering FC in the brain areas pertaining to self-referential processing, reflective awareness, sensory experience and attentional focus,[12] and by impacting the HPA axis to reduce cortisol levels.[13] In a systematic review of 31 studies, the effects of different weight-loss interventions for improving emotional eating were investigated, and it was found that MBIs had a higher interventional effect size than conventional methods such as combined administration of cognitive behavioural therapy with diet and/or exercise.[14] Studies investigating this relationship between MBIs and stress-related eating behaviours have largely relied on self-reported behavioural measures, and the underlying

neural mechanisms have remained unexplored.

To address this gap, Torske and colleagues conducted a pseudo-randomized, actively controlled clinical trial to investigate the influence of MMT on stress-eating and its neural correlates.[15] Participants who self-identified as stress-eaters and reported moderate to high levels of stress were recruited using mailing lists and online advertisements. The pseudo-randomization design of the study refers to how it is not possible for the design to be fully randomized as only those participants who self-identified as stress-eaters and reported moderate to high stress levels (i.e., a subset of the population) were recruited. Sixty-six participants, balanced for sex with 33 female and 33 male participants, were included in the final data analyses. Participants were randomly assigned to complete a web-based MMT program (intervention) or health training (HT) program (active control). This recruitment process may additionally present a sampling bias, wherein participants who volunteer to participate in the study may be different in some way from the population who did not volunteer for participation.[16] Torske and colleagues however mitigated this potential bias by verifying the pseudo-randomization process through comparing the demographic information (age, sex, years of education, body mass index) of the MMT and HT groups, finding no statistically significant differences ($ps > .05$).[15]

The trainings for both MMT and HT groups consisted of daily 15-minute sessions for 31 days and were matched to only differ in the content they delivered. Before and after the MMT/HT completion, participants' resting-state fMRI data, and behavioural self-report data on perceived mindfulness, food-cravings, and stress- and emotional-eating were collected using the Mindful Attention and Awareness Scale (MAAS), Food Cravings Questionnaire-Trait (FCQ-T), Salzburg Stress Eating Scale (SSES), Salzburg Emotional Eating Scale (SEES), and the Restraint scale. The fMRI data were analyzed for FC, identifying the hypothalamus and insula as seed regions due to their involvement in chronic stress and eating behaviours.

The study found that only the participants in the MMT group reported, increased perceived mindfulness via MAAS scores ($p < .01$), decreased food cravings via FCQT scores ($p < .001$), and reduced stress- and emotional-eating via SSES scores ($p < .05$). Critically, the MMT group's behavioural changes were correlated with hypothalamic neural changes, whereas the HT group did not demonstrate FC changes or behavioural correlations. The MMT group demonstrated increased FC between the medial hypothalamus and hub-regions of the default mode network (DMN), like the precuneus and angular gyrus, associated with self-referential thinking. FC decreased between the hypothalamus and the dorsal striatum, a region associated with reward. MMT participants also demonstrated FC increase between the insula and postcentral gyrus — the primary gustatory cortex responsible for taste perception — though this was not accompanied by behavioural correlations.

The findings from the study carry significant implications for health psychology and the management of chronic stress. By analysing both the behavioural and neurobiological changes brought on by MMT, and analysing the ways in which they predict each other, Torske et al. (2024) provide insight into both the behavioural and neural mechanisms involved in regulating stress-eating behaviours and MMT. First, the finding that MMT decreased FC between the medial hypothalamus and dorsal striatum suggests that this intervention can decouple satiety and reward pathways related to food, which are shown to be dysregulated by chronic stress[17] as well as by excessive consumption of palatable foods.[18] Stress-eating most often involves these types of readily available foods, high in sugar and fat.[1] The FC change in the MMT group being accompanied by a reported decrease in food cravings by MMT trainees highlights how

reward-seeking behaviour related to food can be managed by the intervention. MMT's efficacy in reshaping disrupted reward pathways could also be applied in other domains than eating behaviour to reduce cravings, such as for clinical populations struggling with addiction, as suggested by a study highlighting MBIs' influence on self-regulation and reward processing mechanisms[19].

Secondly, it was observed that MMT increased FC between the hypothalamus and the precuneus, the ventral posterior cingulate cortex, and the angular gyrus, which were respectively correlated with participants feeling more mindful, having less tendencies to stress-eat, and having fewer food cravings. This suggests that MMT resulted in increased self-referential processing, self-awareness and interoception while enhancing the sensory integration of food smell and taste. This adds to existing literature on increased self-awareness as an effective strategy to reduce stress-eating.[20] Moreover, self-awareness is among the protective factors identified against the cognitive harms of chronic stress.[21] In the current study, MMT-induced self-awareness and related processes may have acted as a protective factor, leading to reduced instances of stress-eating. Furthermore, the results provide support for the theory that MBIs enhance well-being through cultivating awareness of internal thoughts, feelings, as well as surroundings and sensations, leading to reduced stress through being present in the moment.[22] This can suggest that other practices that increase interoception, such as art therapy,[23] could also be useful in ameliorating stress-related behaviours such as stress-eating.

Another important finding was that MMT was associated with increased FC between the insula and primary gustatory cortex (postcentral gyrus), suggesting greater sensory integration of the taste and texture components of eating. These findings support self-report studies illustrating that higher sensory sensitivity is linked to higher emotional eating.[24] Notably, insular FC changes

were not correlated with any behavioural scores in the study. This may reflect a limitation of the self-report measures, which did not account for changes in sensory perception. The findings should also be interpreted with nuance to avoid problems of reverse inference, wherein researchers reason "backwards" to interpret a mental state solely from neural activation patterns, instead of "forwards" where they observe a mental state coupled with neural activation patterns.[25] With that being said, these findings point to a potential biological basis for MMT altering sensory pathways in the brain, while encouraging further work on stress-eating behaviours and their relation to the subjective experience of sensation. Additionally, MMT's impacts on reducing stress via increased self- and surroundings-awareness are further supported here as the insula is also implicated in emotional regulation, attentional control and interoception.

This research also contributes to building a more robust scientific understanding of MBIs, which have been widely criticized for their methodological and conceptual shortcomings due to lack of active control groups and administration by individuals without necessary training.[26] One of the authors of the study discussed, Hölzel, is a researcher certified in mindfulness practices and has a background in medicine and psychology, and used her expertise in developing and administering the MMT intervention. The study also included an active control group (HT), creating a methodologically and conceptually sound research design.

The study by Torske and colleagues illuminates the mechanisms behind how MBIs work, as they are able to alter processes related to stress at the neural level.[15] This research paves the way for wider acceptance and implementation of MBIs, as it demonstrates both biologically and behaviourally the mechanisms by which MMT leads to positive health outcomes related to stress-eating. The study aligns with the

widely accepted biopsychosocial model in health psychology, which highlights the biomedical, psychological and social context of health. By connecting behaviour with bodily processes and providing an easily accessible intervention with reduced psychological and social barriers (e.g., monetary costs, effort), the study puts forth a promising intervention to promote healthy behaviour outcomes in the stress-eating domain. These outcomes can potentially be applied to other domains with further design of training programs, such as ones targeting clinical populations like eating disorders and addiction.

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LITERATURE REVIEW: WHAT DO MAGIC MUSHROOMS DO FOR INFLEXIBLY DEPRESSED ADULTS?

HANNAH Z. WAN

The human organism is a highly sensitive ecosystem in which emotional, cognitive, and physiological processes are intricately integrated into a dynamic whole influenced by external stimuli.[1] Major depressive disorder (MDD) is a pathologically complex condition that affects this ecosystem at all its levels, thus manifesting as simultaneous systematic impairments at the emotional, cognitive, and physiological levels. Indeed, MDD is primarily defined by negative affect and executive dysfunction, but also marked by pervasive physical symptoms.[2] Critically, MDD represents a global health crisis whose urgency is underscored by estimations that it will become the leading cause of disability by 2030.[3] This article seeks to show that understanding MDD through cognitive inflexibility yields coherent mechanistic models for both the condition itself and promising mechanism-based treatments. Specifically, it will explore how the beneficial therapeutic effect of psychedelics can be understood via their neuroplasticity-mediated increases in cognitive flexibility.

A key level of analysis for understanding MDD is executive function (EF), the domain that encompasses all cognitive functions related to behavioural control. The prefrontal cortex (PFC), the central hub of executive control, is one of the most consistently impaired regions in MDD.[4] Here, cognitive flexibility (CF) is the EF component that enables adaptive shifts between mental schemas in response to changing contexts, and it is supported by a distributed PFC network. Its dysfunctional counterpart, cognitive inflexibility (CI), is a core feature of MDD that manifests as repetitive negative thoughts (e.g., rumination), rigid thinking, and emotional inertia.

Performance monitoring is another relevant executive function in many psychopathologies. The anterior cingulate cortex (ACC) is the neural hub for this EF, where it is tasked with detecting errors, conflicts, and feedback. Importantly, ACC dysfunction is a reliable biomarker of MDD, linked to negative cognitive biases and broader emotional processing deficits. Some of these deficits may stem from upstream impairments in CF: inflexible regulation of ACC function (rather than simple over- or underactivity) predicts poor performance on ACC-dependent tasks in MDD.[5] This suggests CF is a prerequisite for optimal functioning of other cognitive control components, underscoring its importance for health. At the very least, CF is essential to effectively navigate the unpredictable challenges of daily life and for the resilient adaptation needed to overcome hurdles, as evidenced by the correlation between higher CF with fewer depressive symptoms and greater well-being.[6]

Ultimately, cognitive dysfunction, especially inflexibility, may create a vicious cycle: it seemingly predisposes individuals to depression while also impairing the cognitive capacities needed for recovery.[7]

At the neurophysiological level, MDD is characterized by aberrant

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neuroplasticity.[8] Neuroplasticity is the brain's capacity for adaptive, activity-dependent structural and functional changes, ones supported by biochemical processes driving synaptic growth, dendritic branching, and neuronal connectivity.[9] Importantly, CF and neuroplasticity are distinct but bidirectionally linked: engaging CF can promote neuroplastic processes, while experiences that foster neuroplasticity can enhance CF.[10] While it is a general property of the nervous system, intact PFC neuroplasticity is particularly essential for cognitive control, and especially for CF.[11] Given that MDD involves profound impairments in cognitive control, PFC neuroplasticity deficits are thus strongly implicated in its pathophysiology. Some researchers believe that aberrant neuroplasticity does not directly cause MDD symptoms but may instead act as a mediator, disrupting cognitive control and thereby promoting depressive pathology.[11] Accordingly, the demonstrated clinical effectiveness of experimental MDD treatments that target neuroplasticity (e.g., psychedelics therapy) is sometimes theorized to result from their reinstatement of the cognitive flexibility necessary for recovery via neuroplastic changes.[12]

Taken together, these findings highlight the clinical importance of targeting CF and neuroplasticity in MDD. This need is intensified by the rising global prevalence of depression and the limited efficacy of conventional treatments. Notably, interventions that directly enhance neuroplasticity yield more consistent improvements than those targeting CF, both in their mechanistic effects (on neuroplasticity and CF) and in clinical outcomes. Among these, psychedelic therapies are especially promising, producing robust neuroplastic changes alongside lasting reductions in depressive symptoms. Thus, this review will examine psychedelics, focusing on how they may exert their therapeutic effects through mechanisms involving neuroplasticity and specifically CF. First, we synthesize evidence from neurocognitive studies to define the neural basis of CI in psychiatric populations. Next, we examine the mechanistic framework proposed by van Elk and Yaden,[9] which outlines the biochemical processes of neuroplasticity relevant to therapeutic change. We then assess where the selected studies converge, how their methods and models diverge, and what critical gaps remain. Ultimately, we seek to synthesize a coherent framework explaining how psychedelics alleviate depressive symptoms by simultaneously modulating neuroplasticity at the biochemical level and cognitive control at the functional level.

Research on CF and neuroplasticity offers a cohesive, multi-level account of how psychedelics may induce lasting adaptive change in MDD by integrating complementary cognitive and physical processes within a holistic framework. In the selected studies, the universal use of neuroimaging can be seen as the bridge that allowed constructs as different as behavioral, cognitive, and biochemical measures to ultimately be comparable. Let us begin at the cognitive level, where foundational work by Yerys, Gu, Remijnse, and colleagues highlights the neural correlates of CI in psychiatric populations. Using variations of the task-switching paradigm, these studies inferred aberrant CF from behavioural measures such as delayed application of new task rules. Across disorders including OCD, ASD, and MDD, patient groups consistently demonstrated elevated switch costs (i.e., longer response times or increased errors) relative to healthy controls. Crucially, these deficits were linked to reliable neural correlates, with neuroimaging consistently implicating abnormal activity in PFC regions — notably the dorsolateral PFC (superior and middle frontal gyri) — and the ACC, which emerged as a key locus of dysfunction across disorders.

At the neurobiological level, van Elk and Yaden provide insight into the biochemical mechanisms by which psychedelics exert downstream effects on pathology.[9] Their review synthesizes findings from protein analyses and neuroimaging studies,

converging on psychedelics' ability to both enhance neuroplasticity and improve clinical symptoms. Mechanistically, psychedelic compounds act as agonists at cortical 5-HT2A receptors, producing a glutamate surge in the medial PFC. This cascade upregulates enzymes and learning-related proteins that promote synaptogenesis, dendritic growth, and neurogenesis, changes which are then corroborated by neuroimaging evidence of altered functional connectivity. Given that intact neuroplasticity may be essential for PFC-mediated cognitive control and disrupted PFC function may promote MDD symptomatology,[11] the fact that psychedelic-induced plasticity initiates in the PFC is particularly significant. These findings suggest a direct pathway through which psychedelics may restore PFC functional capacity and, in turn, CF; then, this heightened CF may contribute significantly to MDD patients overcoming their symptoms. In other words, these studies lend support to the theory that psychedelics are an effective treatment through their induced-neuroplasticity's direct effect on CF.[12]

Now, the convergence of cognitive and biochemical findings has similarly important implications for understanding ACC function in MDD. First, consistent evidence of ACC dysfunction in CF-deficient groups aligns with its link to CI-related symptoms in MDD, such as negativity bias,[13] underscoring the ACC's central role in depressive pathology. Second, because the ACC lies within the medial PFC (the site where psychedelics stimulate synthesis of neuroplasticity-related proteins) it may be especially responsive to psychedelic-induced remodeling.[9] Together, these insights refine the mechanistic account: psychedelics biochemically promote structural and functional rehabilitation of the PFC, particularly the ACC, thereby restoring CF and enabling disengagement from rigid, negatively biased processing. This more precise model also supports literature attributing psychedelics' efficacy in MDD to their effects on negative cognitive bias.[14]

Critically, although this paper has focused on a neuroplasticity account, it is only one of several theories proposed to explain psychedelics' clinical efficacy — most of which do not implicate CF, neuroplasticity, nor the PFC. Van Elk and Yaden themselves caution that the neuroplasticity model may not be sufficiently specific to account for psychedelics' clinical efficacy, since many other manipulations (e.g., pharmacological, environmental) can also induce neuroplasticity without producing the same benefits.[9] One alternative theory implicates psychedelics' anti-inflammatory effects, a mechanism relevant given the link between MDD and immune dysregulation.[15] Other theories recruit still broader levels of analysis. For example, a psychological account emphasizes the subjective, "mystical" experience of psychedelics, suggesting that shifts in self-concept and connectedness with the world are central to therapeutic efficacy.[16] Meanwhile, a neurocognitive account proposes that psychedelics inhibit a thalamic filter, thereby intensifying sensory processing and creating a state akin to psychosis. This altered sensory integration may in turn produce long-lasting changes in world-perception that help reframe previously maladaptive patterns.[9]

To be sure, the diversity of well-supported theories which imply seemingly unrelated or incommensurable mechanisms should not be seen as contradictory, but as complementary. Indeed, the convergence of studies on distinct constructs (e.g., cognitive flexibility and neuroplasticity) across very different levels of analysis (from abstract cognitive processes to concrete physical changes) into a coherent model highlights the human organism as a delicately integrated ecosystem, blurring the line between mind and body. In fact, understanding a condition as complex as depression may require radical methodological diversity, as its symptoms not only span affective, cognitive, and physiological domains, but exhibit complex inter-domain influences. For instance, distress can cause insomnia, which in turn may impair thinking while causing

constipation, which altogether may create new loops of affective, cognitive and physical alterations. Thus, some or all of the different accounts may represent complementary components of a unified explanation to how psychedelics improve MDD.

An important gap in the literature on psychedelics for MDD concerns their effects in populations with comorbid conditions, who may differ substantially from typical MDD patients in etiology, symptom profiles, and treatment response. A particularly complex subgroup is autistic individuals, who show disproportionately high rates of depression and treatment-resistant depression.[17] Since psychedelic therapy is typically reserved as a last-line treatment for resistant depression,[18] its relevance to this group is evident. Yet no trials have examined psychedelic use in autistic individuals with MDD, nor in autistic populations in any context.[19] This gap is critical because autism often involves sensory hypersensitivity, which could interact unpredictably with hallucinogenic effects.[20] Moreover, ASD features rooted in CI (e.g., restrictive and repetitive behaviours) may intensify MDD-related CF deficits.[21] MDD and ASD already often reinforce one another in negative feedback loops, contributing to elevated rates of alexithymia, suicidality, and anxiety in depressed autistic individuals. Collectively, these factors underscore the urgent need for effective interventions.

Another limitation of this review concerns the homogenized interpretation of CF findings across psychiatric groups. Behavioural and neural measures were simplified as "consistently abnormal activation across patient groups," yet the landscape is more nuanced. For instance, Remijnse et al. found anterior PFC hypoactivation during switch trials in MDD, whereas Yerys et al. observed hyperactivation in overlapping regions in ASD.[22] This illustrates that similar behavioural manifestations of CI may arise from distinct neural mechanisms. This limitation is particularly relevant for comorbid ASD-MDD populations. If psychedelics have consistently similar metabolic effects across psychiatric groups whose underlying neural circuitry differs, treatments that alleviate MDD may produce divergent or maladaptive effects in ASD-MDD patients. Conversely, differential metabolism across different psychiatric groups would similarly undermine generalizing MDD findings to autistic populations. In both cases, the absence of direct evidence leaves substantial uncertainty regarding safety and efficacy in comorbid populations.

To address and clarify these gaps, it will be critical to conduct a pilot trial examining the effects of psychedelics in autistic populations, with particular attention on constructs such as CI, neuroplasticity, and pathological presentations. Such studies will provide the necessary evidence regarding the safety and effectiveness of targeted psychedelic treatments for ASD populations, who remain in urgent need of effective interventions and whose responses to psychedelics are currently unknown. One review points to preliminary evidence suggesting potential benefits of psychedelics for both core ASD symptoms (e.g., behavioural atypicalities) and highly comorbid conditions such as anxiety and MDD.[19] An initial trial might adopt an open-label design, where psychedelic administration is paired with psychotherapy to maximize therapeutic benefit. Importantly, the study should also integrate dense sampling neuroimaging to capture pre- and post-treatment changes across multiple dimensions (e.g., reductions in MDD symptoms versus lack of therapeutic effect, or changes specifically within CF measures), thereby offering a fuller picture of psychedelics' lasting impact on the ASD-MDD brain.

In summary, MDD reflects a breakdown of interactions among cognitive, emotional, and physiological processes, marked by impaired executive function and impaired neuroplasticity. The experimental studies discussed here consistently linked CI to psychiatric groups, a dysfunction that was linked to the executive control network,

particularly the dlPFC and ACC. Critically, research on psychedelics shows that these same regions, especially the ACC, are primary sites of neuroplasticity promotion. Together, this lends a cognitive and physical basis to the view that psychedelics may improve MDD by enhancing cognitive flexibility and other critical cognitive components via neuroplastic action, leaving patients with a remodeled PFC. Yet, the symptom relief associated to this experimental treatment likely arises not from neuroplasticity alone, but from a combination of actions at various levels (e.g., neuroplastic, immunomodulatory and psychological). Given that this proposed mechanism specifically highlights that psychedelics are particularly effective in addressing CI, the reliability of its efficacy and safety needs to be tested in understudied populations where CI is a salient and distinct feature to help develop targeted future clinical treatment. Autistic individuals represent a critical cohort given their high rates of treatment-resistant MDD and pronounced CI. Studying this population could clarify whether induced neuroplastic changes can reverse CI in complex presentations while retaining benefits for MDD, research which would ultimately serve to further validate CF-related neuroplasticity as a core mechanism of psychedelic treatment.

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IN THE HEIGHTS

Spruce-Labrador Tea Rust (Chrysomyxa sp.) on White Spruce (Picea glauca) in Relation to Tree Height and Presence of Bog Labrador Tea (Rhododendron groenlandicum)

MICAH TAN

Rust fungi are parasitic plant pathogens that infect agriculturally and commercially important plants, making them an economic concern. They typically require two unrelated host plants to complete their life cycle. An unusually large outbreak of spruce-Labrador tea rust in the genus Chrysomyxa occurred on white spruce (Picea glauca) at our study site in Churchill, Manitoba, in summer 2025. To investigate the effects of primary-host abundance and proximity on rust abundance, we quantified bog Labrador tea (Rhododendron groenlandicum) within 10 m of infected trees and recorded the distance between the two plant species. To investigate how rust is distributed across the height of white spruces, we quantified rust abundance after dividing trees into 1 m sections of their heights. Rust abundance increased with bog Labrador tea abundance, but no effect was detected for proximity to bog Labrador tea. In addition, rust abundance increased with tree height and was greatest 2–4 m above the base of the trees. These results are consistent with previous research on rusts and provide insight into the spread of Chrysomyxa rusts in North America.

Keywords: White spruce, bog Labrador tea, rust fungi, plant pathogen, plant parasite

Parasites are organisms that depend on a host to survive. Parasitism usually has a negative impact on the host organism, such as mortality or sterilization.[1] As a result, some parasites are pathogens that are studied in the contexts of epidemiology and health.[2] Independent evolutionary shifts to parasitism occurred several hundred times in eukaryotes.[1] Parasite-host coevolution occurs as hosts adapt to resist infection, making parasitism a significant relationship in evolutionary biology.[3]

Rust fungi, or rusts are in the order *Pucciniales*, one of the largest orders of fungi.[3] Rusts are plant parasites that require living hosts to grow and reproduce, a process known as obligate biotrophy.[4] More than 8000 species are described in the order, making it the largest group of plant pathogens.[5] Rusts infect agricultural crops and timber trees, making them a significant economic concern.[4] Rusts have high host specificity and complex life cycles. They are typically heteroecious, where they require five spore stages and two unrelated species of host plants to complete their life cycle. Temperate rusts species overwinter on their primary host, or sporothallus, before being transmitted to their secondary or gametothallus host during the growing season.[3]

Chrysomyxa is a genus of heteroecious rust fungi which causes spruce needle and cone rust diseases. The primary host is typically a shrub in the *Rhododendron* genus, while the secondary host is a spruce tree in the *Picea* genus.[5] *Chrysomyxa* are widespread in the northern hemisphere, with spruce rust outbreaks occurring in China,[5] Europe,[6]

and Canada.[7,8] Some *Chrysomyxa* species negatively impact host spruces, such as *C. rhododendri* infections decreasing photosynthetic rate in Norway spruce.[6] Two species of *Chrysomyxa*, *C. nagodnii* and *C. ledicola* affect species found at the study site of Churchill, Manitoba. They share bog Labrador tea (*Rhododendron groenlandicum*) as a primary host and white spruce (*Picea glauca*) as a secondary host. The spores released during transmission from one host to another are airborne. Both species infect current year needles, which may cause early defoliation. However, the two species differ in spore sizes and are indistinguishable on spruces without microscopy.[7,8]

White spruce is an economically important commercial plant in Canada, with the softwood industry valued at $10 billion in 2020.[9] However, recent research on how North American spruce–Labrador tea rusts are distributed on hosts, and on the factors that influence infection severity, remains limited. There was an unusually large spruce rust outbreak at the study site at the time of data collection (a personal observation). This outbreak provided the opportunity to study the distribution of rust on the host spruces, as well as several factors that may influence the presence of rust on spruces. We predicted that rust on white spruce, the secondary host, increases with abundance and proximity of bog Labrador tea, the primary host. We also predicted that there would be more rust at lower heights of white spruces as bog Labrador tea height would limit the height to which spores can travel.

METHODS

Study Site

The investigation was carried out in the boreal forest near the Churchill Northern Studies Centre in Churchill, Manitoba. The region is Subarctic and has both tundra and boreal habitats. The forest is right at the treeline and is characterized by short trees and low tree diversity (P. Kotanen, personal communication, July 2025). White spruce *(Picea glauca)* is the dominant tree species.

Data Collection

Data collection was done at 20 sites in the boreal forest from August 1 to August 3, 2025. Each site was at least 200 m apart to reduce the likelihood of each site affecting each other.

Three white spruces were sampled at each site. All trees sampled were located along roadsides for ease of access and maintaining a constant microenvironment. We measured tree height and trunk circumference at the base of each tree, using circumference as a proxy for age, and photographs were taken of each sampled tree for analysis of rust quantity. A total of 59 trees were used in this experiment, excluding one site that did not have usable photographs. For trees that were too tall to be measured directly (>180 cm), a stick of known height (124 cm) was placed beside it, and a photograph was taken (Figure 1). Tree heights were then approximated using the stick as a scale on GNU Image Manipulation Program (GIMP) version 3.0.4.[10]

Visual estimates from the photographs were used to quantify rust. Branch ends of entire trees as well as each 1 m high section were analysed and assigned values between 0.1–0.9 to denote the proportion of new leaves infected with rust. This variable was termed "rust abundance" for this investigation. This visual estimate accounted for both the number of orange needles and the intensity of their colour (Figure 2).

A 10 m transect was taken at each site to quantify bog Labrador tea, starting from the sampled trees at the roadsides and extending into the boreal forest. Presence

Figure 1: Photographs of White Spruces Taken During Data Collection. A) A stick of known height was placed next to the tree for scale. This method was used for all trees above 180 cm. B) An image of a 369.5 cm-tall tree was divided into 1 m tall sections to quantify rust in each section. The sections from the bottom upward are 1 m, 2 m, 3 m and 4 m. Divisions were made for all trees taller than 1 m.

Figure 1: Pictures of *Chrysomyxa* on White Spruce Needles. The number of orange needles and the intensity of the orange colour were used to estimate the proportion of new leaves infected with rust. A) Low rust, 0.1. B) Medium rust, 0.4. C) High rust, 0.8

or absence of bog Labrador tea was recorded every 0.5 m using a 0.5 m x 0.5 m quadrat. We recorded the total number of quadrats with Labrador tea present, as well as the distance of the closest patch of Labrador tea to the sampled trees.

Data Analysis

All statistical analyses were conducted using R version 4.5.0.[11] All graphs were generated using the R package ggplot2.[12] Post-hoc tests for linear models were conducted using the R package emmeans.[13]

A Pearson's product-moment correlation test was conducted between tree height and tree circumference. Linear models were used to examine the effect of bog Labrador tea plot number, the distance of the nearest plot and height of trees on rust abundance.

Rust abundance at different heights of trees were examined using ANOVA. A Tukey test was performed post-hoc.

RESULTS

There was a strong and significant positive correlation between height and circumferences of trees ($r = 0.910$, $t = 16.6$, $df = 57$, $p < 0.001$) (Figure 3). As a result, only tree height was used as an independent variable for this investigation.

Rust abundance increased with the number of bog Labrador tea plots ($\beta = 0.0109$, $t = 2.07$, $df = 57$) (Figure 4A) and tree height ($\beta = 0.000983$, $t = 4.06$, $df = 57$) (Figure 4B). Both independent variables were significant predictors of rust abundance ($p = 0.043$ for bog Labrador tea plot number, $p < 0.001$ for tree height). In contrast, there was no significant effect of distance from the nearest bog Labrador tea on rust abundance ($\beta = -0.00306$, $t = -0.220$, $df = 43$, $p = 0.827$) (Figure 4C).

Rust abundance values in 3 m and 4 m height sections of the sampled trees were higher than the 1 m sections on average. The 3 m sections had a mean rust abundance 0.280 higher than that of the 1 m sections ($p < 0.001$) while 4 m sections had 0.205 higher rust proportion than 1 m sections ($p = 0.040$). All other pairwise differences in average rust proportion lack statistical significance (Figure 4D).

DISCUSSION

Rust abundance increased with bog Labrador tea, consistent with the role of bog Labrador tea as the primary host in this system. This is consistent with similar research on plant pathogens. Several plant pathogens require a minimum host density to spread successfully.[14] While the density and abundance of the secondary host, white spruce, was not investigated, it was likely a contributing factor to the large rust outbreak. The dominance of white spruce with little tree diversity as a buffer made the boreal forest of Churchill an ideal area for the spread of *Chrysomyxa*.[14] Decreasing the number of Norway spruces in forests has been proposed as a method to mitigate the spread of *C. rhododendri* in Europe for similar reasons.[6]

While we predicted that trees which were closer to bog Labrador tea plots would have more rust, proximity of bog Labrador tea did not have any effect on rust abundance. Rust outbreak risk in spruce is reportedly lower when primary hosts are more than 300 m away, with no effect when primary hosts are within that range.[15] A 10 m transect was too short to evaluate dispersal at that scale. Plant pathogens, including

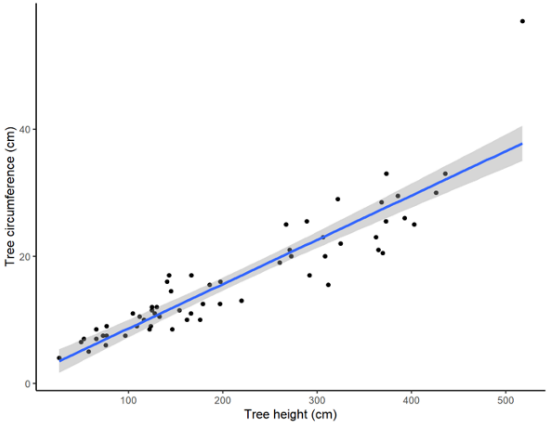

Figure 3: Relationship Between Tree Circumference and Tree Height. There is a strong (r = 0.910) and statistically significant (p < 0.001) correlation between the two independent variables.

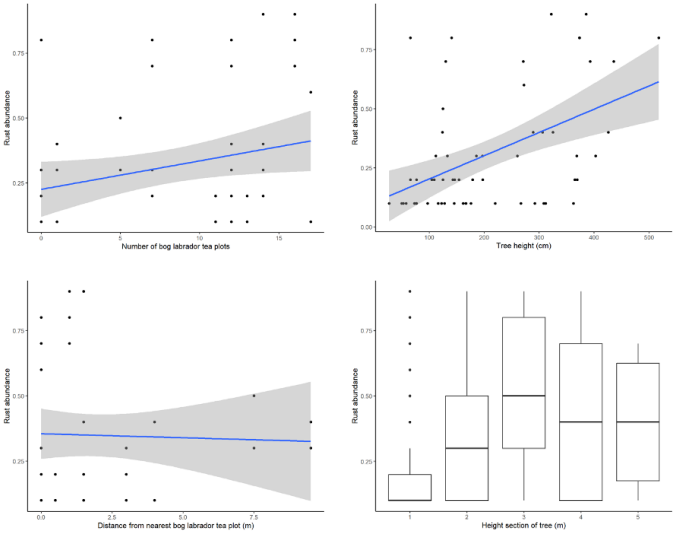

Figure 4: Number of Bog Labrador Tea Plots, Tree Height, Distance From Nearest Bog Labrador Tea Plot and Height Section as Predictors of Rust Abundance. A) Rust abundance increases by 0.0109 with every bog Labrador tea plot (p = 0.043). B) Rust abundance increases by 0.000983 with each cm of a tree's height (p < 0.001). C) No significant relationship found between distance of the trees from the nearest bog Labrador tea plot and rust abundance (p = 0.827). D) Significant differences in average proportion between 3 m and 1 m sections (0.280, p < 0.001) and between 4 m and 1 m sections (0.205, p = 0.040).

rusts transmitted by air, have long dispersal distances.[14] There have been several instances of intercontinental spread of rusts that infect crop plants such as wheat.[2]

Although we did not predict a relationship between tree height and rust abundance, we found a significant positive association between the two variables. It is possible that tree age, not tree height, is a predictor of overall rust abundance. An aerial survey of *C. ledicola* infections in northern British Columbia in 2020 found most infected trees to be 60 to 80 years old.[7,8] Since *Chrysomyxa* causes infected new needles to fall prematurely, it is unlikely that older trees with more rust are a result of infections from the previous year. Ganthaler et al. (2014) found repeated *C. rhododendri* infections to be fatal to saplings while older trees are more likely to survive, as saplings have a higher proportion of susceptible new needles. If *C. nagodnii* and *C. ledicola* cause similar effects, the result of this investigation may be due to survivorship bias towards older trees. However, there is a lack of literature concerning tree age as a predictor of rust infections.

Rust abundance being the highest at 2–4 m contrasted the prediction that lower spruce boughs would have higher abundance of rust. The initial prediction was made as Labrador tea is significantly shorter than white spruce, which may limit spore dispersal. It is possible that the long dispersal distance of *Chrysomyxa* spores negates height limitations by the primary host. However, it should be noted that the accuracy of this result may be limited by the number of taller trees sampled, as only 17 out of 59 sampled trees exceeded 3 m. Further research could be conducted by only sampling trees 3 m and taller for a more reliable result.

The results of this investigation are overall consistent with previous studies on rust abundance and dispersal. A potential future direction for this investigation would be the effects of climate change on rust infections. The Arctic is disproportionately affected by climate change compared to the rest of the globe (P. Kotanen, personal communication, July 2025). Changes in the abiotic environment such as increased temperature, humidity and atmospheric carbon dioxide have been found to impact the survival and spread of rusts[16]. These changes may be the reason larger rust outbreaks and increased long-distance dispersal events have occurred in recent years.[2] *Chrysomyxa* infections of white spruce and bog Labrador tea in Churchill should be studied while accounting for abiotic conditions.

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