

Environmental Justice and the Enforcement of Air Pollution Laws in Canada

by

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B.A., Wake Forest University, 2019

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

(Resources, Environment, and Sustainability)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

October 2021

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Environmental Justice and the Enforcement of Air Pollution Laws in Canada

submitted by Claire Ewing in partial fulfillment of the requirements for

the degree of Master of Science

in Resources, Environment, and Sustainability

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Abstract

Ambient air pollution is one of the leading health and environmental concerns worldwide, including in Canada. To manage air pollution and its impacts, Canadian governments create and enforce various laws and regulations. Most areas in Canada usually experience good air quality, but some communities are disproportionately exposed to harmful air pollution, constituting an environmental injustice. While these concepts of ambient air pollution, environmental enforcement, and environmental justice have each been studied either in isolation or in pairs in Canada, no research has examined the three together. In particular, patterns of enforcement of air pollution laws are understudied, and it is not known whether enforcement varies according to the characteristics of different communities. This study seeks to address these gaps and investigate the nexus of air pollution, environmental law enforcement, and environmental justice in Canada by examining the following research questions:

RQ1: How do enforcement data availability and quality vary between and within provinces?

RQ2: What are the demonstrated models of enforcement? How do they vary across jurisdictions, time, or other factors?

RQ3: What types of violations or offenders appear to be prioritized for enforcement action in Canada?

RQ4: How are the sociodemographic characteristics of areas in which enforcement actions occur different from the provincial averages of those characteristics?

I created a dataset of enforcement actions against air pollution law violations using data gathered from eight provinces and the federal government, which I then analyzed using descriptive statistics and geospatial techniques. I developed a rubric to evaluate and compare jurisdictions' data availabilities and qualities and found that all were generally poor and incomplete, which violates the community right to know and the individual right to information. Through descriptive statistics, I observed that across provincial and federal jurisdictions, regulators appear to employ a cooperative approach to enforcement. Environmental priorities and enforcement outcomes do not seem to align on several levels, especially regarding large emitters and repeat offenders of air pollution laws. Finally, geospatial analyses revealed some environmental injustice patterns related to the location of enforcement actions. I offer several recommendations to improve enforcement strategies within and beyond existing policy systems.

Lay Summary

In this study, I examine the intersection of three concepts. First, air pollution – such as haze from power plants. Second, air pollution law enforcement – the policing of air pollution. Third, environmental justice – the reality that some marginalized communities experience disproportionately high levels of hazards such as air pollution. No previous Canadian research has studied the three concepts together. Accordingly, I analyzed data on the enforcement of air pollution laws from provinces and the federal government. I found that data quality about enforcement was hard to access and of poor quality. Enforcement outcomes do not seem to align with environmental priorities, such as targeting large polluters and minimizing pollution. Regulators appear to work with law violators rather than punish their wrongdoings, which may not be effective for deterring future violations. Finally, enforcement may be inequitably distributed across communities, although more research is needed on this topic. I offer recommendations to improve environmental enforcement and policy concerning air pollution.

Preface

This thesis is the original and unpublished work of Claire Ewing. The research problem was defined by my supervisors Dr. David Boyd and Dr. Amanda Giang. The study was designed with the guidance of Dr. Amanda Giang and Dr. David Boyd and the graduate research design course RES 502 taught by Dr. Stephanie Chang. This thesis is intended for journal publication, with Dr. David Boyd, Dr. Amanda Giang, and Sophie Thornton as co-authors.

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List of Abbreviations

AB: Alberta
AQMS: Air Quality Management System
BC: British Columbia
CAA: Clean Air Act
CAAQS: Canadian Ambient Air Quality Standards
CEPA: Canadian Environmental Protection Act
CO: carbon monoxide
DA: dissemination area
ECCC: Environment and Climate Change Canada
EJ: environmental justice
EPA: Environmental Protection Agency
FOIPOP: Freedom of Information and Protection of Privacy (Act)
NB: New Brunswick
NEMISIS: National Enforcement Management Information System and Intelligence System
NH₃: ammonia
NO₂: nitrogen dioxide
NPRI: National Pollutant Release Inventory
NRCED: Natural Resources Compliance and Enforcement Database
NS: Nova Scotia
OMR: Outlying or Multiple Risk (offense)
ON: Ontario
PE: Prince Edward Island
PM: particulate matter
QC: Quebec
RQ: research question
RSEI: Risk-Screening Environmental Indicators
SK: Saskatchewan
SO₂: sulphur dioxide
US: United States
VOC: volatile organic compounds

Glossary

Compliance: (the state of) obedience to the terms and rules of environmental permits and laws, usually applied to firms and facilities

Enforcement: the administration and prosecution of law violations/noncompliance

Enforcement action: the instrument used to administer or prosecute law violations or noncompliance, such as fines, court convictions, etc.

Environmental justice: the fair distribution of environmental benefits and burdens, and access to decision-making processes that affect this distribution (Global Justice and the Environment 2007)

Environmental injustice: the unfair distribution of environmental benefits and burdens

General deterrence: “the effects of inspections or penalties due to changes in the regulated entities’ perceptions of the overall regulatory environment, [such as] changes in rules or laws governing inspection probabilities, sanction probabilities, or sanction magnitude” (Alm 2014; Stafford 2002)

Noncompliance: (the state of) violating terms or rules of environmental permits or laws

Offense/violation: a breach of air pollution laws or permits

Permits/approvals: an authorization to operate a facility that produces air pollution. Firms or facilities typically apply for a permit or approval from a local or provincial government, and the terms are negotiated between parties. Within the terms of a permit or approval, there may be specifications for what pollutants and how much of them are allowed to be emitted, what pollution abatement equipment is required, what monitoring procedures are required, etc. Permits are typically long-lived documents, rarely revoked and lasting 20+ years before renewal is required. Once signed, they are legally binding, meaning if a facility violates any terms of a permit/approval, it is a law violation.

Specific deterrence: “the effects of inspections or penalties on the future behavior of the monitored or sanctioned firm” (Alm 2014)

Acknowledgements

I would like to express my deepest gratitude to my supervisors, Dr. Amanda Giang and Dr. David Boyd, who gave generously of their kind and supportive guidance throughout my entire program. Thank you for your patience and understanding throughout the many tumultuous processes – all while seeing the bigger picture as I was consumed by the details. You are inspirations in all things!

Thanks to the funding provided through the Social Sciences and Humanities Research Council (SSHRC) Insight Grant (#435-2018-0379) that supported this research.

I greatly appreciate the contributions of the undergraduate research assistants who worked on this project, Rafa Alkalai, Paul Li, and Sophie Thornton. Rafa and Paul were most instrumental in helping to find the specific locations where enforcement actions occurred, which was a significant and much-appreciated time-saver. Sophie Thornton executed the geospatial aspects of this project: processing the demographic data and creating the maps with enforcement actions overlaid. She played a pivotal and essential role in delivering the environmental justice analysis, for which I am immeasurably grateful for her hard work.

Thank you to my department, the Institute for Resources, Environment, and Sustainability, and its focus on interdisciplinarity, which allowed me to pursue other interests simultaneously and combine this research's several disciplines. Thank you to my colleagues and friends inside and outside the department, who helped me think through several aspects of this research and whose support contributed enormously to my wellbeing as we endeavored through the highs and lows of graduate school together.

Thank you ad infinitum to my parents, whose unconditional support has propelled me through every life stage, including this one. A special thank you to my mom, whose above-and-beyond efforts to understand my work and adopt sustainable changes accordingly give me so much hope and will to continue. To you and our red wigglers, I am eternally grateful.

Dedication

To the ponderosa pine, the muscadine grape, the Mediterranean blue, the ochre starfish. To the puzzle, the thrice-tied knot. To the third son, a Song of Myself.

Chapter 1: Introduction

This section introduces the thesis by providing background information on air pollution, enforcement, and environmental justice, a conceptual framework, expected contributions (including research questions), and an outline for the rest of the work.

1.1 Background

1.1.1 Health effects of air pollution

Ambient (outdoor) air pollution poses several human health risks that can lead to disease or premature death. Globally, 25% of deaths and illnesses from stroke, 24% from ischaemic heart disease, 14% from lung cancer, and 9% from chronic obstructive pulmonary disease are attributed to ambient air pollution. Other adverse health impacts can increase with exposure as well, such as the development of asthma, asthma attacks, and depleted lung function (World Health Organization 2018). Approximately 4.4 million people per year die prematurely due to ambient air pollution (Health Effects Institute 2020). These health effects are well documented in Canada (Villeneuve et al. 2007; 2003; Brook Robert D. et al. 2002; Coyle et al. 2003), as are their estimated costs to the Canadian economy (\$120 billion per year, based on 2016 currency (Canada 2021)). According to Health Canada's 2021 "Health Impacts of Air Pollution in Canada" report, approximately 15,300 premature deaths per year can be linked to ambient air pollution – an increase from the 2016 estimate of 14,600 (H. Canada 2016; 2021)).

1.1.2 Emissions Sources

Ambient air pollution comes from several sources, both natural and anthropogenic. Natural occurrences like wildfires, volcanoes, soil erosion, and dust storms can contribute to pollution and poor air quality (ECCC Canada 2004). While several of such natural occurrences are influenced or caused by human behavior, the air pollution from these events is mostly not regulated by Canadian laws, which target anthropogenic air pollution. The notable exception to this rule is provinces' regulation of open burns (fires started by humans that can turn into wildfires); as will be demonstrated, many offenses violating open burn policies are enforced. Canadian laws focus on anthropogenic air pollution. Anthropogenic air pollution can be divided into two broad categories for purposes of this research: point-source and non-point source. Point-source pollution includes emissions from stationary sources, such as factories, refineries, rock-crushing operations, painting facilities, open burns, etc. Non-point source emissions are often from mobile sources, like the transportation sector (cars, planes, etc.) or area sources, such as agricultural lands (Michigan Environmental Education Curriculum Support, n.d.). The particular pollutants emitted and volumes thereof vary between these two categories and vary further between industries and technologies within each category (Michigan Environmental Education Curriculum Support, n.d.; Holman 1999). Some businesses emit relatively little, while a minority of industries and industrial facilities emit a disproportionately high volume and toxicity of pollutants (Collins 2012).

1.1.3 Laws and enforcement

At the policy level, managing air pollution is mainly thought of as managing emissions sources, both point- and non-point. To control emissions, governments in Canada generally set laws based on pollutants or sources of pollutants (Wilkins and MacDonald 2009). These rules are set at many levels of government: local, provincial, and federal. Provincial and federal laws will be the focus of this research. In order to ensure rules are being followed, agencies within governments enforce laws within their jurisdiction. As discussed further in subsection 2.2, there are several strategies for enforcing environmental laws, but the ultimate goal is to deter rule-breaking and encourage compliance (Giles 2020, Gunningham 2011). When enforcement agencies detect law violations, a spectrum of enforcement tools is available, including fines, court trials, warnings, and more (Girard, Day, and Snider 2010; Amos et al. 2011; Boyd 2015). The tools enforcement agencies use and the extent to which they are effective at detecting and deterring violations are important factors for environmental outcomes (Ringquist 2015; Shimshack 2014; Harrison and Antweiler 2003; Alm 2014; Zou 2021). A few private organizations have surveyed environmental enforcement actions in Canada (Berkley Canada 2019; Nimonik 2010). These studies, in conjunction with the work of scholars like Boyd (2015) and Harrison (1995; 1996; 1998; 2011), suggest that penalties for environmental violations in Canada are relatively low and the regulatory environment generally may be considered lax, compared to counterparts in other jurisdictions (like

the United States). However, the particularities of overarching trends in air pollution enforcement have not been investigated. Namely, which types of air pollution violations are enforced with what tools, in what provinces, and for which types of offenders, have not been studied. This research focuses on that critical gap, providing more detailed information on how exactly air pollution violations are enforced across Canada.

1.1.4 Environmental Justice

As awareness of institutional racism, sexism, and other forms of systemic marginalization grows, it is essential to consider how these issues intersect with experiences of the environment. Environmental justice is an applicable framework rooted in the academic, activist, and policy worlds. As Buzzelli et al. (2003) explain, “The environmental-justice movement represents the politicized edge of environmental equity, focusing on the social inequality of human impacts of health-hazard exposure and promoting its abolishment.” The movement exists with the theory, which has been supported over many studies, that “disadvantaged groups face ‘disproportionate’ environmental health hazards” (Buzzelli et al. 2003) – a phenomenon called (distributive) “environmental injustice.” Environmental injustices caused by air pollution have been observed across Canada (Buzzelli and Jerrett 2004; Buzzelli et al. 2003; Giang and Castellani 2020; Michael Jerrett et al. 2001; M. Jerrett et al. 2004; Canadian Institute for Health 2011). Across these studies, the characteristics of communities suffering from environmental burdens vary, but it is clear that environmental injustices are present. The intersection of environmental justice and environmental enforcement – if enforcement mitigates environmental burdens for disadvantaged communities, or if access to enforcement is a privilege which these communities cannot access - has been studied in the United States (US) but not in Canada, (Konisky 2009; Konisky and Reenock 2018; 2013; Konisky, Reenock, and Conley 2021; Spina 2015; Mennis 2005). This study begins to address that gap in the Canadian literature, but much more data and research is necessary to be precise about how enforcement impacts communities. Drawing upon the environmental justice literature writ large and the research described in my literature review, Figure 1 illustrates the framework and set of hypotheses that my research will use,. The diagram exhibits moving from broader assumptions to increasingly specific ones that meet the context of my study. It is important to understand the foundations of environmental justice in terms of exposure to pollution as described, but the preliminary environmental justice analysis I provide centers upon the bottom of the diagram in Figure 1: the double burden hypothesis of inequitable environmental enforcement.

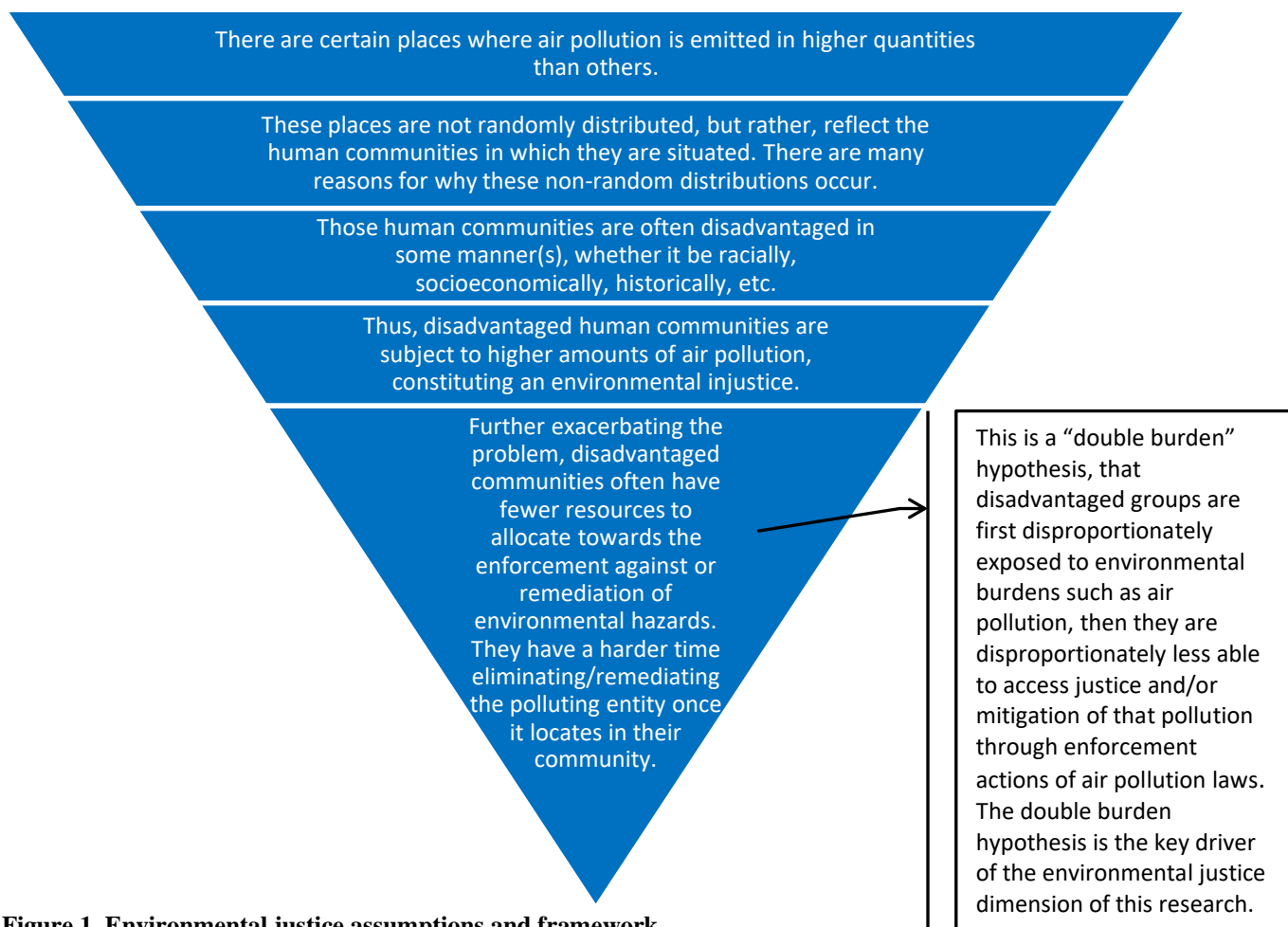


Figure 1. Environmental justice assumptions and framework

1.2 Positionality statement

It is increasingly acknowledged that science is conducted in social and cultural contexts and influenced by scientists’ values and choices (Douglas 2008; 2009; Elliott 2017; Longino 1990; Pielke 2007). Accordingly, it is important to articulate my identities and biases such that they might influence this work. First, I believe that all life – human and nonhuman – has a fundamental right to a clean environment, which underpins my belief that environmental laws should be followed and enforced. Second, I am a privileged, white American. Each of these identities both facilitated and hampered my perspective and access while conducting this research. My privilege, both white and financial, contributed to me being able to spend the extensive amounts of time required to gather and process this data. My whiteness may have facilitated communications with public servants, yet limits my perspective in that I cannot personally relate to the environmental racism experienced by many communities in Canada and beyond. My American nationality gave me an outsider’s perspective of the issues I examine in Canada, which may have led to insights in some areas, but hampered my understanding in many others. Taken together, my identities may have yielded some benefits for this project, but also crucial limitations. Future research should center and include teams of diverse perspectives, such as those from local knowledge holders, people from environmental justice communities, Canadians, and others who may have lived experiences of pollution and enforcement in Canada.

1.3 Expected contribution

Air pollution, environmental law enforcement, and environmental justice have each been studied in Canada, sometimes in pairs (for example, the environmental justice dimensions of air pollution). However, the three have not yet been studied together in Canada and have only been examined in a few studies in other countries, such as the United States (Konisky 2009; Konisky and Reenock 2013; 2018; Konisky, Reenock, and

Conley 2021; Spina 2015; Mennis 2005). This study begins to address that gap in the Canadian environmental justice literature. Another contribution of this project is my publication of the enforcement action dataset I compiled, which contains all of the observations of enforcement actions across Canada that I could find and analyze. It is available online [here](#). As publicly available data, it can serve both basic and applied functions. My goal for this project is that it will elucidate key opportunities for improvement in enforcement and policy, and in doing so, improve environmental and environmental justice outcomes. I offer some of these opportunities as recommendations.

I examine the following research questions (RQ):

RQ1: How do enforcement data availability and quality vary between and within provinces?

RQ2: What are the demonstrated models of enforcement? How do they vary across jurisdictions, time, or other factors?

RQ3: What types of violations or offenders appear to be prioritized for enforcement action in Canada?

RQ4: How are the sociodemographic characteristics of areas in which enforcement actions occur different from the provincial averages of those characteristics?

To assess these questions, I:

1. Collected enforcement data from eight provinces and the federal government
2. Created a rubric to evaluate jurisdictions' data quality and availability
3. Conducted descriptive and statistical analyses of variables extracted from enforcement data
4. Created maps and used geospatial analyses to assess the environmental justice dimensions of enforcement
5. Evaluated evidence from these analyses against literature regarding enforcement models, environmental priorities, and environmental justice
6. Offered recommendations to improve enforcement strategies, outcomes, and policies

This thesis consists of seven chapters. Chapter 1 introduced air pollution, enforcement, and environmental justice, and how each materializes in Canada. The remaining chapters are as follows: Chapter 2 presents a literature review focused on enforcement, policy, and environmental justice. Chapter 3 describes the research methodology used for data collection and analysis. Chapters 4-6 consist of results: Chapter 4 includes an assessment of jurisdictions' data against a rubric, Chapter 5 includes descriptive statistics of enforcement actions, and Chapter 6 includes geospatial analyses of enforcement actions against environmental justice variables. Chapter 7 discusses the results found in Chapters 4-6 in the context of enforcement strategies, environmental priorities, environmental justice, and critical limitations illuminated by data quality. Comparisons to other jurisdictions, namely the American model of enforcement, and several levels of recommendations, are also provided. Finally, Chapter 7 presents the conclusions of the research.

Chapter 2: Literature Review

This chapter presents a review of the literature, elaborating on concepts and literature introduced in the introduction. In particular, I review enforcement concepts like compliance, enforcement models, and deterrence. Second, I explore federal and provincial air pollution policies and government-published enforcement literature. Third, I survey environmental justice literature from Canada and studies of the enforcement lens of environmental justice conducted in the US, which form the foundations for this study. Finally, I compare literature from the US, denoting the markedly different policies, enforcement strategies, data qualities, environmental outcomes, and attention to environmental justice found in the US.

2.1 Compliance

To manage the health and environmental risks of air pollution, Canada's local, provincial, and federal governments establish air pollution laws, regulations and standards, which target point- and non-point emissions sources. The disparities between these policies and the harmful pollution that occurs are partially a function of “compliance.” “Compliance” with environmental laws is the rate at which regulated parties – particularly firms – adhere to the terms of their permits and the environmental laws of the jurisdiction in which they operate. “Noncompliance” is synonymous with law “violations” in this context. (Non)compliance is a function of several factors, including policy design, enforcement actions, social pressures, market incentives, and more (Giles 2020; Cohen 1998; Alm 2014; Ganslandt 2020). Giles (2020) posits most compliance is attributable to policy design and that even the most robust enforcement regimes cannot close the gaps created by poor policy. Still, for the time being, we lean on enforcement to attempt to stem high rates of noncompliance.

In both the US and Canada, Giles (2020) theorizes compliance to be very low, but neither nation knows precisely how low or the seriousness of noncompliance (in terms of harm to people and/or the environment). Because of poor data transparency, the public knows less than regulators, especially in Canada, but even regulators do not have the necessary information to determine these values (Giles 2020). This lack of knowledge is driven by numerous factors, including poor communication and records sharing between levels of government, under-resourced regulators, and other issues on the government side, but perhaps most important is firms’ ability to monitor and report their own emissions – often calculating them indirectly rather than physically measuring – and regulators having to take them at their word (Alm 2014; Giles 2020; Cairns, Turan, and Amos 2011; The Land and Refinery Project n.d.). Sometimes firms’ reports are accurate, sometimes they are not, and regulators have no real recourse to be sure or evaluate this on a large scale, possibly due to resource constraints or political influences. As the Auditor General of Canada said, “Environment Canada does not have adequate systems and practices in place to verify that all facilities required to report their emissions are doing so and that the information they provide is accurate” (Auditor General of Canada 2009). For this reason (in addition to others), a large – but imprecisely calculated - portion of serious pollution violations go unnoticed and unenforced in both countries (Wilkins and MacDonald 2009; Giles 2020).

2.2 Enforcement:

Although enforcement is no substitute for policy reform in promoting compliance, it has nonetheless been demonstrated to improve compliance and environmental outcomes (Ringquist 2015; Shimshack 2014; Harrison and Antweiler 2003; Alm 2014; Zou 2021). Within this realm, there are many models of enforcement, and much debate exists around them. Namely, debates revolve around the various models' effectiveness in deterrence (deterring noncompliance) and how that effectiveness impacts environmental, economic, and other types of outcomes. Avenues of deterrence and multiple models of enforcement are discussed.

Enforcement deters noncompliance through two primary channels: specific and general. “‘Specific deterrence’ is defined as the effects of inspections or penalties on the future behavior of the monitored or sanctioned firm” (Alm 2014). Meanwhile, “‘general deterrence’ [is] defined as the effects of inspections or penalties due to changes in the regulated entities’ perceptions of the overall regulatory environment, [such as] changes in rules or laws governing inspection probabilities, sanction probabilities, or sanction magnitude” (Alm 2014; Stafford 2002). Evidence for how each channel deters noncompliance in Canada is sparse but exists at

length in the US, finding that both specific and general deterrence works, at least to some extent, through the enforcement of the US Clean Air Act (Gray and Deily 1996; Gray and Shadbegian 2007).

Whether specific or general, the most effective mechanism for enforcement to deter noncompliance is disputed. There are several models from which governments may choose to approach regulated parties. They can generally be summarized as a spectrum from “cooperative” to “direct” approaches. On the “cooperative” side, firms set their own rules or work with regulators to negotiate terms that work for them. On the “direct” (also pejoratively called “command and control”) end of the spectrum, regulators set overarching rules, and firms are expected to comply with few exceptions (Harrison 1995). Practically, most governments exist somewhere in between, not entirely adopting one extreme or another (Harrison 1998). The case for cooperative approaches is that they are said to be potentially more cost-effective for regulators and firms and prioritize future compliance over punishment for past infractions (Shapiro and Rabinowitz 1997; Ayres and Braithwaite 1992). Direct approaches are observed to be more effective, particularly in terms of compliance and environmental outcomes, and can be more efficient (Harrison 1998; 1995; Zou 2021; Harrison and Antweiler 2003). While there is a fair degree of choice for how to operate on this spectrum, and how enforcement may be scaled upwards or downwards accordingly – and much of these choices are political – the range of choice is intrinsically constrained by the parameters of the policy being enforced and the resources available to the regulating agency (Gunningham 2011; Harrison 1998).

Gunningham (2011) offers several elaborations on enforcement models. Three of these are described below, as they are most fitting to the approaches adopted in Canada, and can be thought of as existing more on the cooperative end of the enforcement spectrum, with “responsive regulation” being closer to the center. Applications of these models to Canadian governments are discussed in subsection 2.4 Provincial governance and enforcement.

“Advice and Persuasion: emphasizes cooperation rather than confrontation, and conciliation rather than coercion. The aim is to prevent harm—achieved by bargaining, persuasion and negotiation rather than sanctioning. Recourse to the legal process here is rare, the assumption being that the majority of regulatees are willing to comply voluntarily.

Criteria Strategies: provide inspectors and other decision-makers with a list of criteria that they should consider in arriving at a decision in any given case. There is no prescriptive formula, and which mechanism(s) will be used in any particular case will depend on the circumstances.

Responsive Regulation: suggests that best outcomes will be achieved if inspectors employ a blend of persuasion and coercion, the actual mix being adjusted to the particular circumstances and motivations of the regulatee. Regulators should begin by assuming virtue (to which they should respond by offering cooperation and information), but when their expectations are disappointed, they respond with progressively punitive and deterrence-oriented strategies until the regulated group conforms (a form of ‘tit for tat’).” (Gunningham 2011)

2.3 Federal governance and enforcement:

The Canadian federal government has laws and regulations to control pollutant release and monitoring, but they fail to meet the challenge of air pollution for various reasons, namely enforceability. The Canadian Environmental Protection Act (CEPA), 1999, is the main federal law governing air pollution. CEPA “has been identified by the federal government as ‘one of the most advanced environmental laws of its kind in the developed world,’ yet it has never been effectively implemented” (Wilkins and MacDonald 2009). Wilkins and MacDonald levy this claim because although CEPA contains the raw policy materials to reduce emissions and improve environmental outcomes, these powers have largely not been explored or enforced. For example, CEPA governs the most common air pollutants with known health effects, called “criteria air contaminants” or “criteria air contaminants.” The criteria air contaminants include nitrogen dioxides (NO₂), sulfur dioxide (SO₂), carbon monoxide (CO), ammonia (NH₃), particulate matter (PM), and volatile organic compounds (VOC). Critically, the federal government establishes the Canadian Ambient Air Quality Standards (CAAQS) for the criteria air contaminants, as measured by ambient concentrations over different time intervals. However, in contrast to air quality standards in the United States and Europe, the CAAQS are not legally binding or

enforceable, and as such, are voluntary objectives. Voluntary objectives are less effective than legally binding approaches in terms of environmental outcomes (Boyd 2015). As for other dimensions of CEPA, some CEPA regulations have made a substantial difference in pollutant concentrations, such as the Sulphur in Gasoline Regulations (P. S. and P. C. Government of Canada 2021). CEPA authorized the creation of the National Pollutant Release Inventory (NPRI), a system for major polluters to report their emissions and make data publicly available, and an air pollutant surveillance program (Ahmad 2018). Overall, Canada “consistently ranks among the three worst industrialized nations for per capita emissions of [various criteria air contaminants]” (Boyd 2015), and some argue that the under-utilization of CEPA is partly to blame.

Environment and Climate Change Canada (ECCC) is the principal federal department responsible for administering air pollution laws and enforcement, including CEPA. Like CEPA, its potential is unrealized as a department, as its jurisdiction and resources are limited, even though its core mandate is potentially sufficient for enforcement (Cairns, Turan, and Amos 2011). In terms of jurisdiction, its powers are routinely undercut by the reliance on provinces to administer federal laws (Harrison 1996). For example, the Air Quality Management System (as described shortly) began as a federal initiative but shifted to a joint provincial-federal approach over time, with provinces playing the leading role (Beale 2021). What jurisdiction ECCC retains has been limited by repeated budget cuts since the 1990s. Its budget peaked in 1993 with \$2.85 billion in 2021 dollars, fell to \$1.45 billion in 2012, and has only recently increased, now \$2.0 billion in 2021 (E. and C. C. Canada 2020; Boyd 2015). With decreasing and volatile budgets, coupled with limited jurisdiction, ECCC’s capacity for effective enforcement is hampered.

Compliance rates with federal environmental laws are generally unknown, as the federal government does not release compliance rates for CEPA (Amos et al. 2011; Fang, Hipel, and Kilgour 1994). Under the binding sections of CEPA (outside of the voluntary objectives), enforcement has been in continuous decline since 2005, despite an increase in the number of enforcement officers. The Environmental Enforcement Act (2009), intended to strengthen CEPA enforcement, increased the number of inspections officers but did little to actually improve enforcement rates or publicly available data about enforcement actions. The Environmental Enforcement Act requires the government to release annual reports on enforcement actions and publish a registry (the Environmental Offenders Registry) on corporate convictions. Both the reports and the registry lack critical information about offenses, offenders, where violations occurred, and more (Amos et al. 2011). This is not for lack of the federal government collecting data on enforcement – it is collected and aggregated in an internal database called the National Enforcement Management Information System and Intelligence System (NEMISIS) – but it is kept private and can only be accessed through lengthy requests under the Access to Information Act (Cairns, Turan, and Amos 2011). Despite numerous calls to make NEMISIS public, the government has not, and the quality of the information provided through access to information requests has only deteriorated over time (Carty 2014). Cumulatively, according to a report by the Commissioner of the Environment and Sustainable Development, the result is that the “quality of publicly available enforcement data is inadequate, based on accuracy, completeness, and accessibility” (Cairns, Turan, and Amos 2011).

In order to coordinate air quality efforts across Canada, the Canadian Council of Ministers of the Environment (CCME) developed an Air Quality Management System (AQMS) in 2012. The AQMS aims to establish basic public reporting requirements for ambient concentrations of air pollutants and the actions taken to remediate them across provinces and territories. Performance metrics are based on the CAAQS, but the AQMS also established Base-level Industrial Requirements, which institute a floor for performance of major industries. With the information provided by required monitoring, management of problematic air zones can be scaled up, and pollution can be tracked over time and space. According to the AQMS reports, the concentrations of most pollutants have been trending downward since 2000, except for particulate matter (PM) (based on a national average of annual average concentrations). Reports also show trends by sector, province, and more (Canadian Council of Ministers of the Environment, n.d.; Ecojustice 2018).

2.4 Provincial governance and enforcement:

Although provincial efforts are coordinated through the AQMS, provinces retain a great degree of autonomy in designing their air pollution laws and policies, and they vary substantially. Many provinces

(Alberta [AB], British Columbia [BC], Quebec [QC], Ontario [ON], Nova Scotia [NS], and Prince Edward Island [PE]) have umbrella environmental legislation, under which there may or may not be specific air pollution-related regulations or sections. Other provinces (Saskatchewan [SK] and New Brunswick [NB]) have separate legislation in the form of a “Clean Air Act.” Regardless of the legislation type, provinces or local governments set rules broadly applicable to various types of regulated parties (individuals, companies, municipalities, etc.) and issue permits, which allow parties to emit (higher levels of) pollution under a given set of circumstances (using set types of equipment, monitoring their emissions, submitting to inspections by regulators, etc.). Corporate and municipal permits are typically valid for many years, depending on the province and type, and are not usually rescinded once issued. Permits are theoretically legally binding – meaning that a breach of a permit constitutes a violation of provincial or local law. Governments may choose from a suite of enforcement tools if they decide to enforce a permit violation or any other air pollution law.

The larger provinces, AB, BC, ON, and QC, have an umbrella “Environment Act,” under which BC, ON, and QC have air pollution-relevant regulations. We have some information about enforcement and/or compliance for AB, BC, and ON. The latter group is discussed at greater length.

QC has a wide range of regulations under its Environment Quality Act, with the Clean Air Regulation as the one mainly targeting air pollution, but many others also impact ambient air. Most appearing in this research pertain to equipment and emissions standards, with others relating to burns and opacity restrictions. Compliance rates and enforcement strategies are not published.

ON has the most stringent air pollution regulation under its Environmental Protection Act. Ontario Regulation 419/05 sets legally binding air quality standards that are more or less reflective of the CAAQS and is the only legally binding ambient standard for criteria air contaminants in the provinces (MacDonald 2019, Harrison 2011). Carveouts remain for industry; allowing facilities to apply for “site-specific standards,” which are essentially more stringent permits with more monitoring, modeling, benchmarking, and public consultation requirements, and “technical standards,” which are industry-level or equipment-level standards that afford more lax rules for certain parts of a facility or specific contaminants (Ontario Ministry of the Environment, Conservation, and Parks 2021). ON does not publish the distribution of permits between facilities subject to the general air standard, site-specific standard, and technical standards. In terms of compliance with air pollution rules, ON does not publish reports, but it does publish a map of facilities across the province that are and are not planning to reduce their emissions of toxics. Of the 1358 facilities reporting their emissions, 463 are planning to reduce. For each facility, a dataset is available containing details about the toxics reduction plan to reduce and information about that facility’s compliance history (Ontario Ministry of the Environment, Conservation, and Parks 2014). Finally, ON provides an extensive guide regarding its enforcement approach, including a decision-making matrix for selecting enforcement tools based on the scale of the infraction, past compliance history, and more (Gunningham’s “criteria strategies” enforcement model) (Gunningham 2011; Ontario Ministry of the Environment, Conservation, and Parks n.d.).

BC manages air pollution primarily under its Environmental Management Act (EMA) but also under its Waste Management Act and Wildfire Act. Under the EMA, there are a few regulations governing open burns and specific industries, such as asphalt, sawmills, and oil and gas, but otherwise, air pollution-relevant rules are found in the sections of the Act. Under the framework of the AQMS, BC and some local governments set air quality guidelines, but these are nonbinding.

BC publishes the most information about compliance rates with these rules and the province’s enforcement approach, although information is still limited. It posts compliance reports for EMA for 2015-2017 and compliance audits for some regulations, like the Asphalt Plant, Sawmill Air Authorization, and Oil and Gas Air Permit Regulations¹. According to the EMA compliance reports, during the 2015-2017 time period, the number of inspections more than doubled (632 conducted in 2015 and 1,596 conducted in 2017), and overall compliance with EMA was reported to be 40-42%. The Ministry of Environment and Climate Change Strategy aims to inspect at least 25% of all permitted facilities per year. Of this value, the percentage of inspections

¹ The Oil and Gas Regulations Audit only surveyed five facilities from one company, and thus the results from this audit are not considered reliable or discussed.

dedicated to air-related discharges decreased from 29% in 2015 to 18% in 2017, which could correlate with the national trend away from enforcement actions against air violations reported by Berkley Canada (British Columbia Ministry of Environment and Climate Change n.d.; Berkley Canada 2019). For facilities under the Asphalt Plant and Sawmill Air Authorization Regulations, compliance was lower as audited for the year 2015: 27% and 26%, respectively (British Columbia Ministry of Environment and Climate Change n.d.).

According to the BC Ministry of Environment and Climate Change Strategy, “the Ministry is committed to working with regulated parties to achieve voluntary compliance” (2016). Within the Compliance and Enforcement Policy and Procedures, the process from regulators learning of a violation to selecting enforcement tools is delineated, which features a decision-making matrix similar to that in ON. These procedures and matrix have recently been updated, in conjunction with the passage of the Environmental Assessment Act of 2018, which “modernized compliance and enforcement tools” (British Columbia Ministry of Environment and Climate Change n.d.) – increasing limits for fines, requiring regulated parties to respect inspections, etc. Not long before (2015), administrative penalties were introduced as an enforcement tool for the province, allowing the Ministry to levy higher fines without going to court. In other words, there is some suggestion of a transition towards more direct enforcement approaches, but the ethos remains predominantly cooperative and based on criteria strategies, especially for the majority of the study period.

Finally, in AB, most air pollution governance is under a limited number of sections in the Alberta Environmental Protection and Enhancement Act. There are no specific air pollution regulations. Compliance is not published in terms of rates, but detailed information is provided about enforcement strategies and results over time, such as the number of enforcement tools deployed in a given year. In their Compliance Assurance Activities and Enforcement Actions brochure (Alberta Environment and Parks 2015), Alberta’s Ministry of Environment and Parks describes their enforcement approach in terms akin to Gunningham’s “advice and persuasion” model:

“The department may have the option to pursue an enforcement action but choose not to. Building a positive relationship with the regulated party is of inestimable value to the department. Enforcing a strict ‘letter of the law’ policy for small contraventions that caused no loss to Crown revenue, no damage to the resource, or no adverse effect can negatively affect relationships with the public and industry, making gaining voluntary compliance in the future more difficult. In these cases, the department endeavors to change the behavior of the responsible party through educational efforts.”

In their Compliance Assurance Annual Reports, published yearly since 2003 (except for a gap between 2007 and 2012), enforcement strategies are discussed, such as “compliance sweeps,” where specific industries or geographies are targeted, and all facilities within that subset are randomly inspected, then any discovered violators are notified and educated about the rules. High numbers of notices and warnings are typically given during these sweeps (20-30+). 10%+ of permitted facilities are inspected per year. According to the 2006-07 Report, AB staff use an internal compliance website, similar to NEMISIS but on the provincial scale, which is not publicly accessible (Alberta Environment and Parks 2007).

Thus, in the largest provinces, varying levels of attention to air pollution are captured within the scope of general “Environment Acts.” Information about compliance rates is exceedingly sparse, available only for three years in BC. Information about enforcement approaches is somewhat more available, with reports that illustrate cooperative strategies ranging from “advice and persuasion” (AB) to “criteria strategies” (BC and ON).

2.5 Environmental justice (EJ):

In some studies in Canada, researchers have demonstrated that the characteristics of who is exposed to ambient air pollution, who suffers adverse health impacts, where, and why, is connected to various racial and socioeconomic factors (Crouse, Ross, and Goldberg 2009; Buzzelli and Jerrett 2004; Michael Jerrett et al. 2001; M. Jerrett et al. 2004; Buzzelli et al. 2003; Giang and Castellani 2020). Specifically, members of vulnerable and marginalized groups (low income, visible minority, etc.) tend to experience higher levels of pollution, which

can result in more morbidity or mortality. This phenomenon generally – the connection between environmental hazards and socioeconomic disadvantage – is referred to as environmental (in)justice (see subsection 1.3). Most of the air pollution-related environmental justice studies that have been conducted in Canada are on the spatial level of a city or municipal region. Studies from Montreal (Crouse, Ross, and Goldberg 2009) and Hamilton, Ontario, the largest steel manufacturing city in Canada (Buzzelli and Jerrett 2004; Michael Jerrett et al. 2001; Buzzelli et al. 2003), serve as examples of this. Giang and Castellani (2020) considered Vancouver, Montreal, and Toronto. These projects considered different dimensions of air pollution and socio-demographics, but essentially mapped where air pollution occurred relative to the (under)privilege of the communities in those areas, thus investigating the extent of environmental injustice related to air pollution. One similar national-level study found that low-income Canadians are more likely to live within one kilometer of a polluting facility, which applied to approximately 1.03 million low-income urban Canadians living near polluting facilities, while 328,000 wealthy urban Canadians lived in the same radii. Canadians living within that 1km radius of a polluting facility are significantly more likely to be hospitalized for cardiovascular or respiratory illness than counterparts living 2km or more further from a facility (Canadian Institute for Health 2011). Another national study found that immigrants experience higher levels of PM_{2.5} exposure across Canada, peaking in urban cores (Pinault, van Donkelaar, and Martin 2017). As these are some of the only major applications of environmental justice lenses to air pollution on the national scale in Canada, scholarship in this field is incomplete.

While there has been some focus on how environmental laws can exacerbate environmental injustices (e.g., advantaged groups have the resources to use and litigate environmental regulations in ways that disadvantaged groups cannot) (Kaswan 1997), very few studies have been dedicated to the *enforcement* of environmental laws. Konisky (2009) did conduct such a study, and the methods used in my research follow his example. Konisky investigated the enforcement of three American pollution control laws (although not all air pollution), measured by state and Environmental Protection Agency (EPA) enforcement, and collected data at the county level. He compared enforcement rates against various socioeconomic and demographic variables to examine a potential environmental justice link and found significantly lower enforcement rates in poorer counties, but no substantial evidence of race-based inequalities. Konisky has since conducted studies examining the particularities of this reduced enforcement, finding that state agencies take weeks longer to inspect facilities in racialized neighborhoods than in poor or nonracialized neighborhoods (Konisky, Reenock, and Conley 2021). Similar patterns in Konisky's later work and that of other authors are observed as well, where there is not a single monolith of an "environmental justice community" or that all equity-seeking communities experience environmental injustice similarly. The groups that experience disproportionately high burdens depends on the facet of enforcement and/or pollution medium examined (Konisky and Reenock 2018; 2013; Konisky and Woods 2010; Konisky, Reenock, and Conley 2021; Spina 2015). Finally, limited research has found that air-polluting facilities in areas with high percentages of minorities were less likely to receive administrative penalties as enforcement actions than were those in whiter areas (Mennis 2005). Therefore, while one study exemplifies the methods used in this research and there are limited further studies on other dimensions of enforcement and environmental justice, they are based in the United States. This represents a major gap in the Canadian environmental injustice literature.

The study of which polluters contribute to environmental injustices and to what extent is another crucial gap in the Canadian literature. Collins et al. find that in the US, a minority of facilities disproportionately contribute to the total amount of emissions and that this similarly contributes to an unduly exacerbated amount of health risks for the communities that live nearby, creating environmental injustices (Mary B. Collins 2011; Mary B. Collins, Munoz, and JaJa 2016). Collins calls these excessively emitting facilities "toxic outliers." While this is a significant problem, Collins posits that herein lies an opportunity: writing "regulations that target highly polluting firms will likely reduce the overall pollution for an industry at a much lower cost than can be achieved by regulations that require incremental reductions from all firms" (2011). In other words, prioritizing toxic outliers in regulation can yield high returns on pollution reduction (and, by extension, improved health outcomes and environmental justice) relative to the cost of implementation. Konisky et al. (2021) point out that setting regulations is sometimes out of the jurisdiction of enforcement agencies, but enforcement officers do have substantial power to adapt enforcement priorities and allocate resources within their jurisdiction. These

levers could be adjusted to target toxic outliers for enforcement in particular, which could yield improved environmental justice outcomes. Additional research is required to determine whether this phenomenon also exists in Canada.

2.6 The United States

The United States offers a rough parallel to compare performance on various metrics with Canada. On virtually all key metrics for this study - policy structures, enforcement, data availability, and attention to environmental justice – the US has employed different strategies from Canada, with improved results observed in the literature.

Two fundamental pillars in the US support federal air pollution governance: the Environmental Protection Agency (EPA) and the Clean Air Act (CAA). The EPA is a federal, executive-level agency tasked with various aspects of environmental protection, including enforcement. Although states also play a substantial role, it has the principal authority to administer many key federal environmental laws, including the CAA. Broadly considered one of the most comprehensive environmental laws in the US, the CAA sets standards for ambient air pollution, called the National Ambient Air Quality Standards (NAAQS), which are similar to the CAAQS except for the fact that the NAAQS are legally binding – an essential distinction. Canada does not have an equivalent of the EPA nor the CAA. Environment and Climate Change Canada has more limited jurisdictional powers and substantially less resources than the EPA² and thus is not comparable. CEPA does not contain the scope nor the critical enforceability of the CAA and thus is not comparable either. The EPA and CAA are important outcomes in their own rights, but they also enable and support other strategies and outcomes (Cairns, Turan, and Amos 2011).

For example, the centralized and comprehensive nature of the EPA helps to facilitate its data collection about noncompliance and enforcement actions, yielding a user-friendly and relatively complete database. Its database for these purposes, called Enforcement Compliance History Online (ECHO), has machine-readable datasets, maps, comprehensive reports, and many different ways for users to search data (Environmental Data and Governance Initiative 2020; Cairns, Turan, and Amos 2011). In Canada, the federal government's database contains only information about federal prosecutions and is incomplete, without details about provincial activities. Provincial data is fragmented and of low quality (Amos et al. 2011). Meanwhile, the EPA is able to organize the data it receives and present it in a roughly standardized way across observations and jurisdictions. While ECHO has many strengths, it still suffers from various sources of missingness (Giles 2020; Environmental Data and Governance Initiative 2020). The Environmental Data and Governance Initiative (2020) created Figure 2 to demonstrate the many opportunities for CAA violations to go unreported, be incorrectly documented, or otherwise not appear in ECHO as intended. I adapt Figure 2 for the purposes of this study in subsection 3.4.

² Notably, the US's population is 10x larger than Canada's, but the EPA's budget is only 5.9x larger than that of ECCC for 2021 (\$11.8 billion CAD vs \$2.0 billion CAD). There may be differences in the types of regulated facilities, how budgets are distributed among departments, environmental priorities, etc., but on a per capita basis alone, the EPA administers environmental regulations for more people with a comparatively lower budget.

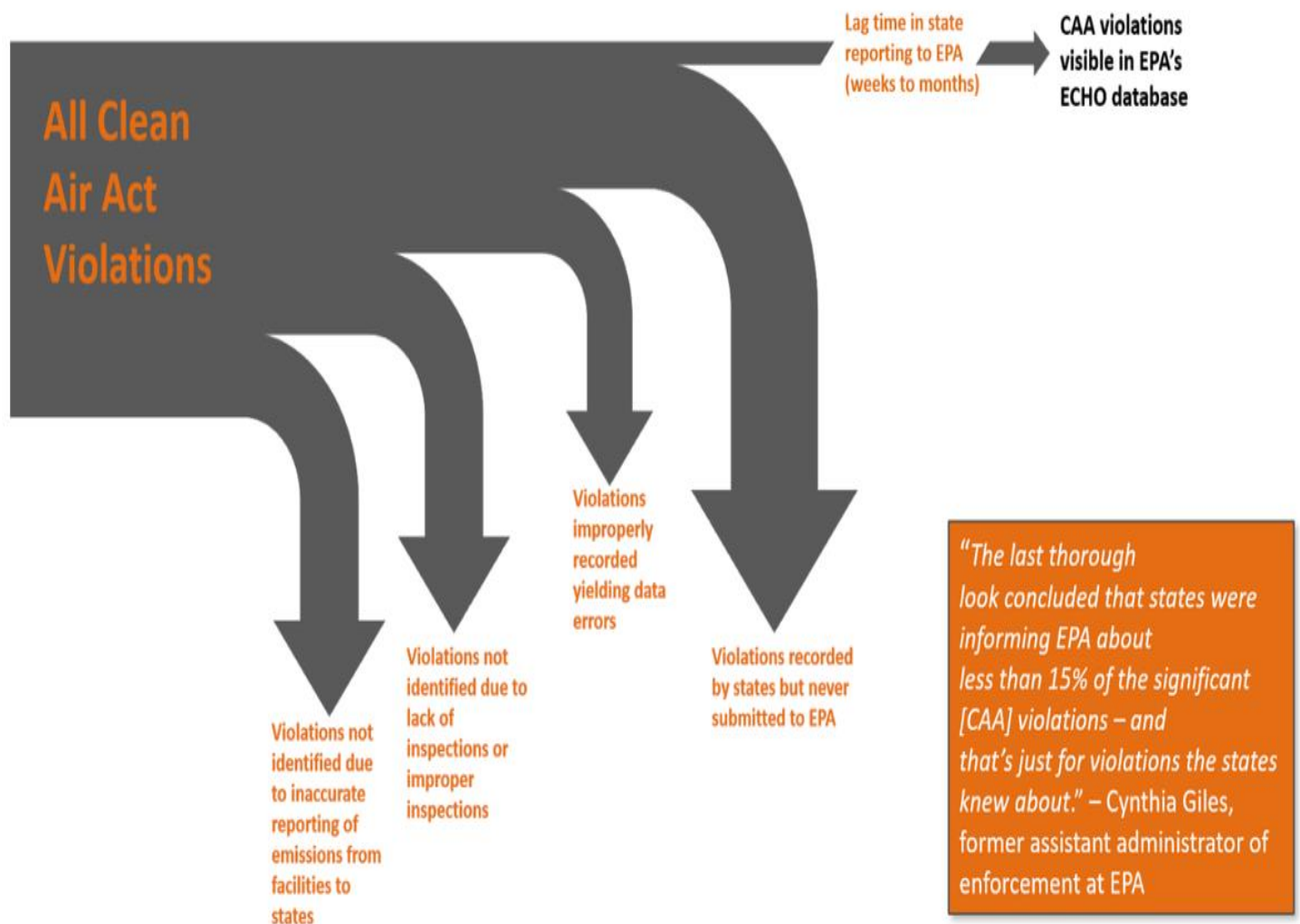


Figure 2. “Illustration of the ways CAA violations go unreported to the EPA” (Environmental Data and Governance Initiative 2020)

Enforcement in the US is a decidedly more direct approach (Harrison 1995; Shimshack 2014; Giles 2020; Alm 2014). This is partly built into the CAA but also a function of the decisions and culture within the EPA. Some facilities or industries, in some counties or states, receive more cooperative treatment from the EPA, akin to Gunningham’s “responsive regulation” model, but especially when compared with those found in Canada, the approach is more “direct.” In recent years, both the number and severity of enforcement actions have declined in the US, particularly under former president Trump, signaling that the strength of enforcement in the US (as administered by the EPA) may be subject to more political influence than in Canada (Malivel 2018). Despite these shortcomings and hypothesized high rates of noncompliance (Giles 2020), enforcement in the US is generally effective for environmental outcomes (Zou 2021; Shimshack 2014). That is, noncompliance rates are high because of poor policy designs, for which, as discussed, enforcement cannot compensate. However, in instances where enforcement is applied to noncompliance, it is observed to be effective for environmental outcomes.

Finally, attention is explicitly called to environmental justice in numerous policies, data applications, (research) initiatives, and more in the US and through the EPA’s dedicated Office of Environmental Justice. Per Executive Order, federal agencies (including outside of the EPA) are required to consider the EJ impacts of their activities and programs (Executive Orders 12898 and 14008). Within the EPA, the organization integrates a tool called “EJSCREEN” onto the ECHO platform, which creates EJ indexes and allows users to view

environmental and demographic indicators in a standardized, geographic format. In terms of enforcement, the EPA recently announced that it was further increasing its EJ focus by “strengthening detection of environmental crimes in overburdened communities, improving outreach to victims of environmental crimes, and enhancing remedies sought in environmental crime cases” (Vinson et al. 2021). Despite these and many more EJ initiatives, environmental injustice is still common in the US. Pollution may be improving in several areas, but the intractable problems of racist and classist zoning, redlining, cumulative effects of pollution, generational traumas, etc., make environmental injustices persistent (Konisky 2021). Therefore, the US continues to be plagued by extensive environmental injustices, but has improved the tools available for agencies and citizens to examine and begin to address the problem. As yet, Canada has few such formalized tools, but Bill C-230 (which proposed the documentation, identification, and monitoring of EJ issues in Canada, alongside improving participation of EJ community members in decision-making [Lee and McLeod-Kilmurray 2021]) presented a valuable opportunity. Although Bill C-230 did not become law, similar legislation could still be enacted in the near future.

Chapter 3: Methods

To analyze patterns of air pollution law enforcement across Canada, I compiled a database of enforcement actions carried out by provincial and federal jurisdictions. Enforcement action data primarily came from provinces, but some came from the federal government as well. Sources of such data ranged from publicly available databases of environmental enforcement to individual news reports about court convictions under environmental statutes. Depending on this source type, I developed several processes to examine the data and find “relevant data” or “air pollution-relevant data.” “Relevant” here means observations that describe enforcement actions related to air pollution law violations, specifically point-source and ground-level pollution. Correspondingly, my dataset does not include infractions that are not point-source or ground-level (the failure to register for carbon emissions cap and trade programs, for example). In the following sections, I delineate how and where I found sources of enforcement data, how I gleaned relevant data from these sources, the variables I extracted and coded to analyze the relevant data, and finally, the analysis techniques I employed to describe and map it.

3.1 Database creation

3.1.1 Data sources

Here I present a high-level overview of the data collection process, with additional details for each province provided in subsection 3.1.1 below. I sought enforcement data from as many Canadian provinces as possible, narrowing the date range of enforcement actions to span the years 2000-end of 2020. Several provinces did not have data available for this complete range, as detailed in Table 1. I gathered most of the data through records aggregated at the provincial level posted on government websites, by directly contacting government agencies, and/or through freedom of information and protection of privacy (FOIPOP) requests. A limited number of observations were garnered through external sites, such as the Canadian Legal Information Institute (CanLII), for provinces without formalized databases or to supplement limited data availability. I used Google searches and detailed examinations of government websites to search for enforcement data. For jurisdictions where data was publicly available and published on government websites, such as for the federal government (abbreviated as FD) and the provinces of BC, AB, QC, and NB, I was able to find the datasets through this internet search. When I could not find data through this method, I directly contacted government agencies via phone and email to learn how to obtain the data. In four other provinces, public servants varied in their responsiveness, with some giving me data directly (PE and NS), some directing me through FOIPOP applications (SK), and some offering context for alternative data sources posted on government websites (ON). As a consequence, I have data for these four provinces from diverse sources with varying quality. In two provinces, Manitoba (MB) and Newfoundland and Labrador (NL), public servants either did not respond (MB) or responded that data was not available (NL), and thus data from these provinces are not included in the analysis. Figure 3 summarizes these processes and outcomes. Information about each jurisdiction’s source data can be found in Appendix A.

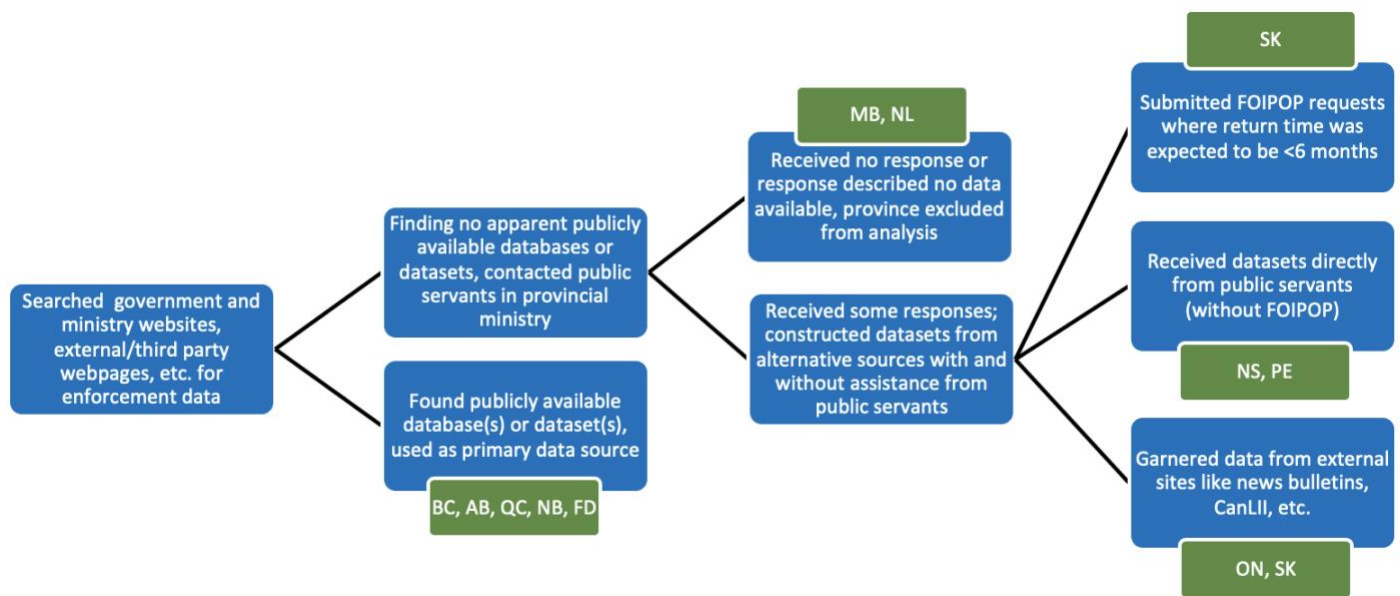


Figure 3. Flowchart of identifying data sources

Table 1. Date range available in jurisdictions' source data

Jurisdiction	Date range available
BC	2006-2021
AB	2002-2021
QC	2009-2021
NB	2000-2018
FD	2006-2021
ON	2000-2021
SK	2001-2018
NS	2009-2020
PE	2011-2020

3.1.2 Gleaning relevant data from the data sources

In the following section, I will describe how I extracted the relevant data from the larger, raw dataset originating from government websites, FOIPOP requests, or public servants. The data-wrangling processes for provinces varied somewhat, based on the mode of raw data, ranging from searching by keyword to reading full documents and manually coding. Some source data was already prepared and did not require extracting relevant data. Ultimately, this process yielded a combined dataset of 2,217 observations.

3.1.2.1 By keyword search

The datasets from BC Natural Resources Compliance and Enforcement Database (NRCED) , AB, QC, Federal, SK FOIPOP output, and ON Environmental Penalty Annual Reports exhibited similar structure and content in their raw forms. Table 3 summarizes the variables/columns included in each province’s raw output. All databases included a “summary of the offense,” although there were variations in the level of detail. I used this field to determine the nature and relevance of the offense and enforcement action. Given the volume of data, I created a set of keywords to identify entries relevant to air pollution for inclusion in the analysis. The keywords reflect the ways in which air pollution is typically described in the literature, whether by the verbs of the violations themselves, the pollutants, and/or sometimes the equipment involved. Generating the keywords was an iterative process: to ensure that the keywords had captured all of the relevant data within a given section, I would conduct reliability checks by randomly selecting sections for detailed review. If missing observations were identified (observations that were air pollution relevant, but my keywords did not detect), I would determine which keyword I was missing that would have led to finding that missing observation, add that new keyword to the list, and re-search the entire database. Table 2 below presents the keywords that emerged from this process, where the portion of the word that was searched is bolded. Using these keywords, I identified the relevant observations for each province and created new datasets for each province in Excel.

Table 2. Keywords used to search for relevant observations in source data

air	atmos- (atmosphere, atmospheric, etc.)	emi- (emit, emitted, emission, etc.)	burn- (burning, burned, etc.)	combust- (combusted, combustion, etc.)	poll- (pollution, pollute, etc.)	odo- (odour, odor, etc.)	vap- (vapour, vapor, etc.)	gas- (gas, gaseous, etc.)
benzene; C6H6	amm- (ammonia, etc.); NH3	lead; Pb	volatile- (volatile organic compounds); VOC	nitro- (nitrogen, nitrogen [di]oxides, etc.); NOx; NO2	sul- (sulphur, sulphuric, sulfur, sulfuric, etc.); SOx; SO2	partic- (particulate, particle, etc.); PM- (PM2.5, PM10)	carbon (carbon monoxide, halocarbon, etc.); CO	dust-
scrub- (scrubber, scrubbed, etc.)	furnace-	stack-						

3.1.2.2 Long-form/non-tabular data

For non-tabular data, particularly as found in the Alberta prosecution and order files, the Saskatchewan and Ontario news reports, and the Ontario CanLII files, reading and manually coding the documents completely was necessary – keyword searches were not as effective. I extracted and manually coded the relevant pieces of information from the long-form document and copied them into a separate Excel document. This Excel document contributed to my dataset for that province, which I further coded and cleaned as per the process described in subsection 3.1.3.

For the BC inspections reports data, it was a combination of tabular (from inspections data CSV files and the NRCED) and non-tabular (inspections reports as PDF files) data formats, which Sophie and I processed and combined into one tabular Excel document, and I later coded per subsection 3.1.3.

3.1.2.3 Tabular, filtered data

In the cases of NB, NS, and PE, the data largely came to me in a format that was already tailored to my needs. As described, New Brunswick's online database was already centered on the Clean Air Act, which filtered observations automatically to be air-pollution relevant (unlike other provinces, where their air laws are part of broader environmental statutes, which include regulations for water, land, etc.). They were also already point-source relevant. I combined the tables from the various sections of the website (orders, court convictions, and AMPs) into one document and copied in the additional observations that public servants sent to me. For Nova Scotia and Prince Edward Island, the data I have came from public servants who understood what I was looking for and sent me documents containing only that - they filtered the relevant data for me. Thus, for each of these data sources, it was mostly a matter of data cleaning to prepare it for use and analysis, as per subsection 3.1.3.

3.1.3 Variables and coding

After selecting only the observations relevant to air pollution for each province, I cleaned the reduced data set to correct spelling errors, standardize word capitalizations, date formats, etc. The coding process included the following three steps, which follow the three types of variables' origins found in my dataset.

1. Organizing and standardizing variable names for the variables that governments coded, provided with the tabular raw data formats (BC, AB, QC (translated), Federal, SK FOIPOP output, and ON Environmental Penalty Annual Reports)
2. Extracting variables from the summaries of offenses (all provinces)
3. Coding variables, per systematized judgments (all provinces)

Thus, the three origins of variables are variables coded by governments, variables extracted from offense summaries, and coded variables. Table 3 describes the methodology and sources behind each variable and the variable type for the main 27 variables I created and used.

Two additional data cleaners and coders (Rafa Alkalai and Paul Li, undergraduate research assistants) assisted with data processing. I created a codebook (available online [here](#)) to train them on the coding techniques, and I conducted multiple rounds of quality checks on coding, ensuring that we were coding observations in the same way. Additional details on intercoder reliability and quality assurance procedures are described in Appendix B.

Table 3. Variables analyzed

Variable name	Variable details	Origin	Type	Provinces represented³	Parameters/levels	Rationale for creation/inclusion
province	Province where the enforcement action occurred	Coded variable	nominal	all	BC, AB, QC, ON, SK, NS, NB, PE, FD (Federal)	Allows users to filter by province
id	Observations' unique identifying number, accompanied by their province's abbreviations (e.g., AB22)	Coded variable	nominal	all	BC(1-1258); AB(1-225); QC(1-366); ON(1-70); SK(1-26); NS(1-30); NB(1-40); PE(1-204)	Provides unique identifying numbers to observations, helping to track them
offense_date	Date on which the violation occurred. ⁴	QC, PE, NB, SK FOI request, ON Environmental Penalty Annual Reports: Government raw data AB, SK News reports, ON News Bulletins and CanLII: extracted from summaries	interval	All except for BC, NS, and FD	Any date 11/8/1991 - 12/26/2020; NA	Only date provided by PE, provides temporal information
enforcement_date	Date on which the enforcement action was issued ⁵	BC, AB, QC, NB, NS, FD, SK FOI request, ON Environmental Penalty Annual Reports: Government raw data; SK News reports, ON News Bulletins and CanLII: extracted from summaries	interval	All except for PE	Any date 3/14/2000 - 12/16/2020; NA	Basis temporal parameter for study (2000-2020), provides temporal information
offender	The name of the offending party	BC, AB, QC, NB, NS, FD, SK FOI request, ON	character	all	(several across provinces)	Provides information about the offender, including the basis for determining the offender type and contributes

³ If listed in this column, at least some observations from that province have information about a given variable, there may be missingness/NA for some observations

⁴ When the violation stretched over a date range, the offense date corresponds to the start date.

⁵ For enforcement actions where there is time elapsed between the detection of violations and enforcement actions being issued (court sentences for example), it is the date when the actual enforcement action is issued.

Variable name	Variable details	Origin	Type	Provinces represented ³	Parameters/levels	Rationale for creation/inclusion
_name ⁶		Environmental Penalty Annual Reports: Government raw data; SK News reports, ON News Bulletins and CanLII: extracted from summaries				to determining the location of the offense (for companies and municipalities)
offender_type	The type of organization of the offender	PE: Government raw data All other provinces: coded variable	Nominal	all	Company, municipality, multiple, individual, other ⁷	Allows users to filter by organization
report_to_NPRI ⁸	Whether the offender reports to the National Pollutant Release Inventory	Coded variable	nominal	all	Yes, no, unknown ⁹	Allows users to filter by facilities that report to the NPRI (and by proxy, for the parameters required by CEPA and ECCC to report to it). Created by cross-referencing offender name, year of offense, and general location with the “NPRI Facility Installation Geolocations 1993-present” file from the federal Open Data portal (Environment and Climate Change Canada and Secretariat 2017). If an offender’s name appeared in the NPRI database, the year of the offense (as extracted from offense_date) corresponded with a year the facility reported to the NPRI, and the general location corresponded with the facility address listed in the database, then I assumed the offending facility in the observation matched that in the NPRI dataset and report_to_NPRI was coded as “yes.”

⁶ Some provinces (BC, PE, NS) protected the names of individual offenders by marking them as “unpublished” or the like, some (AB, QC, SK, ON) did not and published their full names.

⁷ “Multiple” represents when a company(ies) and the individual(s) responsible for the violations at that company were simultaneously charged for the same offense. (In some cases, there are numerous companies charged at one time, but this is coded as “company”, because they are all of the same offender type). “Other” represents offenders that fit none of these categories, such as churches.

⁸ The publicly-posted NPRI database’s most recent year for data is 2017, so if any offenders in my database have begun reporting to the NPRI since then, it is not reflected in my database.

⁹ “Unknown” is for companies and multiple offender types in PE, where the raw dataset also protected their identities (marked as “unpublished” and I was therefore unable to check them against the NPRI database).

Variable name	Variable details	Origin	Type	Provinces represented ³	Parameters/levels	Rationale for creation/inclusion
NPRI_top_20	Whether the offender is in the top 20 polluters by volume of criteria air contaminants and some toxics in a given province	Coded variable	nominal	all	Yes, no; NA ¹⁰	Allows users to filter the observations committed by facilities that on some year 2000-2020, for some pollutant, were among the top 20 largest polluters by volume in that province, of those that (self) reported their emissions to the NPRI. Created by using the “NPRI Releases 1993-present” file (Environment and Climate Change Canada and Secretariat 2017) to sort facilities by highest volumes of some criteria air contaminants (CO, SO _x , NO _x , PM, VOCs, NH ₃) and by measurement type (kg, grams, and g TEQ (ET)) in order to capture pollutants emitted in smaller volumes, like benzene, dioxins, and furans - all within each province, for the period 2000-2020. I copied the top 20 polluting positions from each list onto a separate document. This created a list of the top 20 polluting positions by volume of SO _x in Alberta, for example, then by NO _x in Alberta, and so on. In several cases, one or two facilities consistently emitted large volumes of a pollutant across years, so the top 20 polluting positions could be simplified as one or two polluting facilities (over longer time scales). I collapsed the lists to be distinct facilities only, and the resulting list comprised 134 facilities across all provinces. Finally, I decided an offender within my dataset simply had to appear on the list of 134 facilities to be coded as “yes” for NPRI_top_20; that is, the offender’s facility must only have been a top 20 polluter of some pollutant within the 2000-2017 period in order to be coded as “yes.” (It was not necessary for the offense to occur in that same year as they were a top 20 polluter, or be a top 20 polluter of the same pollutant type).
ministry_or_agency	The Ministry, Department, or otherwise government agency responsible for the enforcement action	BC: Government raw data All other provinces: coded variable	nominal	all	(several across provinces)	Provide information on the ministry responsible for environmental enforcement actions. For coded variables, coded by using the Ministry who published the raw data set or employed the public servants who sent it to me.

¹⁰ NA denotes observations who do not report to the NPRI to begin with, and thus could not be in the top 20 of its polluters.

Variable name	Variable details	Origin	Type	Provinces represented³	Parameters/levels	Rationale for creation/inclusion
act	The legislation under which the charge occurred	BC, AB, QC, NB, NS, FD, SK FOI request, ON Environmental Penalty Annual Reports: Government raw data; SK News reports, ON News Bulletins and CanLII: extracted from summaries	nominal	all	(several across provinces)	Provide information about the legislation used
regulation	The regulation under which the charge occurred (if applicable)	BC, QC, NB, NS, ON Environmental Penalty Annual Reports: Government raw data; ON News Bulletins and CanLII: extracted from summaries	nominal	All except AB, FD, and SK	(several across provinces)	Provide information about the legislation/regulation used
section	The section under which the charge occurred (if applicable)	BC, AB, QC, NB, NS, FD, SK FOI request, ON Environmental Penalty Annual Reports: Government raw data; ON CanLII: extracted from summaries	nominal	all	(several across provinces)	Provide information about the legislation used
penalty_type	The type of enforcement action issued	BC, AB, QC, NB, NS, FD, SK FOI request, ON Environmental Penalty Annual Reports: Government raw data; SK News reports, ON News Bulletins and CanLII: extracted from summaries	nominal	all ¹¹	Administrative Penalty, Ticket, Court Conviction, Fine, Order (Enforcement, Environmental Protection, Information, Pollution Abatement, Pollution Prevention), Long-form Information, Warning, Restorative Justice, Open Court Proceeding; multiple,	Grouping enforcement actions and standardizing terms, allows filtering by type

¹¹ Not all provinces have used all of these penalty types, but all provinces utilize at least one penalty type. Provinces use different terminology for concepts such as “administrative penalty”, all names were standardized for cross-provincial analysis.

Variable name	Variable details	Origin	Type	Provinces represented ³	Parameters/levels	Rationale for creation/inclusion
					NA (SEE TABLE 5)	
fine_imposed	The fine imposed as part of the enforcement action (if applicable)	BC, AB, QC, NB, NS, FD, SK FOI request, ON Environmental Penalty Annual Reports: Government raw data; SK News reports, ON News Bulletins and CanLII: extracted from summaries	ratio	all	(0/NA) - \$5,300,000	For penalty types where fines may apply (administrative penalties, tickets, court convictions, fines, and restorative justice), provides quantitative information about those penalties
regulatory_time_span	The number of days a regulatory infraction occurred ¹²	Extracted from summaries	ratio	all	(0/NA) - 852	Provides a glimpse of how long a regulatory infraction occurred (before enforcement action took place or before the behavior was self-corrected).
regulatory_acute_chronic	An estimation of how long the regulatory infraction occurred ¹³	Coded variable	ordinal	all	Very short (<=1 week), short (>1 week <= 2 months), medium (>2 months <=1 year), long (>1 year <=3 years), very long (>3 years); unknown, multiple, NA	For when there are no specific dates allowing a calculation of regulatory_time_span, but enough information to infer a broader estimate.
pollution_time_span	The number of days a pollution infraction occurred ¹⁴	Extracted from summaries	ratio	all	(0/NA) - 4015	Provides a glimpse of how long a regulatory infraction occurred (before enforcement action took place or before the behavior was self-corrected).
pollution_acute_chronic	An estimation of how long the pollution infraction occurred ¹⁵	Coded variable	ordinal	all	Very short (<=1 week), short (>1 week <= 2 months), medium (>2	For when there are no specific dates allowing a calculation of regulatory_time_span, but enough information to infer a broader estimate.

¹² E.g., if included in the summary is “failure to monitor emissions from a stack from January 2-January10”, I accordingly would code the regulatory time span as 8 (days)

¹³ E.g., if included in the summary is “failure to submit the monitoring reports for three months”, I do not know which months exactly and therefore cannot be sure of the number of days, but I can code that it was a “medium” term (between 2 months and 1 year).

¹⁴ E.g., if included in the summary is “emissions exceeded permitted hourly limits January 2-January10”, I accordingly would code the pollution time span as 8 (days).

¹⁵ E.g., if included in the summary is “used an unauthorized piece of pollution abatement equipment”, I do not know for how long they used it, but I assumed that most pollution abatement equipment is not easily installed and uninstalled (on a weekly basis, for example), so the shortest amount of time that is reasonable is a “medium” period (2 months - 1 year), and coded the pollution_acute_chronic variable as “medium” accordingly

Variable name	Variable details	Origin	Type	Provinces represented ³	Parameters/levels	Rationale for creation/inclusion
c					months <=1 year), long (>1 year <=3 years), very long (>3 years); unknown, multiple, NA	
pollutant_type	The type of air pollutant emitted or concerned in an enforcement action	Extracted from summaries or coded variable	nominal	all	(several across provinces)	Allows users to group observations by pollutants. Some summaries of offenses explicitly named the pollutant (NOx, odor, etc.), in which case I extracted the pollutant type from the summary, but many did not, requiring me to code the variable based on other dimensions of the summary or context. ¹⁶
number_of_violations	The number of violations that occurred	Coded variable	interval	all	1-6	Some provinces, particularly Alberta ¹⁷ , but also BC, QC, and ON, bundled multiple violations into one enforcement action/observation. This allows users to note how many violations occurred under a single enforcement action observation.
keyword	The general category of infraction that occurred	Coded variable	nominal	all	Burn, Emissions, Equipment, Excess Emissions, Standards, Multiple, Monitoring, Notification, Order, unknown (SEE TABLE 4)	Group similar offenses together, in terms of what the violation was from the legal perspective. Created as synopses of the raw-data summaries of offenses, and checked against the Act, Regulation, and Section (where applicable) to provide additional information.
summary	The extended summary of the offense and/or enforcement action	BC NRCED, AB, QC, NB, NS, FD, SK FOI request, ON Environmental Penalty Annual Reports: Government raw data; SK News reports, ON News Bulletins and CanLII, BC inspections	character	all	(several across provinces)	Provides the fullest narrative of the offense. Ranges from a few words to several paragraphs between observations

¹⁶ E.g. when enforcement agencies describe burn violations (different offender types illegally burning items or land), they rarely name “smoke” as the pollutant type from that offense. Accordingly, I assumed all burns produce smoke, and coded “smoke” as the pollutant type.

¹⁷ Alberta frequently cited multiple types of regulatory infractions together, often in a warning, such as failures to monitor emissions and submit reports. These constitute the majority of observations where the number of violations was greater than 1.

Variable name	Variable details	Origin	Type	Provinces represented ³	Parameters/levels	Rationale for creation/inclusion
		reports: condensed from raw data versions				
general_location	The municipality, administrative region, or otherwise larger geographical location where the offense occurred	BC, AB, QC, NB, NS, SK FOI request, ON Environmental Penalty Annual Reports: Government raw data; SK News reports, ON News Bulletins and CanLII: extracted from summaries	character	All except FD	(several across provinces)	Provides a general location of where an offense occurred, available for offender types.
specific_location	The street address where the offense occurred	BC inspections data: government raw data; All other provinces: coded variable (on rare occasion, summaries from other provinces would include the street name, but the number)	character	All except NS	(several across provinces)	Provides a street-level location where the offense occurred, allows latitude and longitude calculations to be derived therefrom. Only available for companies, multiple, and municipality offender types (individuals' privacy protected). Created by using Google to search offender names and find addresses associated with the name, cross-referencing the address with the general location provided by the raw data to check for alignment, and checking any other sources that may populate in the search (for example, news reports about the offense which may provide more information about location or other details, or maps of mine sites) ¹⁸ . For facilities reporting to the NPRI, the street address and latitude and longitude housed in the NPRI database was used (instead of internet searches).
lat	Latitude of the offense location (as extracted	Coded variable ¹⁹	interval	All except NS	42.175-59.928; NA	Provides coordinate information on the location of an offense; extracted from specific location or NPRI

¹⁸ It was often difficult to discern whether the business address of a company, for example, was where an infraction occurred, or if it occurred off-site. Sometimes this was obvious (emissions from a factory), but sometimes less so (concrete companies with fugitive dust - did the fugitive dust emissions occur at their business address, or while out on a job and mixing?). In the less obvious cases, specific locations were either marked as "NA" (resulting in the latitude and longitudes also being NA) or the specific location was listed, with the caveat of "uncertain" being the term populated in the "fill" variable (see below). In other cases, businesses had closed, moved, or simply had no apparent internet presence, and we were unable to discern location entirely, in which cases we marked the specific location as "NA".

¹⁹ Some observations' locations, such as mines, oil sites, municipalities, etc., were not represented by street addresses that could be appropriately assigned to specific_location. In such cases, a point was dropped as close as possible to the estimated location of the violation and the coordinates were recorded from that

Variable name	Variable details	Origin	Type	Provinces represented ³	Parameters/levels	Rationale for creation/inclusion
	from the street address or NPRI database)					database where applicable
lon	Longitude of the offense location (as extracted from the street address or NPRI database)	Coded variable ²⁰	interval	All except NS	-131.075--61.873	Provides coordinate information on the location of an offense; extracted from specific location or NPRI database where applicable
fill	A measure of my confidence in the observation	Coded variable	nominal	all	Certain, uncertain	Provides users with an accounting of uncertainty, and where more information may be necessary. I assigned an “uncertain” coding whenever there was conflicting or insufficient information, such that it hampered my ability to interpret and code other variables ²¹ .

Table 4. Description of keywords

Keyword	Description
Burn	an illegal burn (burning material or land out of season, without a permit, without taking the prescribed precautions, etc.)
Equipment	failure to install, register, update, or properly use or maintain air pollution abatement equipment
Monitoring	failure to document, maintain a register/record of, test samples, or otherwise monitor air emissions
Notification	failure to communicate with the relevant government/enforcement body about air pollution activities (that an air pollution event has occurred, that permitted emissions limits have been exceeded, that pollution reports will be submitted late, etc.).
Standards	failure to comply with a jurisdiction-wide standard governing a particular emissions limit, equipment type, etc.

²⁰ See “lat” (latitude) footnote

²¹ For some observations, an “uncertain” code may be assigned when I cannot be sure that the pollution was to air (several summaries fail to specify whether ammonia pollution is to air or water, for example). For others, the location information may be shaky, or the coding may not reflect all of the pollutants, for example. This variable is my attempt to allow as many observations as possible to remain in the dataset, while representing the existence of holes in the data and uncertainties, pointing to where more information is needed.

Excess emissions	failure to comply with the terms of a permit, as it relates to emissions limits in particular, or failure to hold a permit at all
Order	used sometimes when the penalty type is an “order” of some kind, and the pollution or regulatory infraction has not yet occurred, it is merely anticipated by the enforcement agency
Emissions	when an air pollutant is emitted (used only when there is not enough information to allocate any of the above keywords- e.g., when summaries simply state “emitted dust”)
Multiple	used when a single observation/enforcement action captures multiple infractions (see number_of_violations comments)
unknown	used when there is insufficient information to determine another keyword

Table 5. Description of penalty types

Penalty group	Penalty type ²²	Description
Monetary penalties	Administrative Penalty	A monetary penalty issued by enforcement agencies, usually to companies. It is a flexible and usually higher value than tickets, allowing officers to scale the fine according to the noncompliance, but avoids courts (since it is issued by the enforcement agencies), facilitating a more streamlined and inexpensive process for the agency.
	Fine	A monetary penalty, unknown whether it was issued as a Ticket, Court Conviction, or Administrative Penalty
	Ticket	“Issued by designated officials to persons and businesses for minor offenses such as littering, hunting violations, and illegal campfires. Tickets are an efficient deterrence to harmful behaviours as they are often issued in the field” (Ministry of Environment and Climate Change Strategy n.d.). The fine amount associated with a ticket is usually set by local law – it is not scalable or flexible per the scope of the violation.
Order types	Order (Enforcement Order, Environmental Protection Order, Information Order,	“Written legal documents that require regulated parties to address non-compliance issues or take measures to protect human and environmental health and safety. Designated officials issue orders, requiring a person or business to follow specific instructions to prevent, alter, or stop activities or repair works that may have damaging impacts.” (Ministry of Environment and

²² Provinces have different definitions and thresholds for what types of violations (and violators) warrant a given penalty type and for the scopes and applications of penalty types (such as the range of fines that can be applied). However, for the most part, these considerations are not made public and can be considered flexible, per provinces’ “cooperative approach” to enforcement, discussed in the literature review and further in the discussion. For purposes of generally understanding each penalty type, British Columbia offers definitions of the ones they employ, which are basically applicable across the provinces studied (Ministry of Environment and Climate Change Strategy n.d.).

	Pollution Abatement Order, Pollution Prevention Order)	Climate Change Strategy n.d.). Each of these order types serve slightly different purposes, but the basic principle of an Order as described here is consistent across types.
Official proceedings	Court Conviction	“A legal process where a person or business is formally charged and found guilty in a court of law by a judge. Guilty convictions may result in a range of penalties, typically including fines, creative sentencing orders, forfeitures, probation or jail time” (Ministry of Environment and Climate Change Strategy n.d.). Some court convictions include mandates for environmental remediation or cleanups, but rarely are these communicated through offense summaries.
	Open Court Proceeding	An ongoing court proceeding, where a conviction has not yet been reached.
	Restorative Justice	A forum with offenders, victims, and trained facilitators where offenders accept responsibility and the group collectively agrees upon restitution. “Restorative justice forums offer a timely and cost-effective way to deal with certain environmental offenses in an inclusive forum designed to promote offender accountability, repair the harm caused by the offense and restore compliance. Restitution can take a variety of forms such as environmental restoration projects, financial penalties, community service, and a public declaration by the company of their responsibility and remorse” (Ministry of Environment and Climate Change Strategy n.d.).
Letters	Warning	“Notifies the non-compliant party in writing that they are not in compliance with a specific regulatory requirement [and signals the] possibility of an escalating response should non-compliance continue. It serves as a formal record of the alleged non-compliance and forms an element of the compliance history of the party in question” (Ministry of Environment and Climate Change Strategy n.d.).
	Long-form information	Similar to a warning, but more like an advisory notice that a party is out of compliance; does not necessarily signal the possibility of an escalating response.
	multiple	Multiple of the above penalty types were issued
	NA	presumed error or perhaps informal enforcement action was issued (one observation in PE is marked in source data as “NA” penalty type)

3.2 Descriptive Analysis

I used R statistical computing package, version 4.0.2 “Taking Off Again” to perform descriptive analyses of the variables described. I built the code for each province individually, adding and subtracting analyses as warranted by the unique sets of variables available in each province. I utilized some of these pieces of code to create the final inter-provincial analysis code, while adding features to discern provinces from each other on graphs and other visualizations. I calculated various descriptive statistics: comparing the distributions of fines, penalty types, keywords, offender types, etc., across provinces and over time, and used different types of t-tests to examine statistical differences. Additional descriptive statistics were calculated for subsets of observations, particularly those representing potentially larger impacts on environmental and human health.

3.3 Environmental Justice Analysis

The analysis on the environmental justice dimensions of enforcement was conducted by comparing the locations of enforcement actions to the demographic population contexts in which they occurred.

To do so, undergraduate research assistant, Sophie Thornton, created maps and geographical datasets using ArcGIS Pro. First, the locations of enforcement actions were plotted in the NAD 1983 geographic coordinate system in ArcGIS Pro using each observation's coordinate data, as defined in subsection 3.1.3 (lat, lon variables). Locations were only obtained for non-individual offenders, and for some non-individual violations, location information was not available. Then, shapefiles denoting dissemination area (DA) boundaries, provincial boundaries, and major waterways were downloaded from the Abacus Dataverse Network and added to the map of enforcement actions (Statistics Canada 2016). Then, layers from the 2016 Canadian Census were downloaded at the dissemination area (DA) level from the University of Toronto (CHASS) portal (Canadian Census Analyzer 2017) for several census profiles known to correspond with environmental justice (Fryzuk 1996), hereafter called "EJ variables." EJ variables included age and sex, immigrant population, aboriginal population, after-tax family income, median rent, median property value, and visible minorities. Data on EJ variables were joined to the boundary shapefiles. Additional columns were calculated for percentages of the total population; for example, percent non-male population, percent immigrant population, percent aboriginal population, and percent visible minority population were calculated and used in the analysis. A similar process was conducted for two additional "EJ variables": material and social deprivation. The material deprivation index is calculated based on the proportion of the population without a high school diploma or equivalent, the employment to population ratio, and the average income for the population aged 15 and over. The social deprivation index is calculated based on the proportions of the population aged 15 and over who are living alone or separated, divorced, or widowed and the proportion of single-parent families. Data on these variables were downloaded from the Quebec National Institute of Public Health (2016) and then joined to the boundary shapefiles. Following these processes, many EJ variables were joined to DA shapefiles, alongside the plotted locations of enforcement actions. Bivariate color maps were then created to demonstrate the distribution of EJ variables with the points of enforcement actions overlaid (Figures 7 and 8).

Next, statistical calculations were performed to compare the distribution of these EJ variables in proximity to enforcement actions against the distribution of EJ variables across provinces in general. A three-mile buffer was applied to each enforcement action point to capture the EJ variables of the DAs in the surrounding area (following the areal apportionment technique utilized by Mohai and Saha [2006], Glickman, Golding, and Hersh [1995], and Sheppard et al. [1999])²³. Then, a weighted average of each EJ variable was calculated, weighting by the shape area of each DA within the three-mile buffer of each enforcement action. These values were compared to cross-provincial averages, which were unweighted average calculations of all of the provinces with point data considered (BC, AB, ON, QC, SK, and NB).

3.4 Summary and limitations:

A few private organizations have gathered data about environmental enforcement actions in Canada using a methodology similar to my data collection process. Berkley Canada (2019) produces reports that summarize and analyze the environmental enforcement actions which received large fines (>\$75,000) in Canada every year since 2015. They garner data about these enforcement actions from publicly available sources - mostly news articles and the news reports posted on government websites. While the Berkley report covers fines across all pollution media (including water, land, etc.), they do separate and label air offenses. From their data, I was able to cross-validate the observations in my dataset with the air-related enforcement actions found in theirs. Likewise, Nimonic (2010) produced a report about environmental fines in Canada spanning 1990-2009, using both publicly available information and information obtained through information requests. While Nimonic's report does not separate fines by pollution media, it does provide insights into the trends of fines across and between provinces. Parallels between my findings and that of Berkley and Nimonic are discussed in subsection 7.5.

I adapted and expanded the Environmental Data and Governance Initiative (2020) figure (Figure 2) (which delineates the pipeline of violations of the US Clean Air Act to the EPA's ECHO dataset) into Figure 4, which I

²³ A three-mile buffer (4.83km) was selected because of the many studies cited that employ such a buffer for similar methods and purposes, but also because a larger buffer (compared to a one- or two-mile) was considered appropriate to capture the larger community that could influence or be influenced by enforcement actions.

describe as the “violations pipeline.” This figure details the many points at which observations may fall out of the pipeline on the path from point-source air pollution in Canada to my dataset. Pollution may be compliant with legal requirements, noncompliant pollution may not be recognized as a violation by regulators, or it might not be recognized as a violation but not subject to any enforcement action. The enforcement actions that do occur might not be publicly published, and finally, those that are publicly posted as the provincial source datasets I use are subject to the filters I employ for purposes of this study. As such, my dataset is a fraction of the source data detailing enforcement actions, a smaller fraction of all enforcement actions that occur in Canada, a smaller still fraction of the violations that occur across Canada, and an even smaller still fraction of ambient air pollution in Canada. Because of the poor data quality and reporting mechanisms described in subsection 2.1, regulators and the public do not know how much pollution or how many violations exist and fall out of the pipeline at most levels. It is essential to recognize that regardless of where observations fall out of the pipeline, human and nonhuman systems are affected by pollution. Even “compliant” pollution can adversely affect ecosystems and human communities (and disproportionately so for EJ communities). Thus, just as my dataset represents but a fraction of the total pollution that occurs, it represents just as small of a proportion of its impact.

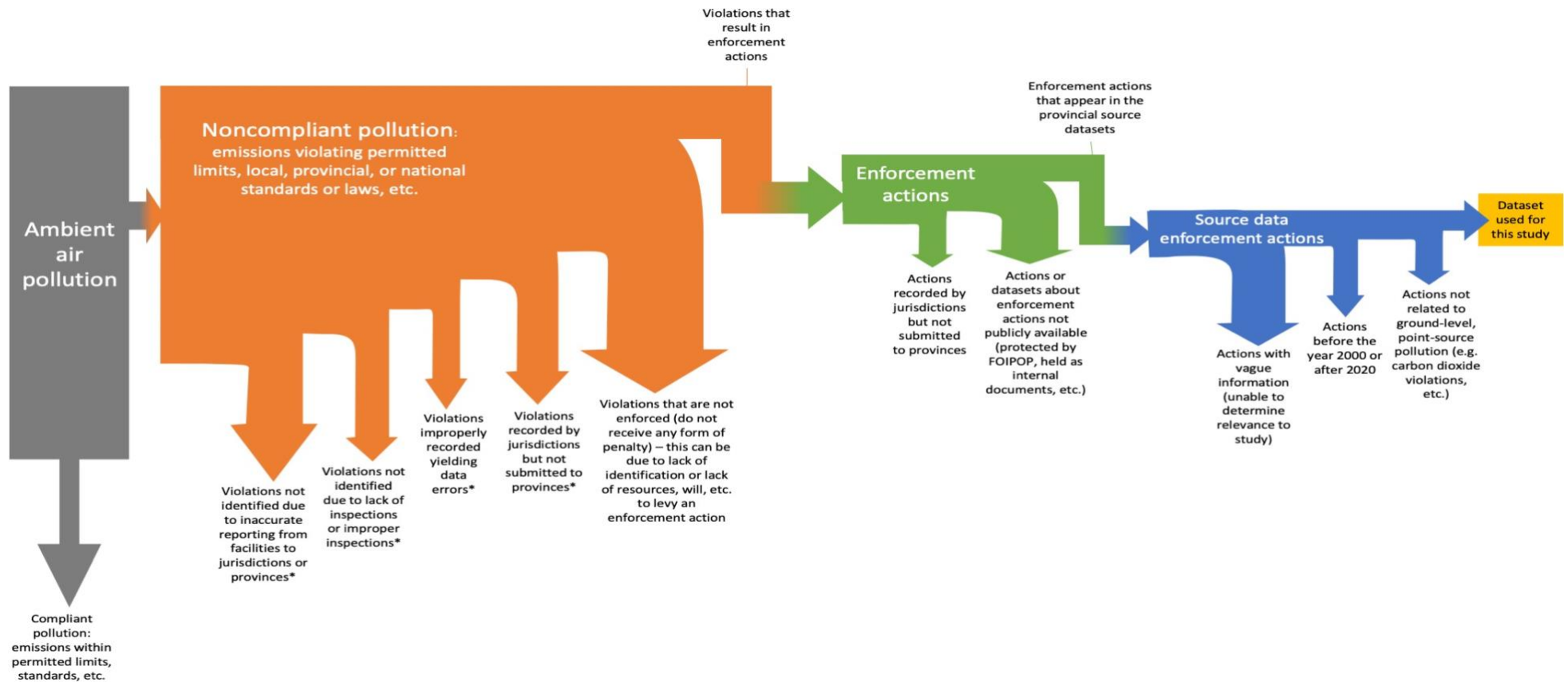


Figure 4. The “violations pipeline”

Descriptions marked with an asterisk are quoted or adapted from the Environmental Data and Governance Initiative's figure (Figure 2, 2020). Similarly, as in the Environmental Data and Governance Initiative's figure, varying widths of arrows are used to communicate estimates of proportions or quantities of violations that fall out of the pipeline at a given point. For example, there are estimated to be many more violations that are not enforced than violations that are improperly recorded, hence the former's wider arrow. However, because of poor data quality and reporting, we cannot know the exact quantities behind each pipe.

As described, the dataset I've compiled is mostly a reflection of what is publicly available online, what public servants are willing to send through email communications, and the products of (relatively) quickly-returned FOIPOP requests. The dataset may not reflect the total number of law enforcement actions related to air pollution within each province. There is substantial variation between and within provinces in terms of the availability and quality of information. This variation is partially demonstrated by the difference in years for which provinces have data available, as well as which variables needed to be coded, versus which were provided by the raw data, and so on. Even still, these measures do not adequately portray the vast variation that occurs both between and within provinces. While I endeavor to draw trends and preliminary conclusions from these data through the following analyses, the picture is by no measure complete for understanding the landscape of enforcement actions across provinces.

Chapter 4: Results – Assessing Jurisdictions’ Data

Because of the wide disparities between provinces in terms of the availability, accessibility and quality of their data on enforcement actions, I developed a rubric to assess and compare provinces on such metrics. This rubric was inspired by the data availability rubric in the “Democratizing Data” report (Environmental Data and Governance Initiative 2020), alongside similar “report cards” for legislation, like “Waterproof 2: Canada’s drinking water report card” (Christensen and Sierra Legal Defence Fund 2006). It draws on environmental data justice and open data literature, as well as my experience in obtaining and working with datasets from different sources.

First, each level of the scale is provided and explained (Table 6). Then, data concepts, acting as rows of the rubric, are given, followed by each jurisdiction’s grade for that concept (Tables 7-20). Overall jurisdiction grades, calculated as the average of each individual concept grade, are provided in Table 21.

Table 6. Data availability rubric levels

<p>7: Just, open data. Drawing on the Dillon et al. (2017) definition of environmental data justice, environmental data justice is "embracing public accessibility and continuity of environmental data and research, supported by networked open-source data infrastructure that can be modified, adapted, and supported by local communities." It is a participatory model of open data, "where open data becomes an explicit conduit between citizen and government, where citizen contributions are dynamic, and government becomes responsive to demand-side requests for data" (Sieber and Johnson 2015). It is supported by details explaining context and provenance - it attempts to minimize extractive logic (Vera et al. 2019). Data is able to be held, checked, and maintained by multiple parties - it is open to "contributions as well as contestations, becoming a possible realization of the democratic and open government principles of transparency and participation" (Siebers and Johnson 2015) (it is not subject to the fragility and volatility of government maintenance alone, nor to industries self-reporting emissions, for example) (Walker et al. 2018). Data infrastructures promote critical</p>	<p>6: Open data. While there are numerous definitions of open data and disagreement about what meets the threshold of sufficiently "open," this rubric adopts the definitions that set a high standard for governments. To take Agranoff's definition, mere raw data is insufficient; organized, aggregated forms are instead necessary to "make data accessible in a way that transforms pure data into knowledge" (2006). As such, this standard demands explicit transparency from data creators and managers on the origins, maintenance, and shortcomings of their datasets. It demands ample science communication skills and translating complex realities into understandable summaries, alongside opportunities for additional learning. The main differences between open data and just, open data are that the onus for open data remains</p>	<p>5: Imperfectly open data. The government is on a path towards open data, but there are some combinations of missing factors, whether it be less user-friendly interfaces or terminology, less transparency about the data's creation and maintenance, less flexibility in file formats, filtering, or organizing the data, less context and detail provided about observations, etc.</p>	<p>4: Flawed open data. There is some semblance of a database or organized dataset, but it has a long way to go before it can be considered "open data." There are notable gaps in accessibility, (transparency about) completeness, usability and flexibility, data detail, and public interpretability. Contacting government staff and/or FOIPOP-type requests may become necessary to fill in the gaps.</p>	<p>3: Raw data. Data is published onto a website or database in a more or less unprocessed, unorganized format. These may take the form of internal government documents that are not explained or contextualized. As a result, users need to already have expertise in using or interpreting a given file type or devote time to learning the particularities and jargon that might be employed by this</p>	<p>2: Fraught path to data. There are no obvious, relevant raw or organized data available publicly. Through additional searches, the user is able to find either data behind a privacy wall (warranting a FOIPOP request) (described below through the "a" pathway) or "workarounds" or alternative methods to aggregating data, creating their own dataset (described below through the "b" pathway). This requires significant effort</p>	<p>1: No data. There appears to be no data publicly or privately available that is relevant, and government staff is unresponsive. There is no apparent path to obtaining data by any means.</p>
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assessment and justice and services, especially for the communities that the data describe, and infrastructures attempt to minimize the potential for exploitation by bad faith users (Johnson et al. 2017). For emissions data: data is "verified" by multiple knowledge holders (e.g., it is not solely reliant on the self-reported emissions by emitters) (Walker et al. 2018). The principles below contain all or most of the necessary pieces for open data (see 6: Open data), plus dimensions that (can) contribute to justice, as described above. Open data criteria appear <i>italicized</i> below justice criteria.	primarily with the government (as opposed to multiple knowledge holders) and that it offers some, but less context and detail than can be provided by just, open data. To this point, open data maintains the "extractive logic: the act of pulling relations from bodies and lands into data" (Vera et al. 2019). While even just, open data participates in the extractive logic to some extent, despite its orientation towards justice, it can be mitigated somewhat by adding the rich context and stories just, open data seeks.			data. Consequently, it is an exclusionary form of data. Users may have to compile multiple raw datasets, file FOIPOP requests, and/or contact government staff in order to fill in gaps.	from the user, and unless the returned FOIPOP request is complete and full of the desired information, it will likely result in significant missingness, lack of detail, lack of transparency, and more.	
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Table 7. Rubric metric - Database accessibility

7: Just, open data	6: Open data	5: Imperfectly open data	4: Flawed open data	3: Raw data	2: Fraught path to data	1: No data
1. There are accessibility features for differently-abled people, and the platform is available in multiple languages. 2. Data is archived, available, and maintained outside of the central platform. <i>1. The path to the data platform is clear and simple, and begins from the government's home page. It takes fewer than ten clicks/pages to access the data platform from the home page starting point. 2. There are several pathways to get to the database from different segments of the government's website, and there are descriptive guides along those pathways (for example, a blurb below links saying "this page contains information about air quality in X province and our database on air pollution law enforcement actions"). 3.</i>	1. The path to the data platform is clear and simple, and begins from the government's home page. It takes fewer than ten clicks/pages to access the data platform from the home page starting point. 2. There are several pathways to get to the database from different segments of the government's website, and there are descriptive guides along those pathways (for example, a blurb below links saying "this page contains information about air quality in X province and our database on air pollution law enforcement actions"). 3.	1. The path to the data platform is somewhat clear coming from the government's home page, but it may take more than ten clicks or a few backtracks to get there. 2. There are limited pathways to get to the database from different segments of the government's website, and there are few descriptive guides along the way. It would help users to know what they're looking for, but it's possible to find it unguided. 3. There are some filters or organizing features,	1. The path to the data platform is not clear, coming from the government's home page. It takes more than ten clicks and a few backtracks to get there. 2. There is one pathway to get to the database and no descriptive guidelines along the way. Users must know what they are looking for in order to identify it and the proper pathway. 3. There are no filters or organizing features. 4. The data platform and/or its contingent websites are not well-maintained nor user-	1. There is no "database" currently available describing the desired phenomena - that is, no "organized, aggregated form to transform pure data into knowledge" - rather, there is only raw data or internal documents. 2. Users must know what they are looking for in order to identify it and the proper pathway, and they may need to know where to look for multiple sets of raw data in order to compile the information they require. 3. As it is raw data, it is only as user-friendly as the user is familiar with the format, terminology, etc.,	1. There is no "database" or "dataset" currently publicly available describing the desired phenomena. Any data on the topic is (either) behind a privacy wall and/or is only available as disjunct entities, such as through news reports or other knowledge holders. It becomes the job of the user to submit FOIPOP requests and/or create a database	1. There is no "database" or "dataset" currently publicly available describing the desired phenomena. There appear to be no alternatives from which to obtain the data - whether sources behind privacy walls or disjunct entities. The path for a user to create their own database or submit FOIPOP requests is extremely unclear. 2. Users must contact the government in pursuit of data, but

<i>database on air pollution law enforcement actions"). 3. There are filters or other organizing features contributing to the data platform's usability 4. The data platform and its contingent websites are generally well-maintained; they are user-friendly, load quickly, and do not crash or have bugs.</i>	There are filters or other organizing features contributing to the data platform's usability 4. The data platform and its contingent websites are generally well-maintained; they are user-friendly, load quickly, and do not crash or have bugs.	but they are limited or do not work properly. 4. The data platform and/or its contingent websites are somewhat well-maintained and user-friendly. They might take a while to load or have a few bugs.	friendly. They take a while to load and have bugs. 5. Users may have to contact the government in order to find, access, use, or understand the database.	employed by the data. As such, it is exclusive to those who may not have the proper skillsets. 4. Users may have to contact the government in order to find, access, use, or understand the disparate datasets.	themselves through the disjunct sources of information. 2. Users must contact the government in pursuit of data.	they are unresponsive or unable to direct users to resources.
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Table 8. Jurisdiction grades on database accessibility

AB	BC	FD	QC	NB	PE	NS	ON	SK
5	4.5	5.5	3.8	4	2	2	2.1	2

Table 9. Rubric metric - Data completeness

7: Just, open data	6: Open data	5: Imperfectly open data	4: Flawed open data	3: Raw data	2: Fraught path to data	1: No data
<p>1. Data managers (multiple stakeholders and knowledge holders) state explicitly and in detailed terms what, who, where, and when is represented by the dataset. 2. Detailed methodologies are provided regarding how the dataset was gathered, compiled, and checked by multiple knowledge holders, where applicable. 3. Multiple perspectives are hosted on the dataset (for example, a government report may state that an air pollution event lasted for 4 hours [reflecting the amount of time an accidental emission was occurring], but community members are able to add to the same observation to include their perspective, which might be that they suffered a headache for several days as a result). 1. Data managers state explicitly and in detailed terms what, who, where, and when is represented by the dataset. 2. Detailed methodologies are provided regarding how the dataset was</p>	<p>1. Data managers state explicitly and in detailed terms what, who, where, and when is represented by the dataset. 2. Detailed methodologies are provided regarding how the dataset was gathered, compiled, and checked, where applicable. 3. Missingness and potential reasons for it are stated explicitly and in detailed terms. 4. Data has been updated or maintained within the last year, and this is stated alongside the dataset. 5. Through these explanations and via</p>	<p>1. Data managers of the data platform state in brief or incomplete terms what, who, where, and when is represented by the dataset. 2. cursory descriptions of the methodologies are provided regarding how the dataset was gathered, compiled, and checked, where applicable. 3. cursory descriptions of missingness and potential reasons for it are given. 4. Data was last updated or maintained within the past 2-5 years, and this is stated alongside the dataset. 5.</p>	<p>1. Data managers do not state what, who, where, or when is represented by the dataset. 2. No descriptions of the methodologies are provided regarding how the dataset was gathered, compiled, and checked, where applicable. 3. No descriptions of missingness and potential reasons for it are given. 4. It is unstated when the dataset was last updated or maintained. 5. Because these explanations are absent, the user has to</p>	<p>1. Data managers do not state what, who, where, or when is represented by the raw data files. 2. No descriptions of the methodologies are provided regarding how the raw data was gathered, compiled, and checked, where applicable. 3. No descriptions of missingness and potential reasons for it are given. 4. Because these explanations are absent, the user has to rely on their own independent assessment of the</p>	<p>1a. If the user is provided with information through FOIPOP, it may be difficult to assess its completeness or ask further questions about it from the providers - it is up to the user's independent assessment. 1b. If the user is creating a database themselves, it is likely that their database will be significantly less complete than what knowledge holders could provide. It is</p>	<p>NA (the data is not present, and therefore it is entirely incomplete)</p>

<i>gathered, compiled, and checked, where applicable. 3. Missingness and potential reasons for it are stated explicitly and in detailed terms. 4. Data has been updated or maintained within the last year, and this is stated alongside the dataset. 5. Through these explanations and via independent assessment of the dataset, it appears that the dataset is relatively complete, and what is missing is clear and explained.</i>	independent assessment of the dataset, it appears that the dataset is relatively complete, and what is missing is clear and explained.	Through these explanations and via independent assessment of the dataset, the user is not sure whether it is relatively complete, without a clear understanding of what is missing.	rely on their own independent assessment of the dataset, and the user is not sure whether it is relatively complete, but it appears to be less complete.	raw data, and the user is not sure whether it is relatively complete, but it appears to be less complete.	difficult for the user to know what proportion of the true count they have found via their alternative methods and been able to include in their dataset.	
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Table 10. Jurisdiction grades for data completeness

AB	BC	FD	QC	NB	PE	NS	ON	SK
4.1	4.2	4.1	4.2	4	4.3	3	2.1	2

Table 11. Rubric metric - Dataset usability

7: Just, open data	6: Open data	5: Imperfectly open data	4: Flawed open data	3: Raw data	2: Fraught path to data	1: No data
1. Requests for alternative forms of data delivery are accommodated by data managers and/or knowledge holders (printed versions for those without internet access, for example). <i>1. Data is available for download in multiple file formats. 2. Measurement units are clearly communicated and can be changed (depends on the unit).</i>	1. Data is available for download in multiple file formats. 2. Measurement units are clearly communicated and can be changed (depends on the unit).	1. Data is available for download in one or two file formats. 2. Measurement units are communicated but cannot be changed.	1. Data is not available for download (must be copied over from the website in order to use it). 2. Measurement units are not communicated.	1. Raw data may be available for download, but (depending on the user's usage) may require translating into another dataset, combining with other raw data, etc.	1a. For data received through FOIPOP, it is delivered in difficult-to-read formats (such as PDFs), or must be translated from other types of documents. 1b. For data gathered from disjunct sources, it must be tabularized and coded by the user.	NA (the data is not present and therefore not available for download)

Table 12. Jurisdiction grades for dataset usability

AB	BC	FD	QC	NB	PE	NS	ON	SK
4.5	5	5	4	4	3	3	2.1	2

Table 13. Rubric metric - Privacy protections and FOIPOP requests

7: Just, open data	6: Open data	5: Imperfectly open data	4: Flawed open data	3: Raw data	2: Fraught path to data	1: No data
1. Consideration is given to privacy	1. Any privacy-compromising	1. Privacy-compromising	1. Privacy-compromising information about individuals is	1. Where applicable, a FOIPOP or FOIPOP-	1a. The turnaround for FOIPOP requests is slow, four months+	NA (the data is not present and

concerns where open data privacy standards may be insufficient to protect vulnerable populations. 1. <i>Any privacy-compromising information about individuals - namely their names and locations of infractions - is redacted from the dataset.</i> 2. <i>All other information from those observations and from other types of offenders is included in the dataset.</i>	information about individuals - namely their names and locations of infractions - is redacted from the dataset. 2. All other information from those observations and from other types of offenders is included in the dataset.	information about individuals is revealed. 2. Limited redaction privileges are extended to non-individual offenders, such as removing the names or locations of companies or municipalities (which should be made public), but the dataset remains otherwise usable.	revealed. 2. Extensive redaction privileges are extended to non-individual offenders, such that the dataset becomes unusable. As a result, a FOIPOP or FOIPOP-type request becomes necessary in order to obtain the relevant information. 2a. The turnaround for FOIPOP requests is relatively quick, ~4 months or less. 2b. Processes and costs to submit requests are clear and easily available online. 2c. When the FOIPOP information is received by the user, it is relatively complete and contains the information which was originally requested.	type request may become necessary in order to obtain the relevant information. 1a. The turnaround for FOIPOP requests is relatively quick, ~4 months or less. 1b. Processes and costs to submit requests are clear and easily available online. 1c. When the FOIPOP information is received by the user, it is relatively complete and contains the information which was originally requested.	1b. Processes and costs to submit requests are unclear and require further explanation from government staff. 1c. When the FOIPOP information is received by the user, it is incomplete and contains only some of the information which was originally requested. 2a. The user, who is creating the database, is unclear about what privacy rules should or should not apply to their dataset and may provide privacy-compromising information about individuals. 2b. If extensive redaction privileges are extended in the alternative sources for the user's database creation, they may perpetuate the same undesirable opaqueness that the source information included.	therefore has no privacy implications)
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Table 14. Jurisdictions grades on privacy protections and FOIPOP requests

AB	BC	FD	QC	NB	PE	NS	ON	SK
5	5.5	6	5	5	4	4	2.3	2

Table 15. Rubric metric - Data detail

7: Just, open data	6: Open data	5: Imperfectly open data	4: Flawed open data	3: Raw data	2: Fragmentary path to data	1: No data
1. Additional, justice-relevant information is provided, particularly surrounding the "who, what, when, where, and why" of observations, and multiple knowledge holders are able to contribute to this additional information. The context of violations is made clear. <i>This may include providing such information as "this emitter is located on the traditional lands of the X community, and local leaders have described the impacts on their community (link provided), alongside studies by the University of Y finding Z health effects in the local population (link provided)" or connecting observations that are committed by the same emitting</i>	1. Numerous, complete details are provided about the observation. These may include location details of the violating facility, enforcement and offense dates, pollutants emitted, etc. 2. The core "who, what, when, where, and why" of	1. Several details are provided about the observation. 2. At least "who, what, and when" is communicated by the observation and is	1. Few details are provided about the observation. 2. Some combination of "who, what, when, where, and why" is answered, but it is inconsistent and not organized	1. Quality and number of the details contained in raw data vary widely depending on the data source. Because the raw data is unorganized (and it becomes the user's responsibility to organize it), users may need to significantly distill	1. Very few details are provided about the observation. 2. Additional research is necessary to gain enough information about the "who, what, when, where, and why" of an observation, beyond what is provided by a FOIPOP request or independent	NA (the data is not present, and therefore there are no details about it)

<p>facility, but registering under different names or subsidiaries.</p> <p>1. Numerous, complete details are provided about the observation. These may include location details of the violating facility, enforcement and offense dates, pollutants emitted, etc. 2. The core "who, what, when, where, and why" of observations are clearly communicated and organized tabularly and/or geographically where applicable.</p>	<p>observations are clearly communicated and organized tabularly and/or geographically where applicable.</p>	<p>organized tabularly.</p>	<p>tabularly (might be in the form of a news release or extended summary).</p>	<p>lengthy descriptions from inspection reports, for example, or find additional information from alternative sources. 2. Organization of the information is similarly varied.</p>	<p>investigation. 3. The number of details, quality of details, and the organization of the data are inconsistent.</p>	
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Table 16. Jurisdiction grades for data detail

AB	BC	FD	QC	NB	PE	NS	ON	SK
5.3	5.3	5.9	5	4	4	4	2.8	2

Table 17. Rubric metric - Data public interpretability

7: Just, open data	6: Open data	5: Imperfectly open data	4: Flawed open data	3: Raw data	2: Fraught path to data	1: No data
<p>1. Not only are observations' details complete and explained clearly, but resources about the potential environmental and public health impacts are made available. <i>For example, observations about sulphur dioxide pollution events contain links to publicly-understandable, trusted communications about the impacts of sulphur dioxide, as well as peer-reviewed studies, and resources from local knowledge holders where applicable.</i> Similar communications and resources about the relevant policies are also linked.</p> <p>1. Details about the observation are complete and clearly explained in jargon-free, publicly-understandable language (see subsection 7.8, recommendation 4a and 2a). 2. Where applicable, links are included which may contain additional and technical information (news releases, inspection reports, policies, etc.). 3. There are README files or other descriptive documents accompanying the data to help explain any missing details and provide additional resources. 4. There are clear legends or glossaries defining any acronyms or unavoidable jargon that might be used.</p>	<p>1. Details about the observation are complete and clearly explained in jargon-free, publicly-understandable language (see subsection 7.8, recommendation 4a). 2. Where applicable, links are included which may contain additional and technical information (news releases, inspection reports, policies, etc.). 3. There are README files or other descriptive documents accompanying the data to help explain any missing details and provide additional resources. 4. There are clear legends or glossaries defining any acronyms or unavoidable jargon that might be used.</p>	<p>1. Details about the observation are complete, but might be explained using some jargon. 2. Limited links to additional information and resources are provided, if any. 3. README files mainly describe the technical aspects of the data or database, but provide limited resources aimed to help increase knowledge and understanding. 4. Most acronyms are defined, but jargon might not be.</p>	<p>1. Details about the observation are incomplete, and jargon is used frequently. 2. No links are provided to additional information or resources. 3. README files are missing or purely technical. 4. Neither acronyms nor jargon is explained. 5. Users may have to contact a data manager or staff member to understand the data.</p>	<p>1. As raw data or internal documents, jargon is used consistently. 2. Users must contact a data manager or staff member to understand the data.</p>	<p>1. Details about the observation are incomplete or missing. Jargon is used where sufficient language is present. 2a. No README files or similar resources are present.</p>	<p>NA (the data is not present and therefore is not [publicly] interpretable)</p>

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Table 18. Jurisdiction grades for data public interpretability

AB	BC	FD	QC	NB	PE	NS	ON	SK
5	4.6	4.4	4.5	4.2	3.2	3.1	2	2

Table 19. Rubric metric - Staff responsiveness

Staff responsiveness is evaluated separately from data type. That is, it is possible to be working with raw data (typically level 3), but to be able to easily find, contact, and receive capable help from a data manager (such as described in level 6). There are fewer practical levels to staff responsiveness, and as such, levels 5 and 3 are removed.

7: Just, open data	6: Open data	5: Imperfectly open data	4: Flawed open data	3: Raw data	2: Fraught path to data	1: No data
<p>1. Community members are not depended upon to respond to other members or the public, but they have the opportunity to respond when they have the capacity, or to modify or add context to other knowledge holders' responses. 2. Recognizing knowledge asymmetries and the power of data, communicators center justice as they interact with users.</p> <p><i>Ultimately, it should not be necessary to contact a data manager to use the dataset - it should be sufficiently detailed, explained, and with a highly functional platform such that users can navigate it easily on their own. 1. However, when a user does encounter a problem or seeks additional resources beyond what is offered, a data manager responds promptly and capably to the request. 2. The data manager's contact information is listed alongside the dataset. 3. The data manager is employed by a department relevant to the dataset and has a familiarity with and is capable of answering questions about the data itself (not merely the technical aspects of downloading different files, for example).</i></p>	<p><i>Ultimately, it should not be necessary to contact a data manager to use the dataset - it should be sufficiently detailed, explained, and with a highly functional platform such that users can navigate it easily on their own. 1. However, when a user does encounter a problem or seeks additional resources beyond what is offered, a data manager responds promptly and capably to the request. 2. The data manager's contact information is listed alongside the dataset. 3. The data manager is employed by a department relevant to the dataset and has a familiarity with and is capable of answering questions about the data itself (not merely the technical aspects of downloading different files, for example).</i></p>	<p><i>(Intermediary between levels 6 and 4)</i></p>	<p>1. The data manager takes several days or longer to respond to a user's request 2. The data manager partially answers the request, but is unable to provide the user with what they were looking for. 3. The data manager's contact information is findable, but not listed alongside the dataset 4. The data manager is employed by the relevant Ministry, but may be too many levels removed to discuss the particularities of the data.</p>	<p><i>(Intermediary between levels 4 and 2)</i></p>	<p>1. The data manager takes weeks to respond to a user's request. 2. The data manager is unable to answer the request. 3. The data manager's contact information is difficult or impossible to find, perhaps leaving the user to contact anyone adjacent in the government or managing organization 4. The data manager is either not employed by the relevant Ministry or department, or is only able to respond to technical requests about the dataset.</p>	<p>1. A "data manager" position within the relevant Ministry does not exist, is not accessible to public inquiry, or does not respond to user's requests.</p>

Table 20. Jurisdiction grades for staff responsiveness

AB	BC	FD	QC	NB	PE	NS	ON	SK
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6	6	4	5	5.8	3	2	2	2
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Table 21. Jurisdictions average grades on the data availability rubric

AB	BC	FD	QC	NB	PE	NS	ON	SK
4.9	5	4.9	4.6	4.4	3.3	3	2.2	2

Taking the overall grades into account, BC, AB, and FD had the best source data, being roughly “imperfectly open data.” However, each jurisdiction was relatively successful for different reasons. For example, BC’s database was highly usable and accessible, with supplemental documentation, and had a highly responsive and capable data manager. AB’s summaries of offenses were communicated in consistent and clear formats, making them more publicly interpretable, and provided relevant details. AB was the only jurisdiction I did not have to contact at all, earning a “6” on the staff responsiveness scale. FD’s database was usable and accessible, with more relevant details than any province, but the staff was less responsive. QC trailed closely behind: mainly penalized for its relatively inaccessible and unusable database. NB had capable and responsive staff, but the database was less accessible and usable, and some observations required clarification from staff (reflecting incomplete data detail). PE and NS were similar experiences, insofar as they both involved public servants sending me relevant data; however, the PE data was more complete, and the public servant assisted me more quickly, yielding PE’s higher overall score. The ON data is problematic on multiple fronts, only scoring slightly higher for data detail because of the lengthy information provided by news reports and CanLII documents. Finally, SK receives the lowest score, consistently receiving grades of “2” across metrics because of the incomplete, uninterpretable data, which was received on a delayed basis, with slow communications from public servants. All provinces appear to be missing a fair amount of data, although it is unclear how much or where in the violations pipeline missingness was created.

As discussed in the Methods chapter, the pathway to acquiring data for this research was indirect and variable between jurisdictions. These qualities were reflected, in large part, in jurisdictions’ source data quality, as measured by the open data rubric. The most notable dividing line between jurisdictions’ source data was whether they had an organized database or dataset of some kind that explicitly detailed environmental enforcement actions. NB, QC, FD, BC, and AB all had a database or dataset for these purposes, and their grades per the open data rubric ranged from 4.4 – 5.0, or a bit better than “flawed open data” to “imperfectly open data.” By contrast, jurisdictions that did not have any sort of publicly available database or dataset for enforcement actions were penalized heavily for this, with scores ranging from 2 – 3.3, or “fraught path to data” to a bit better than “raw data.” These jurisdictions included PE, NS, ON, and SK. There is some variation between jurisdictions’ grades within each group – for example, even though AB and QC have roughly similar dataset availabilities, the qualities therein vary, which the rubric grades reflect (4.9 vs. 4.6, respectively). But overall, the key factor in determining data quality, so far as the rubric is concerned, is the extent to which data is organized and publicly available because this is the core of “open data,” as defined by this research. In this way, the rubric grades were impacted mainly by factors that were obvious in the Methodology, when I was either able to use a publicly available dataset or forced to resort to more time- and labor-intensive means for a given jurisdiction. The nuanced differences between jurisdictions within each group, however, are revealed by the rubric.

It is crucial to underscore the relational and ordinal nature of these grades and of using my rubric. As I have employed it here, these grades serve a valuable purpose to illustrate what is otherwise difficult to compare – the vastly different availabilities and qualities of data provided by each province. It is essential to take these disparate data availabilities and qualities into account while reviewing the analysis of these data, as follows in Chapters 5 and 6. At the same time, the ordinal nature of the rubric categories means that small variations in average scores should not be overinterpreted or considered absolute. These grades should be weighed within the context of Canada, while keeping in mind that far superior options are available in the US.

Chapter 5: Results – Descriptive Analyses

5.1 Overview

In total, 2,217 enforcement actions related to point-source air pollution were observed spanning the years 2000-2020. Observations distributed by jurisdiction are shown in Table 22, including the federal government and eight provinces. The majority of the observations (67%) occurred from 2012-2020. Although proportions vary by province, the overall landscape of observations across provinces is dominated by burning offenses (as measured by keyword) and individual offenders (as measured by offender type), illustrated in Tables 23 and 24. Forty pollutant types were observed, with varying proportions between provinces, but the most abundant are listed in Table 25. All others each comprised less than 1% of observations. Criteria air contaminants (particulate matter, volatile organic compounds, sulphur dioxide, nitrogen dioxide, ammonia, and carbon monoxide) collectively make up 4.87% of the observations. Most observations (92%) represent single violations – that is, the number of violations = 1. Of the remaining 8%, representing multiple violations, half of these are concentrated in Alberta, and half are dispersed among other provinces. The sum of all fines in my database totals \$16,277,516.

Over half of my observations come from BC, although most of these enforcement actions are tickets from burning offenses (Figures 5 and 7). The overwhelming majority, 92.7%, of my observations come from four provinces: BC, QC, AB, and PE. Ontario has surprisingly few observations, given its size and the high number of NPRI-reporting companies in the province. In contrast, PE has a seemingly high number of observations, given its small size and fewer NPRI-reporting companies in the province. In general, the distribution of counts and percentages does not seem to reflect the population size of provinces nor the amount of polluting industry therein. Differences in data availability are likely responsible, at least in part, for the distribution.

Table 22. Distribution of observations across jurisdictions

Jurisdiction	BC	QC	AB	PE	ON	NB	NS	SK	FD
Count	1258	366	223	204	69	40	30	26	1
Percentage	56.7%	16.5%	10.1%	9.2%	3.1%	1.8%	1.4%	1.2%	0.05%

Box 1. The Single Federal Observation

Note that from my dataset of 2,217 observations, there is one offense from the federal government (FD) (Table 22). The source FD data only represents successful court convictions – not any other penalty types, unlike most provinces – which can help to explain this low count. Even so, it is noteworthy that across 14 years' worth of data (2006-2020, as captured by the source data), the federal government has only successfully prosecuted one point-source air pollution case in court, while Ontario, for example, has done the same for 57 cases in this dataset.

The federal observation comes from Alberta in 2012, when an ice arena's refrigeration system released gaseous ammonia into the atmosphere and the company, Edmonton Ice Box, failed to take reasonable emergency measures accordingly, contrary to CEPA Section 201(1)(b)(i). Edmonton Ice Box was fined \$20,000.

Tables 23, 24, and 25 interact in meaningful ways. First, it is important to note that the majority of my dataset is comprised of burning offenses (74.3%) (Table 23), mostly committed by individuals, who represent the majority of offenders (62.8%) (Table 24), and thus the predominant pollutant type in my dataset, as produced by these burns, is smoke (75.8%) (Table 25). In other words, each of these proportions is loosely mutually inclusive of each other. Burning offenses are usually relatively minor, often to the effect of illegal campfires, burning waste, open burns, or burning without a permit. Setting burns aside, the other keywords

involve violations committed mainly by the remaining offender types (companies, municipalities, multiple, and other), who emit some of the other types of pollutants. “Multiple” offenses, meaning multiple infractions occurred but bundled into one enforcement action, was the second most common keyword and predominantly came from AB. Often, these are multiple “administrative” violations (failure to monitor emissions, failure to submit reports, etc.) bundled together. Violations pertaining to Standards (violated a jurisdiction-wide rule), Excess emissions (violated a term of a permit), and Emissions (otherwise emitted air pollution) – the keywords that most directly relate to companies emitting air pollution – are rarely enforced. Only 8.1% of observations concern these keywords. Equipment violations can be directly related to pollution events, but they are also often administrative, such as failing to register a new piece of equipment. Because of poor data quality, pollutant types are unknown for 9.7% of observations.

Table 23. Distribution of observations across keywords

Keyword	Burn	Multiple	Equipment	Standards	Emissions	Monitoring	Notification	Excess emissions	Order	unknown
Count	1647	165	137	89	63	34	32	29	17	4
Percentage	74.3%	7.4%	6.2%	4.0%	2.8%	1.5%	1.4%	1.3%	0.8%	0.2%

Table 24. Distribution of observations across offender types

Offender type	Individual	Company	Municipality	multiple	other
Count	1392	762	42	14	7
Percentage	62.8%	34.4%	1.9%	0.6%	0.3%

Table 25. Distribution of observations across most common pollutants

Pollutant type	Smoke	unknown	Dust	Particulate matter	multiple
Count	1681	216	78	60	49
Percentage	75.8%	9.7%	3.5%	2.7%	2.2%

5.2 How enforcement actions are allocated – provincial breakdown

The following graphs demonstrate the general themes of offenders (as measured by offender type), offenses (as measured by keyword), and enforcement strategies (as measured by penalty type) within provinces, as proportions of each province’s total number of observations.

5.2.1 Keyword

Some provinces enforce a diversity of offenses, as shown by a mixed distribution of keywords across the total proportion of observations within a given province (Figure 5). Among these are AB, NB, ON, and QC. Meanwhile, in other jurisdictions, namely BC, NS, PE, SK, and FD, most offenses (75%+) center on one type of offense. In BC, NS, PE, and SK, the most common offense is burning, while the federal offense (one observation) is an emissions offense.

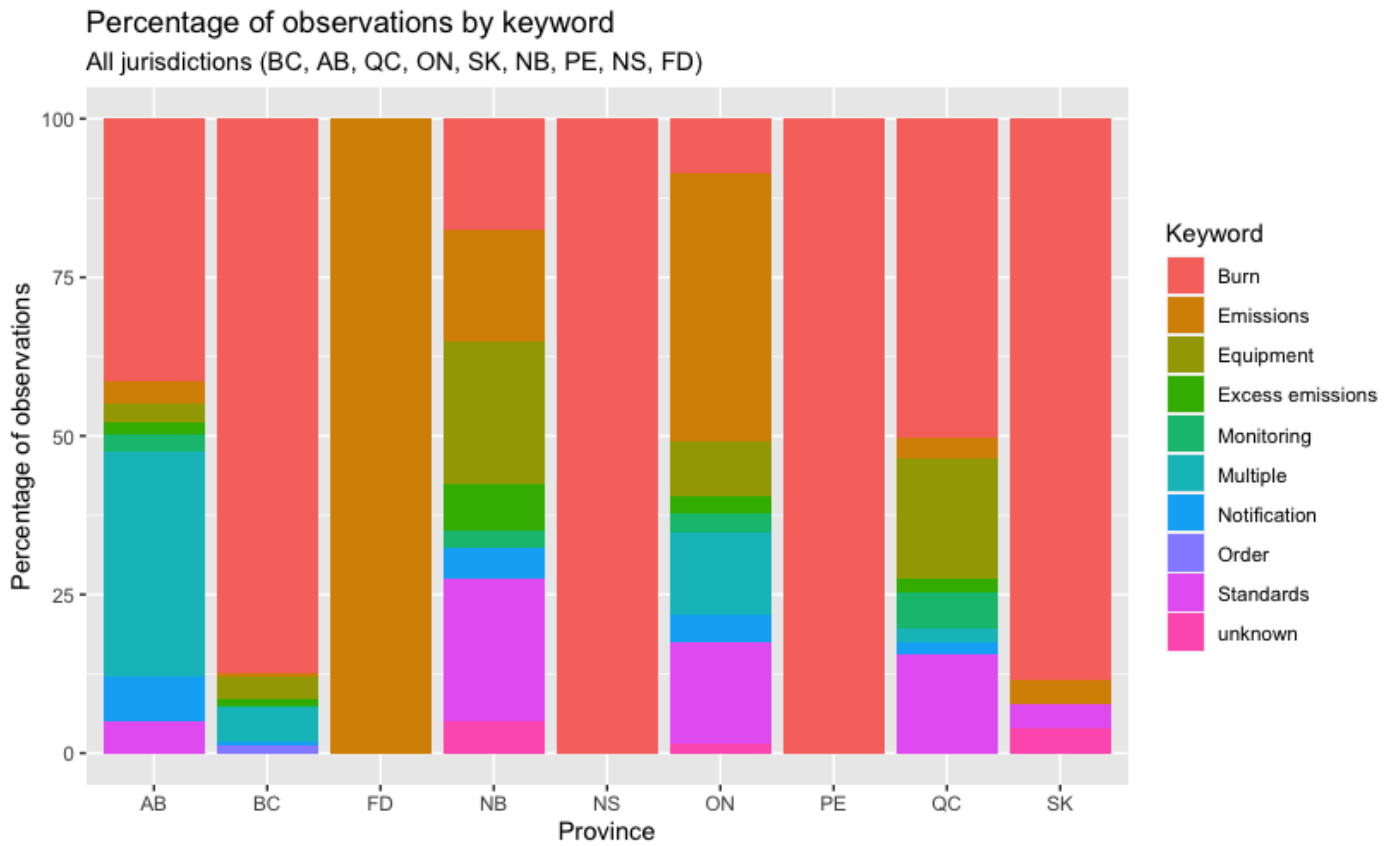


Figure 5. Percentage of observations by keyword across provinces

5.2.2 Offender type

Similarly, observations reflect different groups of offenders (i.e. individuals, companies, and municipalities) who have been subject to enforcement actions in varying proportions between provinces (Figure 6). Based on my dataset, AB, FD, NB, ON, and QC have enforced violations mostly committed by companies (50%+ of observations), while BC, NS²⁴, and PE have enforced violations committed mostly by individuals (75%+ of observations). The majority of enforcement actions in SK involved violations committed by municipalities, with >75% of observations linked to this offender type.

²⁴ All observations from NS were violations committed by individuals, since the source data from NS only captured individual-level offenders (see Appendix A).

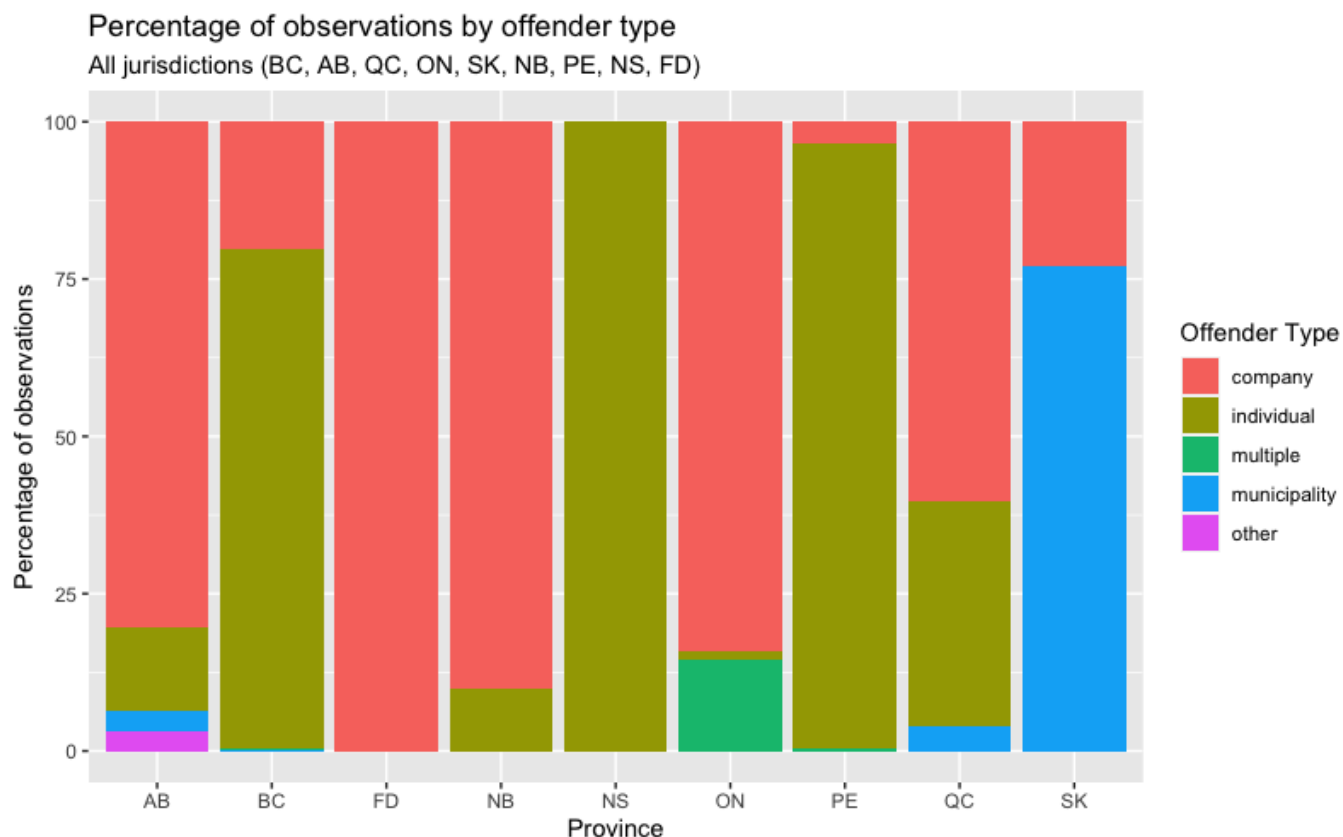


Figure 6. Percentage of observations by offender type across provinces

5.2.3 Penalty type

Given these offenses and offenders, provinces use various penalties to address noncompliance. Broadly speaking, the penalty types can be categorized as monetary penalties (administrative penalty, fine, and ticket), orders (enforcement order, environmental protection order, information order, pollution abatement order, and pollution prevention order), court proceedings, where there is usually a monetary penalty but sometimes also an additional penalty (court conviction, open court proceeding, restorative justice), or a letter (warning, long-form information). Provinces vary widely in the penalty type they most commonly use (Figure 7). All observations in QC, NS, and FD have a monetary penalty of some kind attached. Over half of AB's enforcement actions are warnings (52%). PE and SK also use letters in higher proportions (~23%) than other provinces, although much less so than AB. ON and FD have the highest proportions of court convictions.

Considering the interactions of Figures 6 and 7, the proportion of tickets and fines is roughly proportional to that of individual-level offenses in most provinces, consistent with the aforementioned point that individuals are usually ticketed (most often for burns). The more variable point presented here is how the proportion of other penalty types – namely administrative penalties, court convictions, and warnings – compare to proportions of non-individual level offenders (companies, municipalities, multiple, and other) in each province. In each AB, ON, and QC, >50% of observations concern non-individual offenders. However, these provinces each levy different penalty types for this group. In AB, 61% of non-individual offenders receive warnings; in ON, 84% are convicted in court; and in QC, 90% receive administrative penalties.

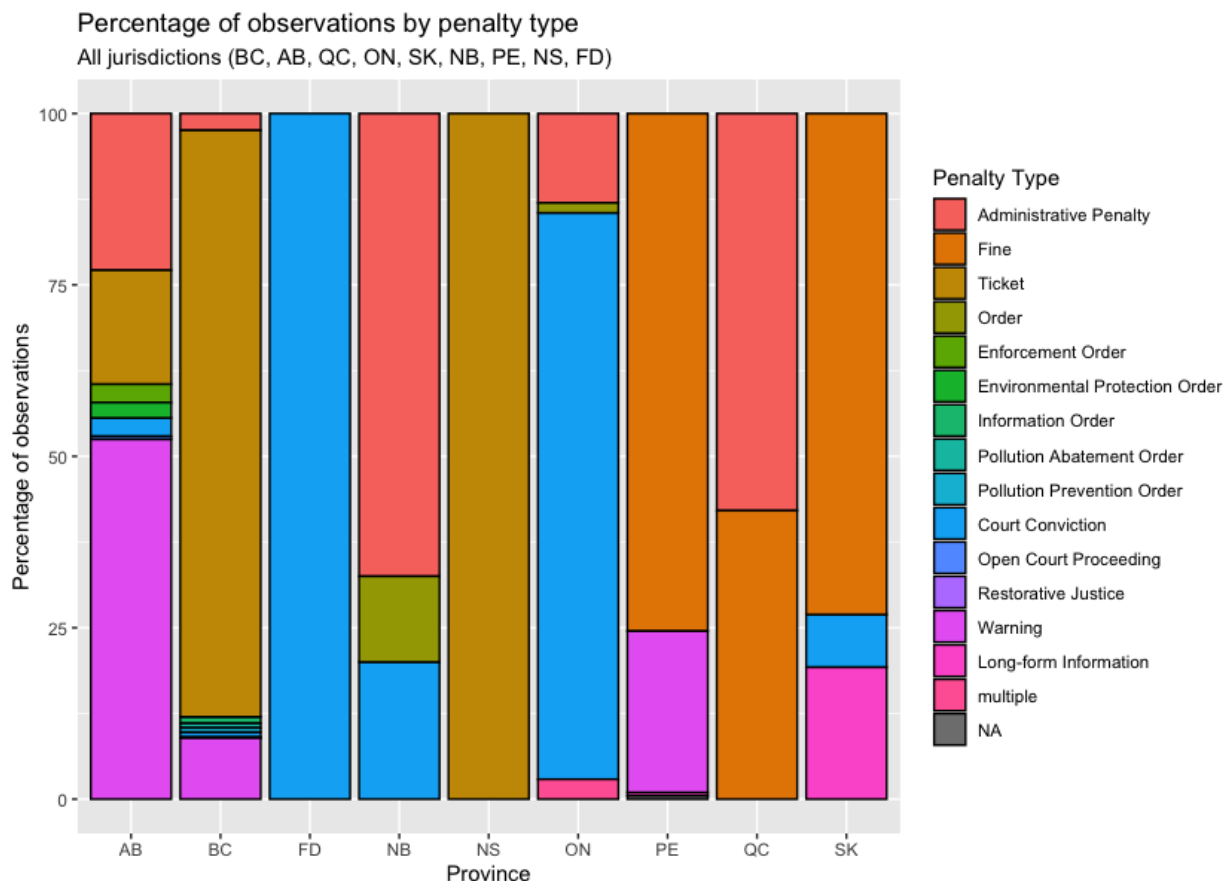


Figure 7. Percentage of observations by penalty type across provinces

5.3 Fines

When enforcement agencies do levy fines as part of an enforcement action, the median fine varies between provinces, ranging from \$200 in PE up to \$62,774 in ON. Most provinces' median fine is less than \$3000. The minimum fine, \$45, comes from an individual ticketed for burning in BC, while the maximum fine, \$5.3 million, comes from a high-profile gas explosion in ON. Table 26 considers fines from all offender types, but as Tables 27 and 28 and Figure 8 show, the median fine varies between province and offender types.

Table 27 also includes the maximum fine observed levied by each province and the maximum fine possible under the primary law governing air pollution in the province, whether it be a general "Environment Act" or a specific "Clean Air Act" as previously discussed. The maximum fines possible under the laws vary substantially between offense types, an offender's previous compliance record, and whether the offender is an individual or a company, etc. Some are calculated on a daily basis (the maximum fine listed is the maximum amount that can be fined per day an offense occurs, so if it occurs for multiple days, it could be higher). These maximum fines are listed here to illustrate that the median and even maximum fines observed in my dataset are a small fraction of what is possible under provinces' air pollution legislation.

Table 26. Distribution of fines for all observations

Minimum	1 st quartile	Median	Mean	3 rd quartile	Max
45	300	345	8,705	1,150	5,300,000

Table 27. Distribution of fines by jurisdictions, with maximum fines possible under relevant legislation

Province	ON	FD	AB	QC	SK	NB	NS	BC	PE
Median fine	62,774	20,000	2,750	2,500	1,400	1,200	802	345	200
Maximum fine	5,300,000	20,000	150,000	150,000	42,000	10,000	813	250,000	1020

Maximum fine possible under jurisdiction's main air pollution law	10 million	12 million	1 million	6 million	1 million	1 million	1 million	3 million	50,000
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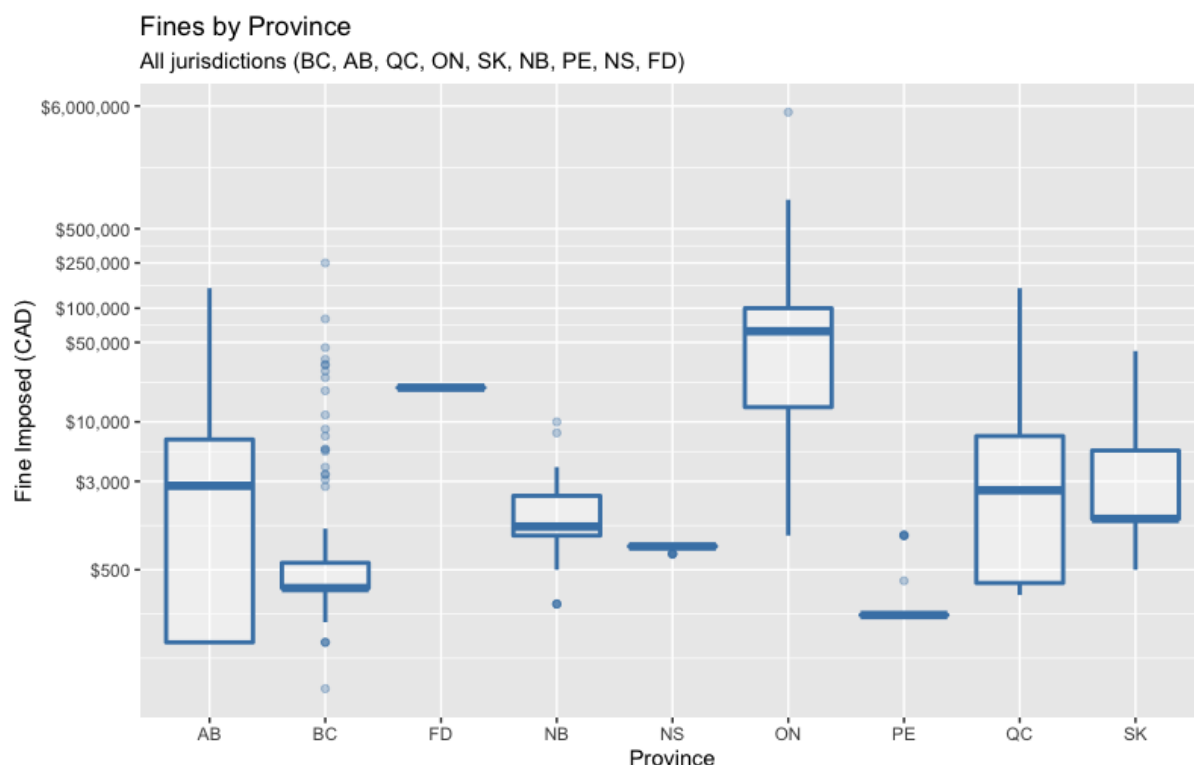


Figure 8. Boxplot of fines issued by jurisdictions, log scale

Table 28. Median fine issued by offender type

Offender type	Multiple	Municipality	Company	Individual	other
Median fine	39,000	6,000	3,000	345	115

Across provinces, the spread of fines is consistent across keywords (Figure 9) and over time (Figure 10). The median fine for all keywords falls between \$2,500 and \$10,000, except for Emissions and Burn, which can be attributed to provincial influences. Ontario has the highest fines and largest proportion of Emissions observations. British Columbia has the largest proportion of burn observations and consistently tickets \$345 for those burns, which is the median shown. The median fine in NS is also consistent with a typical ticketed amount for burns. Tickets most often have fixed values, as assigned by the relevant legislation. Other penalty types have discretionary fine amounts.

Similarly, fines are generally consistent over time within provinces. The high number of individual offenders, as previously discussed, serves as a moderator for these graphs, as individuals typically receive a consistent fine (as a ticket) while non-individual offenders may receive penalty types where enforcement agencies have more discretion in selecting the amount (administrative penalties, etc.) or making sentencing recommendations. Thus, even when outlying high fines are present, they tend to minimally affect the shape of the graph. Fluctuations in Alberta and Quebec in 2019-2020 can be attributed to a proportional increase in the

number of non-individual offenders, which are usually subject to higher fines. In AB and QC, from 2008-2018, observations with individual offenders composed an average of 30% of the total observations for a given year, but in 2019-2020, that decreased to an average of 10%. Fluctuations in BC cannot be as easily explained by other variables. While the proportion of enforcement actions involving individuals did decrease in BC as well, this does not account for the peak in 2018 and subsequent return to previous levels. Rather than a comprehensive trend in enforcement, the fluctuation in BC is probably better explained by a concentrated number of one company's serious violations, which were met with escalated penalties. Of the eight fines greater than or equal to \$20,000 in BC, six were issued during the 2018-2019 period, four of which were issued to the Mackenzie Pulp Mill Corporation. The Mackenzie Pulp Mill violations were two Excess emissions and two Multiple keywords violations, which received relatively high (> \$30,000) administrative penalties.

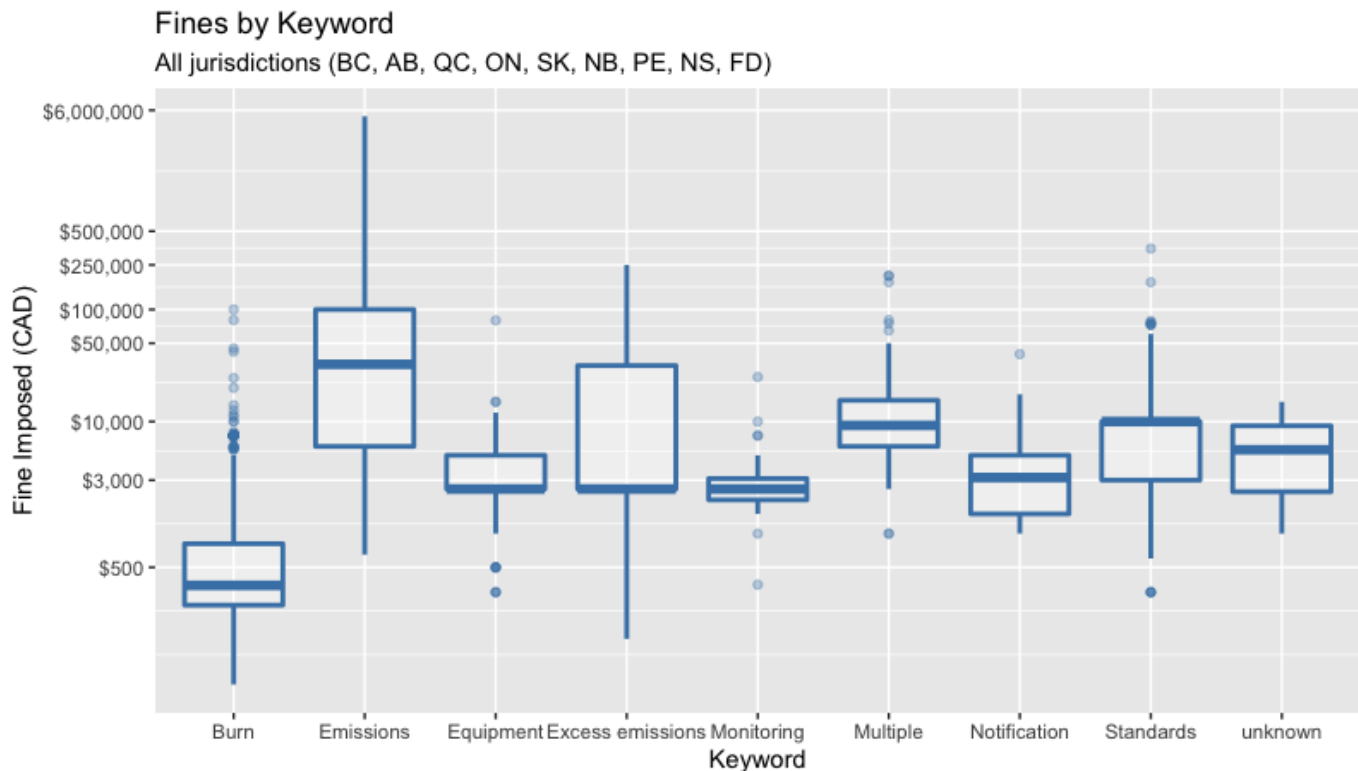


Figure 9. Boxplot of fines issues by keyword, log scale

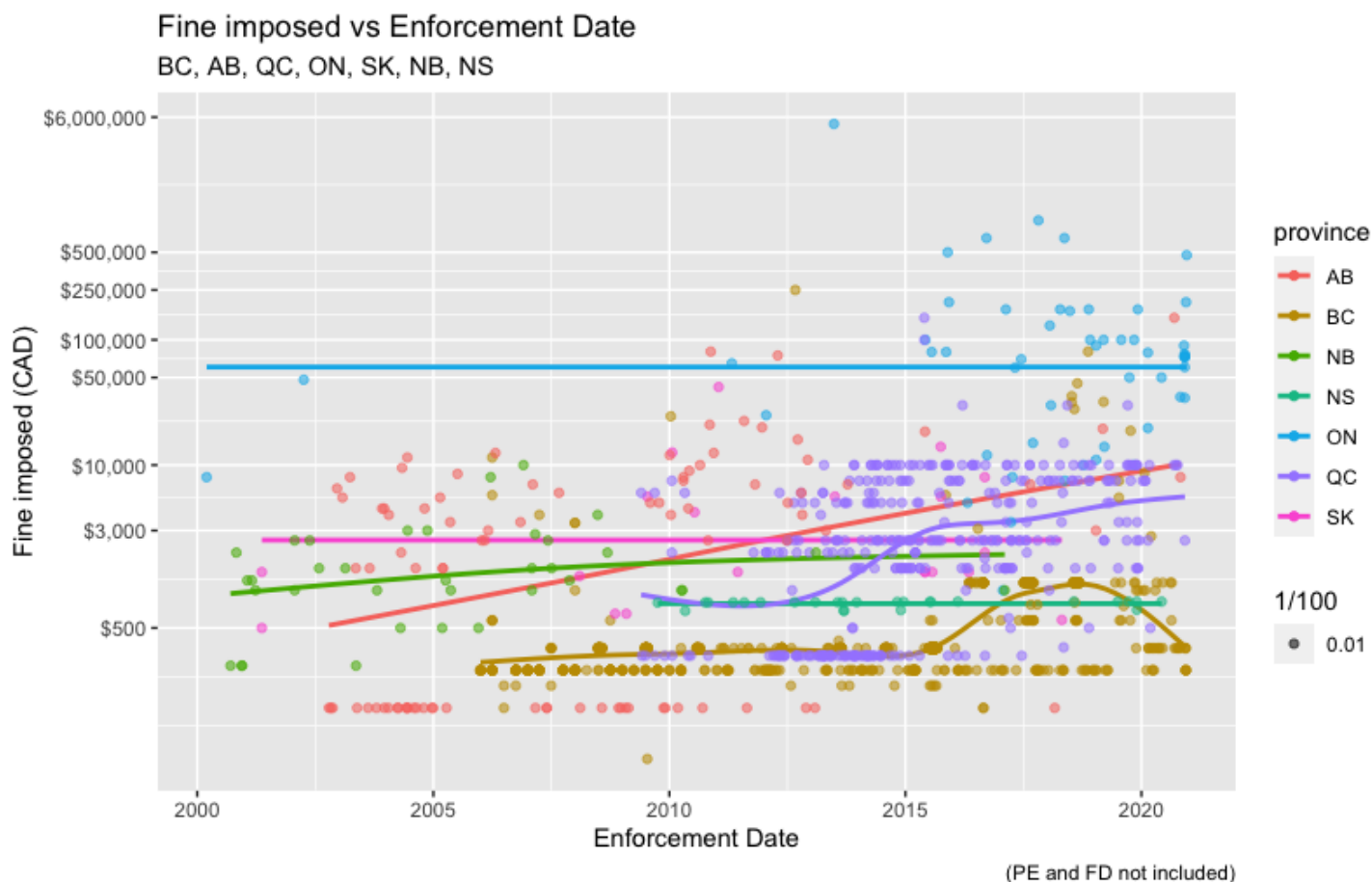


Figure 10. Fines over time, as measured by enforcement date and separated by province, log scale

5.4 High-risk Offenses

As demonstrated, most observations involve individual offenders (62.8%) and burns (74.3%). While the source data does not provide enough information about violations to determine their severity in terms of impact on air quality, human health, or environment, it is reasonable to assume that these types of offenses are generally less severe than those committed by other types of offenders (companies, municipalities, multiple, and other) and other types of offenses (other keywords). Namely, the scale of an offense committed by non-individual offenders is usually more extensive, as the offense relates to the operations of a company, municipality, etc., thus the pollution level is assumed to scale up accordingly. While burns can certainly have a significant impact on air quality, individual-level burns are usually short-lived, whereas issues with air pollution abatement equipment, exceeding emissions limits, etc., can be longer-term or indicative of noncompliant behavior in general. Accordingly, in this section, I identify various subgroups of violations called “high-risk offenses” that are **potentially** more impactful on air quality, human health, and/or the environment on account of one or more factors within the observation. These subgroups include:

1. **Criteria air contaminants:** observations where a criteria air contaminant was the pollutant type emitted. This category was created following the criteria air contaminants identified by the CAAQS, which are fairly common byproducts of industrial activities and have well-known adverse impacts on human health.
2. **Repeat offenders:** non-individual offenders who were subject to enforcement action multiple times across observations. These are considered at the corporate or municipality level (not facility level). This category was created in large part to evaluate provinces’ enforcement approaches. According to the literature AB, BC, and ON provide about their enforcement approach, it is cooperative but theoretically escalates if there is repeated noncompliance. Within this realm, it also helps to assess whether specific

deterrence is working within provinces. Facilities or companies at which there is repeated noncompliance may be a bigger risk for unlawful pollution events.

- a. Cross-provincial repeat offenders: a subset of “repeat offenders,” where a company was subject to enforcement action in multiple provinces. This category was created to examine how different provinces address the same company committing offenses in their region, and similarly assess any evidence of specific deterrence. Companies with a track record of repeated noncompliance may pose a greater risk for unlawful pollution events.
3. NPRI-reporting facilities (follows the report to NPRI variable): Under CEPA, facilities of a certain size and emissions profile must report to the NPRI. Thus reporting to the NPRI is a rough proxy to select for facilities that are known to emit substances of concern for human health (although not all facilities that do so are required to report to the NPRI). This category is included to capture those facilities that are found within my dataset.
 - a. NPRI top 20 facilities (follows the NPRI top 20 variable): a subset of NPRI-reporting facilities, these are the facilities that are ranked in the top 20 most polluting by volume of a given pollutant within a province (see NPRI top 20 variable [subsection 3.1.3] for more information). These may be “toxic outliers” and may therefore be of the greatest concern among the high-risk categories in terms of impact on human and ecological health.
4. Non-individuals: individual offender types are filtered out (see above regarding assumed individual offenses’ smaller impact)
5. High-risk offenses: all of the above groups

Some observations overlap between groups, e.g., cross-provincial repeat offenders who are also NPRI top 20 facilities, but groups are considered separately here.

There is a “spectrum of severity” captured within each of these groups (as with all observations); some of these offenses are more “administrative,” such as failing to submit reports, while some are major pollution events. Even for the NPRI top 20 facilities, for example, while a given offender is a highly polluting facility, it is not necessarily the case that an observation in my dataset was a high pollution **event**. In other words, it is essential to underscore that these categories are best understood as capturing *potentially* risky and impactful offenses and offenders.

5.4.1 Overview of high-risk offenses:

Over one-third of the total number of observations (37.3%) are high-risk offenses, which largely reflects of the proportion of non-individuals (four individuals emitted criteria air contaminants, explaining the difference in four observations between the two groups) (Table 29). Many burns are captured by the high-risk offenses group (contains 264 burn observations), as non-individuals also commit burns, but these burns are still often ticketed (rather than receiving higher penalties). Repeat offenders received the lowest median fine, but the criteria air contaminants group received the lowest average fine (the average is influenced by low fines issued for the aforementioned individual-level violations). Criteria air contaminants received the highest median fine, while cross-provincial repeat offenders received the highest average fine. Each group’s average fine is significantly different from the average fine of the overall dataset at a 10% confidence level (calculated using a Welch two-sample t-test).

Table 29. Distribution of observations and fines across high-risk groups

	Criteria air contaminants	Repeat offenders	Cross-provincial repeat offenders	NPRI-reporting facilities	NPRI top 20 facilities	Non-individuals	High-risk offenses
Number of observations	108	279	50	272	50	825	829

Proportion of overall dataset	4.9%	12.6%	2.2%	12.3%	2.3%	37.2%	37.3%
Number of offenders	87	92	10	156	24	620	624
Median fine	10,000	3,050	5,000	8,500	4,000	3,500	3,500
Average fine	16,869.23	32,881.45	90,312.00	44,467.59	53,182.76	28,535.97	28,334.16
P value (testing group average fine against overall dataset average fine)	<.005***	0.006***	0.021**	<.005***	0.046**	0.06*	0.062*

5.4.2 Provincial breakdown of high-risk offenses

Provinces enforce high-risk offenses significantly differently from each other when comparing the proportion of observations in each province that are high-risk offenses (out of the province's overall count of observations) (Table 30). For example, 87% of observations from Alberta are high-risk offenses, while 21% of observations from BC are high-risk offenses. A proportions test (8-sample test for equality of proportions without continuity correction) was used to test the null hypothesis that each province enforces high-risk groups at equal rates. At a 99% confidence interval, this null hypothesis is rejected, suggesting that provinces enforce high-risk groups at significantly different rates from each other. While proportions between groups vary, a higher proportion of observations in AB, NB, ON, and FD are generally “high-risk” per the definitions of these groups.

Table 30. Proportion of observations belonging to high-risk groups within jurisdictions

Group	AB	BC	FD	NB	ON	PE	QC	SK	P-value
Criteria air contaminants	12%	1%	100%	3%	19%	0%	14%	0%	<.005***
Repeat offenders	28%	11%	0%	43%	29%	0%	11%	8%	<.005***
Cross-provincial repeat offenders	7%	2%	0%	5%	9%	0%	2%	0%	<.005***
NPRI-reporting facilities	44%	7%	0%	30%	43%	0%	12%	0%	<.005***
NPRI top 20 facilities	3%	1%	0%	28%	9%	0%	3%	0%	<.005***
Non-individuals	87%	21%	100%	90%	98%	4%	64%	100%	<.005***
High-risk offenses	87%	21%	100%	90%	99%	4%	65%	100%	<.005***

Provinces also penalize high-risk offenses significantly differently from how they penalize all other observations within their jurisdictions, as measured by a paired t-test between the median fines of high-risk

offenses and that of all offenses in each province (95% confidence level) (Table 31). For FD and SK, the two median values are equal because all offenses in both provinces are high-risk offenses. ON, AB, QC, NB, and PE fined high-risk offenses more than their total offenses, while BC fined them less.

Table 31. Median fines for all observations compared to median fines for high-risk offenses across jurisdictions

Province	ON	FD	AB	QC	SK	NB	BC	PE
Median fine for overall dataset	62,774	20,000	2,750	2,500	1,400	1,200	345	200
Median fine for high-risk offenses	65,000	20,000	4,000	5,000	1,400	1,500	230	1,000

5.4.3 Outliers and Multiple Risk Observations

“Outliers and multiple risk” (OMR) observations are observations that are outliers and observations belonging to multiple high-risk groups.

First, within the “multiple risk” category, eight observations were committed by cross-provincial repeat offenders and at NPRI top 20 facilities (Table 32). All three of Aditya Birla’s facilities in the dataset are NPRI top 20 facilities. Suncor Energy is one of the most frequently enforced companies in my dataset, receiving nine enforcement actions across AB and ON, but only its ON location is a top 20 polluter. Similarly, three of seven of Rio Tinto Alcan’s facilities in this dataset are top 20 polluters. One of Lafarge’s two facilities in this dataset is a top 20 polluter. The average fine for offenses from this group is \$82,650.

About the offenders:

1. Aditya Birla is a multi-national conglomerate based in India, involved in extracting many types of natural resources and producing end products (Aditya Birla, AV Group n.d.). The NB and ON operations listed below are pulp and fiber facilities.
2. Suncor Energy is an energy firm based in Calgary, AB, specializing in the development of the oil sands (most of Suncor’s violations in my dataset are from its oil sands operations in AB) (Suncor Energy n.d.). The NPRI top 20 facility below, in Ontario, is its refinery in Sarnia, ON.
3. Rio Tinto Alcan is a metals and mining multi-national corporation jointly based in London and Melbourne and is the largest mining and metals company currently operating in Canada (Rio Tinto Alcan Canada n.d.). The observations below are from some of its aluminum smelting facilities.
4. Lafarge is a French multi-national concrete and cement company (Lafarge Canada 2017). The observation below is from a cement manufacturing plant in Saint-Constant, Quebec.

Table 32. Observations belonging to both the cross-provincial repeat offenders group and NPRI top 20 group

Offender name	Province	Enforcement year	Fine imposed	Penalty type	Pollutant type	Keyword
Aditya Birla, AV Group	ON	2018	175,000	Court conviction	Sulphur	Standards
Aditya Birla, AV Group	NB	2007	1,200	Administrative penalty	Unknown	Excess emissions

Aditya Birla, AV Group	NB	2007	2,500	Administrative penalty	Unknown	Equipment
Suncor Energy Inc.	ON	2020	475,000	Court conviction	Sulphur	Emissions
Rio Tinto Alcan inc.	BC	2020	NA	Warning	Multiple	Emissions
Rio Tinto Alcan inc.	BC	2019	NA	Warning	Particulate matter	Multiple (2 violations)
Rio Tinto Alcan inc.	QC	2013	5,000	Administrative penalty	Unknown	Monitoring
Lafarge Canada Inc.	QC	2016	2500	Administrative penalty	Dust	Equipment

Nine additional companies are repeat offenders, for which at least one of their facilities is a top 20 polluter, yielding 29 further observations (Table 33).

Table 33. Repeat offenders with at least one NPRI top 20 facility

Offender name	Number of observations at top 20 facilities	Province	Industry
Aluminerie Aloutte inc.	2	QC	Metals and mining
Catalyst Paper Corporation and Catalyst Pulp Operations	3	BC	Pulp and paper
Essroc Canada inc.	2	ON	Cement
Fraser Papers Inc.	2	NB	Pulp and paper
Irving Oil Limited (Refinery)	3	NB	Oil and gas
Synchrude Canada Ltd.	4	AB	Oil and gas
Teck Resources Ltd.	9	BC	Metals and mining
UPM-Kymmene Miramichi Inc.	2	NB	Pulp and paper
West Fraser Mills Ltd.	2	BC	Pulp and paper

5.4.3.1 Top fines

The highest fines from each province (Table 34) share a few commonalities. They are often products of court convictions (the “fine” penalty types could also be court convictions; there was not enough information provided by the source data to determine whether it was a court conviction or a ticket). Emissions and burns are the most common keywords. Except for NB and some in NS, all of the jurisdictions’ maximum fines have occurred since 2011. As previously discussed, these top fines fall far below the maximum possible fine under the applicable legislation (Table 26).

Table 34. Observations that were issued the highest fine observed in each province

Juris dicti on	Enforce ment year	Offender name	Offender type	Report to NPRI	Penalty type	Fine imposed	Pollutant type	Number of violations	Keyword	Summary
ON	2013	Sunrise Propane Energy Group Inc. et al.	Multiple	No	Court convicti on	5,300,0 00	Multiple	1	Emissions	Gas explosion
BC	2012	Encana Corporation	Company	Yes	Restorat ive justice	250,000	Hydrogen sulfide	1	Excess emissions	Introduced business waste
AB	2020	Regional Municipality of Wood Buffalo	Municipality	Yes	Court convicti on	150,000	Chlorine	1	Emissions	Released gas at wastewater treatment plant
QC	2015	Rio Tinto Alcan Inc.	Company	Yes	Fine	150,000	Bauxite dust	1	Emissions	Discharged dust from bauxite residues
SK	2011	FRP Manufacturi ng	Company	No	Fine	42,000	Smoke	1	Burn	Burned unauthorize d materials in an open fire or incinerator
FD	2012	1073612 Alberta ltd.	Company	No	Court convicti on	20,000	Ammonia	1	Emissions	Release of gaseous ammonia from refrigeratio n system
NB	2006	Pecheries FN Fisheries Ltd.	Company	No	Fine	10,000	Odour	1	Emissions	Release of contaminan t (odours)
PE	(offense date) 2011	Unpublished	Company	Unkno wn	Fine	1,020	Smoke	1	Burn	Burning waste (commerci al)
NS	(several observat ions)	(several observations)	Individual	No	Ticket	813	Smoke	1	Burn	Burned solid waste

Chapter 6: Results - Environmental Justice

All observations have the potential to affect environmental justice communities disproportionately. As discussed, following the work of Konisky in particular, it is of interest not only how the pollution from these observations affects EJ communities, but how the (lack of) enforcement actions against violations may exacerbate the injustice. Because of data limitations, we cannot assess exactly which observations had what effects on which communities. We do not have information on the actual pollution amounts, types, or distributions from a given observation, the health impacts from most observations and who bears these burdens, or the location information of many violations. As such, I evaluate the potential EJ dimensions of my dataset from the standpoint of where some non-individual level violations occurred, mapped against the demographics for that area. Recall that only some non-individual violations are considered, as these are the observations for which I have point location data (see subsection 3.1.3 and 3.3).

The cross-provincial averages and enforcement area averages of each EJ variable were compared using Welch two-sample t-tests, and several significant correlations were found. Highlighted values represent where an environmental justice community/equity-seeking group was found to be over-represented in a enforcement area compared to the provincial average: where median property values are less than the cross-provincial average, where there are higher proportions of non-males, where there is less income (on a family basis after-tax), and where there is a higher social deprivation index. Median rent is significantly higher in enforcement areas, which could reflect an environmental justice issue, depending on perspective and context. For other variables, such as percent immigrant population and percent visible minority population, the enforcement areas' values are significantly different from the cross-provincial average but suggest that immigrant and visible minority residents are not over-represented in enforcement areas.

In practical terms, these trends indicate that people in enforcement areas are generally whiter but are more socially deprived (higher proportions live alone, are separated, divorced or widowed, and/or are single-parent families), poorer, and more are female. Notably, there is a significant difference in after-tax family income between the two averages, but not in material deprivation. Although the material deprivation index includes the average income of the population, other variables included such as educational attainment and employment, may offset this difference.

Table 35. Values of EJ variables observed across select provinces and within enforcement areas

EJ variable	Cross-provincial average	Enforcement area average (weighted)	P-value
Median property value	398,307.80	361,789.70	<.005***
Median rent	540.92	636.41	<.005***
Percent immigrant population	19.15	19.12	0.76
Percent non-male population	50.68	50.77	0.006***
Average after-tax family income	89,605.99	87,238.63	<.005***
Social deprivation index	0.000067	0.010	<.005***
Material deprivation index	0.004	0.004	0.81
Percent aboriginal population	4.86	4.04	<.005***
Percent visible minority population	18.92	18.55	0.078*

The maps below (Figures 11 and 12) demonstrate the locations of non-individual enforcement actions for which the coordinate locations are known (marked by black points). We have coordinate location data for

offenses in BC, AB, SK, ON, NB, and QC. In the Material and Social Deprivation Index (MSDI) map (Figure 11), darker purple values indicate higher levels of social and material deprivation, with blue representing material deprivation and red being social. In the second set of maps (Figure 12), bright red represents higher vulnerability, with a high percentage of visible minorities and low income. Sky blue areas represent regions of low vulnerability, with a low percentage of visible minorities and high income. Purple areas have high percentages of visible minorities and high income.

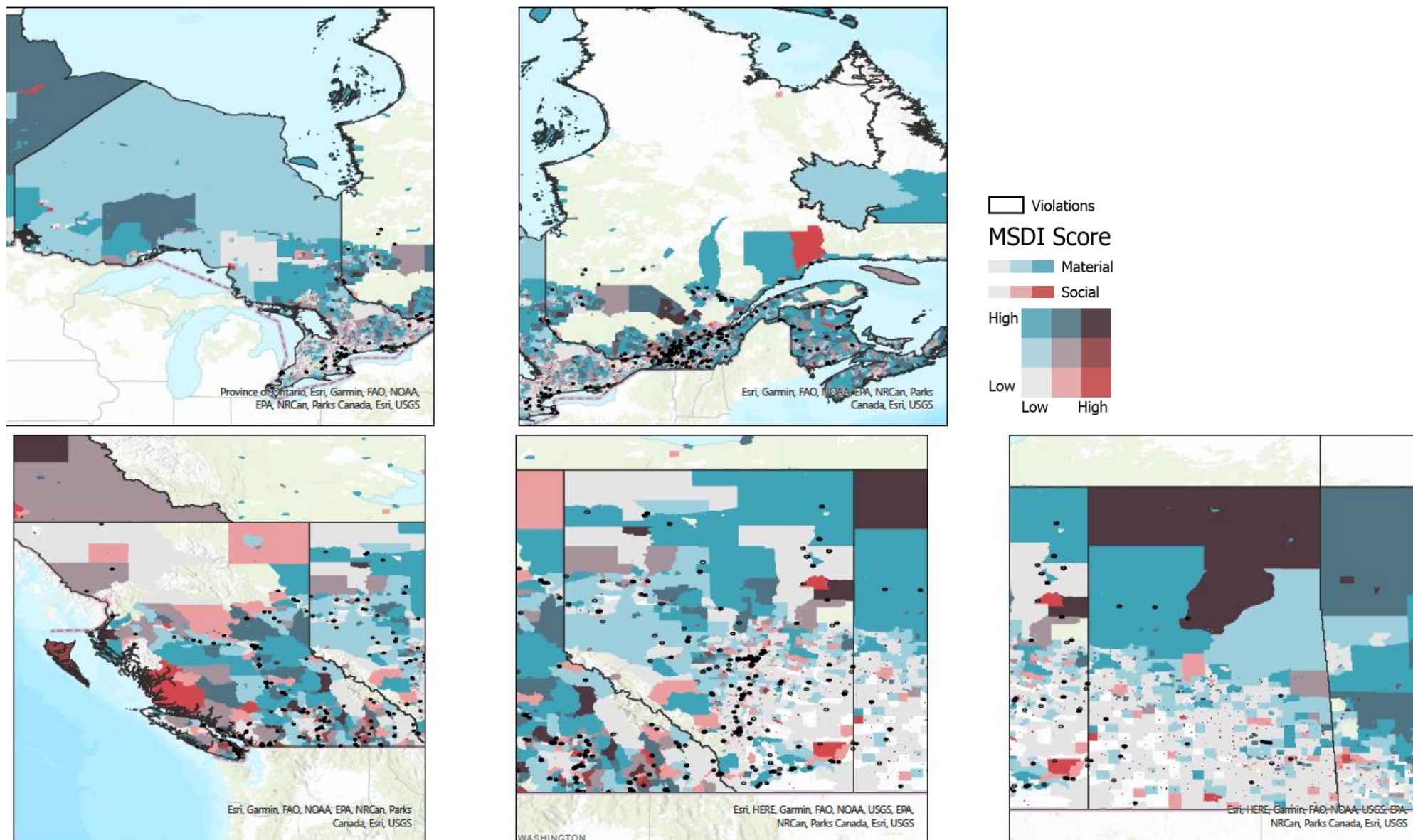


Figure 11. Non-individual enforcement action sites against bivariate color map of material and social deprivation indices by Census DA

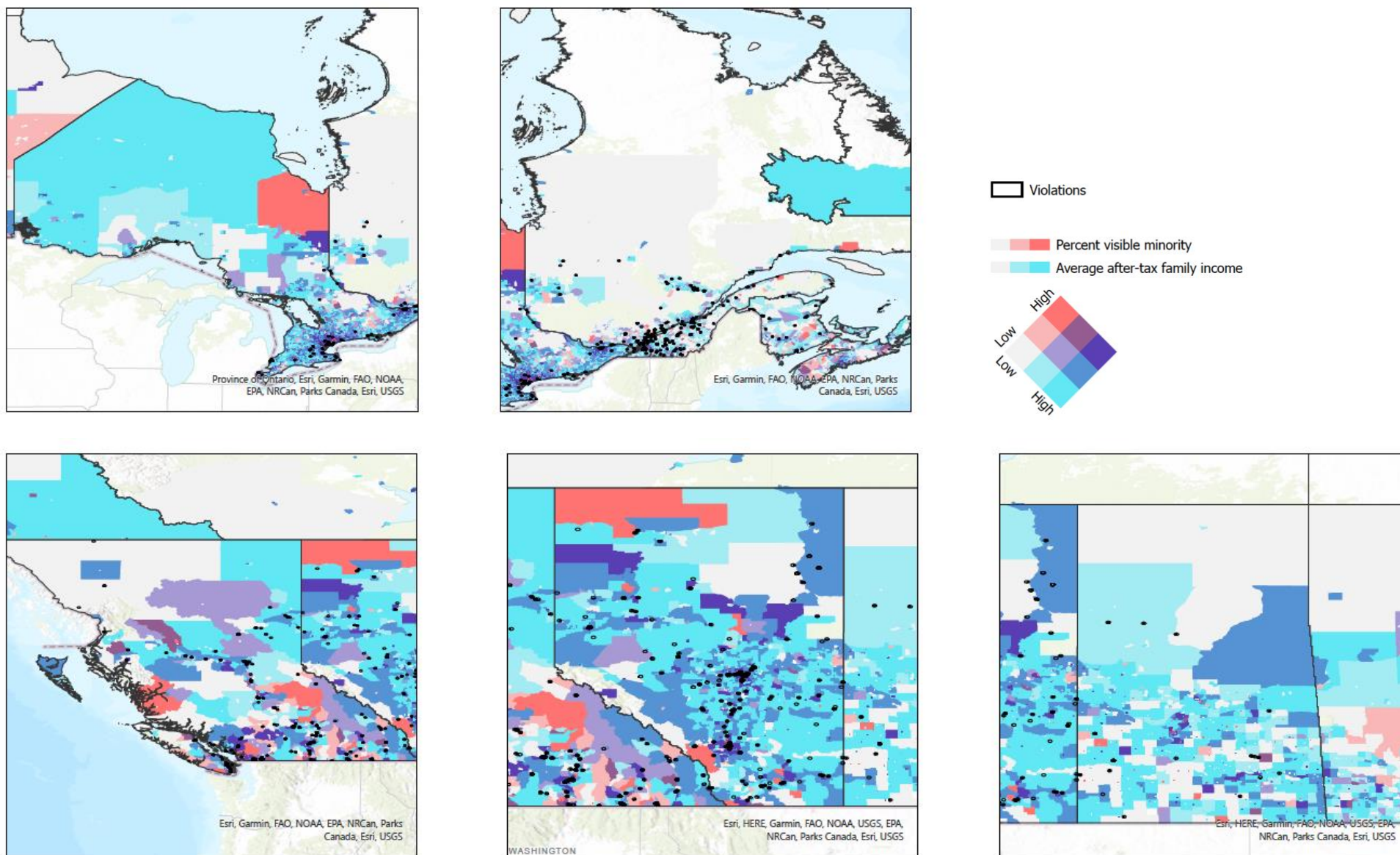


Figure 12. Non-individual enforcement action sites against bivariate color map of percent visible minority and average after-tax family income by Census DA

These maps can potentially provide some information visually regarding EJ variables, but because of the large scale of the maps and small DAs, particularly in urban areas, they are presented primarily to illustrate the distribution of points across provinces. For example, observations in BC and SK appear to be primarily rural, whereas, in AB and NB, there are several observations in rural areas and some in urban zones. Meanwhile, in ON and QC, the bulk of observations are concentrated in more urban areas. Further research is necessary to evaluate the impact of the rural/urban divide on the EJ variables considered.

Chapter 7: Discussion and Conclusion

A few key findings and trends emerge across these analyses:

1. Enforcement data in Canada is lacking in availability, accessibility and quality, ranging from being a “fraught path to data” to “imperfectly open data.”
2. The large majority of enforcement actions observed involved burns and individuals.
3. Provinces have diverse data and enforcement outcomes on several metrics. They share data differently, enforce different proportions of offender types, levy different penalties with varying severity, enforce high-risk offenses at unequal rates, and seemingly enforce violations in different regions (rural or urban).
4. Provinces are similar in their underutilization of fines (compared with what is possible under legislation) and poor data sharing overall (especially compared to the US, for example).
5. High-risk offenses represent a small proportion of the overall dataset, but important offenses and offenders are captured within this subset.
6. Enforcement of observed industrial violations does significantly interact with some, but not all, environmental justice variables. Enforcement may occur at higher rates in areas that are whiter, but more socially deprived, poorer, and with higher proportions of females. Maps suggest that there may be differences in how enforcement actions are concentrated between rural and urban communities.

In the following section, I discuss the results as they relate to my research questions and previous literature. First, I describe the results from the data rubric, finding that the openness of data varies substantially between and within provinces. Because data quality is generally poor and incomplete, it violates the right to information. This is intrinsically problematic, as Canada is legally bound to this principle,²⁵ but it also has vital implications for environmental justice. Next, I discuss the results from the descriptive analysis, as they suggest widespread use of a cooperative approach to enforcement and a misalignment of environmental priorities and enforcement outcomes. Several observations, including the distributions of fines, penalty types, high-risk offenses, and more, are offered as evidence, alongside analyses of literature from specific cases and provinces. Third, I examine the environmental justice findings, considering the trends of enforcement actions in disadvantaged communities compared to other EJ literature from Canada and the US. I suggest another potential source of environmental injustice within my dataset, although it is not measured explicitly, which is the role of the public and public complaints in driving enforcement actions. Finally, I offer comparisons to methodologically similar studies, limitations of this work and discussions of missingness, comparisons to the American enforcement model on several metrics, recommendations for enforcement and policy reforms, and conclusions.

7.1 Open data

7.1.1 Data rubric and methods

The openness of data varies substantially between and within provinces. Between provinces, data ranges from being a “fraught path to data” (a “2” on the open data rubric) to “imperfectly open data” (a “5” on the rubric). Notably, no Canadian jurisdiction achieves “open data” or “just, open data.” Within provinces, data quality varies from observation to observation, but the nuanced dimensions of provinces’ data quality are simplified by the rubric metrics. There is not a straightforward explanation for the considerable variation in data quality and availability between provinces, as measured by the rubric. Interestingly, three of the four largest provinces (BC, AB, and QC) plus the federal government had basically similar data systems, with similar variables reported by each, and these systems earned the highest grades. Therefore, one explanation might be that larger jurisdictions have more resources or have allocated more resources to data sharing. This hypothesis could still apply to ON as a large province with a more robust data system, even though ON was a low scorer on the rubric, because of ON’s extensive open data catalogue. ON’s barrier to sharing relevant air pollution data seems to be related to privacy issues rather than financial resources. However, cases like NB confound, because this small province manages to post a public dataset, especially when compared to SK, which is also small but

²⁵ Canada is a party to the International Covenant on Civil and Political Rights, wherein Article 19 provides for the right to receive and impart information.

does not post publicly and where FOIPOP results are poor. Further research is necessary to examine how decisions are made about publishing enforcement data, how resources for such are allocated, and how differences in provincial FOIPOP laws may impact these outcomes.

7.1.2 Calculating average grades

I elected to calculate jurisdictions' overall grades based on an average of each data metric. Each metric had a significant bearing on my success or failure in using at least one jurisdiction's data, so the choice to weight metrics equally reflects a balanced approach. Depending on their interests and application contexts, future rubric users may judge that various metrics are more important and should be weighted more heavily. For example, those hoping to increase community mobilization surrounding environmental enforcement may increase the weight of "public interpretability." The nature of the rubric is subjective and relative, and grades should be updated regularly to reflect any comprehensive changes to jurisdictions' data availabilities.

7.1.3 Open data and the community right to know

Cairns, Turan, and Amos (2011) compare federal data availability in the US and Canada relative to the principle of the community right to know²⁶: the notion that individuals should have access to information about environmental exposures, such that they can make informed decisions and manage their own risks. The authors consider not only information about emissions and exposure to be necessary for the community right to know, but also information about environmental enforcement. They find that despite both countries legally committing to the principle (albeit in different ways), only the US honors it through the provision of ECHO. Canada's lack of publicly accessible information on enforcement actions and reliance on FOIPOP requests that often involve extensive delays and produce only partial information does not honor the community right to know. My research supports and extends this conclusion, finding that not only does the Canadian federal database on enforcement (Environmental Offenders Registry) not fulfill communities' right to know, but provinces' databases do not either.

ECHO offers various services facilitating the community right to know, including a ZIP code search function, which allows users to find numerous details on facilities in an area, including their compliance and enforcement histories, their pollutant profiles (coupled with a toxicity index for emissions and exposures [Risk-Screening Environmental Indicators, also known as RSEI²⁷]) and more, alongside useful map layers such as EJSCREEN²⁸. With these tools, users can fairly easily access all of this information and assess their risk accordingly. Meanwhile, in Canada, the dimensions of data are far fewer, siloed, of lower quality, and do not facilitate the community right to know. The NPRI does offer a postal code search function, allowing users to view facilities in an area and their pollutant profiles, but this is entirely separate from enforcement information (whereas in ECHO, the emissions and enforcement dimensions are integrated). In the NPRI, pollutant profiles are not accompanied by toxicity indices or any other contextualizing information. Even the best enforcement databases/datasets in Canada do not offer a postal code search function. At most, users can attempt to search a city or county, but this usability is extremely limited, and almost none of the observations have specific locations listed. As such, it is an exceedingly difficult task for users in Canada to assess their environmental risks based on their location, as information about pollutants and enforcement is siloed across sources, not easily searched by location, and incomplete at best. Thus, the community right to know in Canada is not upheld.

The (lack of) community right to know has vital implications for environmental justice. In both countries, EJ community members know their communities are impacted by environmental burdens but may not have the tools to identify types of pollutants, where the pollutants are coming from, which are the most harmful, whether levels are increasing or decreasing, who is most vulnerable, what legal recourse is available to them, or what is already being done about the pollution (by way of enforcement and/or compliance promotion). Facilitating the right to know for each of these questions is helpful for members to organize, promote change

²⁶ As mentioned, in Canada, this is the right to information, but the American term "community right to know" will be used henceforth, as it is more directly applicable to this context.

²⁷ "RSEI incorporates information from the Toxics Release Inventory (TRI) on the amount of toxic chemicals released, together with factors such as the chemical's fate and transport through the environment, each chemical's relative toxicity, and potential human exposure. RSEI model results can be used to help establish priorities for further investigation and to look at changes in potential human health impacts over time." (US EPA 2014)

²⁸ EJSCREEN is a tool developed by the EPA that creates EJ indexes and allows users to view environmental and demographic indicators in a standardized, geographic format

within their communities, and defend their human rights from potential violations. ECHO enables access to data that can support answering several of these questions, whereas the NPRI only begins to address the pollutant/emissions-oriented ones, and the Canadian enforcement data does not facilitate the right to know for enforcement-related questions. Thus, the Canadian hindrance of the right to know is not just important in terms of Canada violating its own commitments to the principle; it is also vital in its application for communities who may need it the most, whose risk is higher because of environmental injustices, and who could benefit from information being available about environmental hazards, but are denied access to this information because of disparate, inaccessible and incomplete data.

7.2 The cooperative approach to enforcement

The observed enforcement approach across provinces can be considered “cooperative,” which is mostly unchanged over time and is consistent with the academic and government literature suggesting this approach persists in Canada (Harrison 1995; 1996; 1998; British Columbia Ministry of Environment and Climate Change 2016; Alberta Environment and Parks 2015; Ontario Ministry of the Environment, Conservation, and Parks n.d.). Key findings from my analysis support the hypothesis that Canadian jurisdictions favor cooperative rather than “direct” enforcement:

1. Jurisdictions issuing low fines despite the ability to issue larger ones under a given piece of environmental legislation
2. The low number of court convictions, except for Ontario
3. The frequent usage of low-level penalties, such as warnings, especially for high-risk offenses
4. The apparent lack of escalating enforcement actions for many repeat offenders, despite this being an alleged criteria for selecting penalties in some jurisdictions,

The low counts of observations might also be evidence for a cooperative approach, although this should be interpreted with caution, because of various weaknesses identified earlier regarding the violations pipeline.

7.2.1 Low penalties

Low fines, few court convictions, and the frequent usage of low-level penalties are all suggestive of Canadian jurisdictions’ cooperative enforcement approach. The enforcement action that tends to levy the highest fines is prosecutions leading to court convictions, but these comprise only 3.8% of all observations (Figure 7). When cases do go to court²⁹, courts are apparently unwilling to utilize the full range of fines available under a given environmental statute (Table 27). In the absence of court convictions, the evidence suggests that lower-level penalty types are used instead, even for serious offenses, like the 8.1% of observations where companies emitted noncompliant pollution (Table 23). Most notably, 87% of AB’s offenses are high-risk (involved criteria air contaminants, repeat offenders, facilities that report to the NPRI, facilities in the top 20 polluters in a province [NPRI top 20], and/or non-individual offenders), yet 61% of them received warnings (Table 30 and Figures 6 and 7). In QC and NB, also provinces with large proportions of high-risk offenders, enforcement agencies make regular use of administrative penalties, the penalty type designed to issue higher fines to companies without going to court (Figure 7). Yet, the average fines from these provinces are still quite low, relative to firms’ revenues and maximum fines under the legislation. It turns out that in QC and NB, the maximum fine for administrative penalties is set extremely low: \$10,000 and \$5,000 respectively (Quebec Environmental Quality Act, section 115.26; New Brunswick Clean Air Act section 31(5)), hindering the efficacy of administrative penalties’ deterrence in these locales. Consequently, although QC and NB technically employ a higher-level enforcement action, the outcome is still a low fine levied on offenders. Taking all of these factors into account – low fines, few court convictions, and lower-level penalties – a decidedly cooperative or lax landscape of enforcement is clear within the scope of my dataset. Polluters can view the regulatory environment, assess their prospects for operating (anywhere except Ontario), and conclude the following: if a violation does occur, the polluter will probably only receive a warning or an inexpensive administrative penalty or ticket. In the extremely unlikely event that a violation yields a prosecution leading to an out of court settlement or a court conviction, a polluter will probably still receive a low fine.

²⁹ Critically, jurisdictions do not publish unsuccessful court cases as enforcement actions, so we do not know if more cases do actually go to court and defendants are found not guilty. Without this information, it is assumed that the count of court convictions roughly represents the count of court cases the enforcement agencies bring.

7.2.2 Lack of escalating offenses

Perhaps one of the strongest pieces of evidence for the cooperative approach being employed in my dataset – and being even more “cooperative” than some provinces acknowledge – is the lack of escalating enforcement actions, particularly as manifest in repeatedly issuing warnings and letters to repeat offenders (in addition to the high proportions of warnings and letters in general). There is a high propensity to give warnings and letters to repeat offenders (32% of repeat offender observations), as well as repeated warnings issued to OMR offenders (BC’s two warnings to Rio Tinto Alcan in 2019 and 2020, for example [Table 32]). According to BC’s and ON’s penalty type criteria matrices and AB’s Compliance Assurance Annual Report, these types of enforcement actions should be avoided for repeat offenders (Ontario Ministry of the Environment, Conservation, and Parks n.d.; British Columbia Ministry of Environment and Climate Change n.d.; Alberta Environment and Parks 2007). Yet, in several provinces, including AB and BC, they are regularly used. It is important to note, though, that subsequent warnings are rarely issued for the **exact same** offense at the **exact same** facility. Considering the BC Rio Tinto Alcan example again, both warnings occurred at the same facility, but there were different criteria air contaminants emitted in different quantities between the two violations. Thus, this calls into question what exactly warnings are “warning” against, and what exactly BC and AB mean when they define “repeat offenders” as those who should not receive warnings again. Are warnings notifying of noncompliance and warning against breaking point-source air pollution laws encouraging firms to come into compliance with those laws overall? Or are they warning against very specific instances of noncompliance, treating these as more or less independent of each other, and indicating only that violating a particular point of noncompliance repeatedly constitutes a “repeat offense”? The evidence suggests that either provinces define “repeat offenders” as this latter group (repeated violations of specific points of noncompliance), or BC and AB, in particular, are simply ignoring their own enforcement policies by issuing warnings to repeat offenders instead of taking stronger action. Regardless, the cooperative approach is clearly the prevailing approach in the enforcement of Canadian air pollution laws and regulations, as observed in this study, where offenders continue to receive warnings and letters, even if they previously violated similar rules.

7.2.3 Few observations

The count of observations (2,217), which represent enforcement actions, I consider to be “low” in an absolute sense. Amos et al. (2011) referred to the low count of prosecutions and convictions under CEPA in similar terms, but it is helpful to contextualize further for this study. The most persuasive evidence for the count of enforcement actions being “low” would be if we had access to reliable data on the number of violations. We could then assess the proportion of violations that received enforcement actions. Because we do not have this information (due to poor data availability as illustrated by the violations pipeline), we can focus on the low number of federal court convictions (one conviction, see Table 22 and Box 1). While the federal data is missing other, lower-level penalty types, I believe it is at least nearly complete for court convictions (based on historic trends like those documented by Amos et al. [2011]). If true, the fact that there has been one court conviction for point-source, ground-level air pollution across the 14 years of data available in the Environmental Offenders Registry demonstrates two possible pieces of evidence for a cooperative approach. Either the federal government has issued few enforcement actions in general, or few “high-level” enforcement actions like court convictions, in favor of (more cooperative) lower-level penalties (see subsection 6.2.1). In either case, the low count of observations (court convictions) issued by the federal government suggests a cooperative approach.

The low count of observations, especially for non-individual offenders, is evidence of a cooperative approach, where pollution may or may not be compliant. To follow the hypothesis where the approach is cooperative and pollution is noncompliant: when violations are detected, enforcement agencies do not issue enforcement actions, opting instead to educate violators, issue verbal warnings, etc., (or perhaps do nothing at all), which would not appear as formal enforcement actions in my dataset (resulting in a low count of observations). This hypothesis is most clearly supported in Newfoundland and Labrador, where the public servant I contacted said that there was no enforcement data (the count of observations was [nearly] zero) because pollution there is either compliant or a cooperative approach is used to address noncompliance (see Appendix A). Conversely, as will be discussed further, if the approach is cooperative but pollution is compliant, the cooperative approach is “working,” and compliance is achieved – the count is low because there are few violations to enforce. Finally, a third hypothesis is that the low count of observations has less to do with the enforcement approach and is instead a consequence of poor data quality and availability. We cannot assess

which of these hypotheses is most accurate without more data and research, but the low count of observations raises questions about the efficacy of cooperation.

7.2.4 Comparisons to provincial enforcement literature

Given the foregoing evidence for provinces using cooperative approaches, we can examine how this evidence fits with the approaches outlined by provinces in their enforcement literature. As discussed previously, the lack of escalating penalties for repeat offenses not only demonstrates a cooperative approach but also potentially undermines BC's and AB's enforcement policies. However, aside from the treatment of repeat offenses, these provinces' demonstrated approach is more challenging to interpret.

In BC, the government's literature establishes that enforcement mechanisms were only recently "modernized," adding the ability to levy administrative penalties since 2015, increasing maximum fines, doubling the number of inspections, etc. (British Columbia Ministry of Environment and Climate Change n.d.). In small measure, these changes are observed, such as with the relatively high administrative penalties issued in 2018 (Figure 10), although fines returned to previously low levels thereafter. The literature did not include a discussion on what types of offenders the agency might prioritize for enforcement actions (e.g., individuals or non-individuals), but if increasing the focus on corporate offences is part of "modernizing," that change is also observed (subsection 4.3). It is possible that the increased number of inspections resulted in this change. The high noncompliance rate of asphalt plants and sawmills, noted by the compliance audits of the respective regulations, is demonstrated, as several of BC's company-level violations stem from these industries. Aside from failing to escalate penalties for repeat offenders, there is weak evidence in either direction of BC employing or failing to employ its decision-making matrix because the matrix only loosely defines each criterion (and the summaries of offenses seldom provide readers enough information to measure offenses against the matrix). Penalties remain low and few for companies and are even lower for high-risk offenses (Table 31). Overall, despite "modernization" efforts, the Ministry of Environment and Climate Change remains decidedly cooperative, consistent with its 2016 claim that it is committed to voluntary compliance (British Columbia Ministry of Environment and Climate Change 2016).

For AB, the enforcement landscape is perhaps more complex. The core juxtaposition in AB is that most observations are non-individual or high-risk offenders (87%) (Figure 6, Table 30) – a non-cooperative posture – but most observations receive warnings (Figure 7) – a cooperative posture. This suggests AB is monitoring firms and dedicating most enforcement resources to them (as opposed to individuals), but instead of responding to their noncompliance with more direct or punitive actions, like high fines, prosecutions and court convictions, etc., the common choice is responding with cooperative measures and low or nonexistent financial penalties. As such, AB's enforcement strategy has the foundation for more direct measures but fails to deliver when enforcement actions are implemented. For example, the Ministry's "compliance sweeps" are less cooperative, insofar as they are random inspections (which are less cooperative than the scheduled, predictable inspections in other provinces), but since noncompliance observed during compliance sweeps usually only results in letter penalty types, their effectiveness as a direct enforcement measure may be curbed. Notably, AB inspects 10%+ of its facilities per year, while BC inspects 25%+. Yet, comparing the provinces' proportions of high-risk offenses, 87% of AB's observations are high-risk offenses, compared to BC's 21% (Alberta Environment and Parks 2007; British Columbia Ministry of Environment and Climate Change n.d., Table 30). In other words, this suggests that AB is prioritizing inspections and/or enforcement actions for higher-risk facilities, arguably using its inspections more effectively. However, we do not know how whether and to what extent this approach affects environmental outcomes. Given the high likelihood that these inspected facilities will receive a warning or low administrative penalty, it is debatable. In general, Alberta Environment and Parks' reliance on warnings supports the notion that they employ an "advice and persuasion" model, although the foundations for a more direct and punitive/aggressive model may exist.

Finally, ON's enforcement approach, as observed in this study, differs substantially from claims made in the literature published by its Ministry of Environment, Conservation, and Parks. While its enforcement actions are still less frequent and less punitive than the US, its approach is much less cooperative than any other jurisdiction in Canada. However, these conclusions are based on the available data, which is especially limited in ON and has particular implications for this discussion.

A few possibilities can be imagined given ON's enforcement record. Consider that 83% of the time, ON offenses are enforced with a prosecution resulting in a court conviction. One explanation is that the Ministry of

Environment, Conservation, and Parks uses the decision-making matrix it provides in its Compliance Policy (as a criteria strategy model), and the Ministry prioritizes identifying and enforcing the dangerous violations that warrant such an action according to the matrix. If this is the case, the criteria strategy is not actually cooperative because the Ministry uses it to select for high-risk offenses and high-yield penalties (Table 30, Figure 8). Another explanation is that the Ministry is misusing or ignoring the matrix and over-zealously applying prosecutions when lower order penalties might be appropriate. Given the content of the matrix and the offenses that have occurred in ON, this is unlikely. Finally, the situation I judge to be most likely is that because of the poor data quality and data sources, the shape of the ON data is slanted towards prosecutions resulting in court convictions, and there are probably many more instances of the Ministry using lower-level penalty types for “lower risk” offenses. Still, considering only the data presented, ON appears much less cooperative than other provinces, securing several times as many court convictions and imposing much higher fines than any other jurisdiction (Figures 7 and 8).

7.2.5 Effect on deterrence

It is unlikely that specific or general deterrence is successfully working to promote compliance in Canada, at least among the observations captured in my dataset. The lack of specific deterrence is evidenced by the high number of repeat offenses, which constitute 34% of the high-risk offenses (Table 29). If specific deterrence was working, one might reasonably anticipate a lower proportion of these, with a larger proportion of one-time offenders. Instead, numerous offenders violate air pollution laws repeatedly, some offending many times over the years and across provinces.

The cooperative approach, as manifest in the low fines and apparent unwillingness to levy higher ones, perhaps plays a role in decreasing specific deterrence. Consider Rio Tinto Alcan as an example, a cross-provincial repeat offender, one of whose offenses warranted QC’s highest fine (\$150,000) in 2013. Less than one month after receiving the largest fine recorded (in publicly available data) for point-source air pollution in the province, Rio Tinto Alcan violated another law, receiving another \$100,000 fine. The same facility would violate again in 2016 and in 2019 (each yielded a \$10,000 administrative penalty). All four violations were Emissions and Standards offenses, and all four received financial penalties. But clearly, as evidenced by the repeated noncompliance, the facility was not deterred by these penalties (not to mention violations at Rio Tinto Alcan’s other facilities in QC and other provinces). Taking Rio Tinto Alcan’s annual revenue into account can help to explain why. In 2013 (the year of the largest fine they received), the company’s revenue was \$64.73 billion CAD (Rio Tinto Alcan Canada 2013). The \$150,000 fine from QC amounted to 0.00023% of that annual revenue. For an average Canadian family, earning \$62,900 after taxes, to be fined 0.00023% of that income would be equivalent to \$14.47 (S. C. Government of Canada 2021). While we do not have enough data or information to demonstrate how much offenders benefit from violating air pollution laws, the cost-benefit threshold is obviously low relative to revenue. That is, for firms, fines/costs are so low (relative to revenue) that even marginal benefits from polluting may be worth extracting. It is possible that other factors outside of fines, like market responses or social pressures (such as described by Alm [2014] and Ganslandt [2020]) may add to the cost-side calculation for these firms, but it is outside of the scope of this research to determine those factors’ effect on specific deterrence.

Whether general deterrence is functioning is perhaps harder to determine, but is similarly unlikely to be working to promote compliance. Chiefly, general deterrence takes into account firms’ perception of the regulatory environment. As described, the regulatory environment is cooperative and has relatively few absolute standards across provinces. High-risk offenses are often issued warnings (35% of observations), and rarely are emissions-based violations enforced (8.1% of observations) (Table 29, Figure 3, Table 23). Firms may view this landscape of enforcement and regulations and judge it as fairly lax. There are a few factors that may offer some general deterrence, against this cooperative landscape. In ON, the province’s propensity for prosecutions, court convictions and higher fines, plus their ambient air quality standards (although it has exceptions for industry) and attention to air-related violations (Berkley 2019), may yield a more deterrent culture in ON than in other provinces. To a lesser extent, the increasing number of inspections in BC (British Columbia Ministry of Environment and Climate Change n.d.) and the increasing proportion of companies subject to stronger enforcement actions in AB and QC may have a deterrent effect in those provinces. Since these trends in BC, AB, and QC are recent (within the past five years), more research will be necessary to assess their effect, if any, on the compliance landscape.

As previously alluded to, it is also possible that, in fact, general deterrence is working quite well in Canada, and explains the low counts of observations and the minority of high-risk offenses. This would suggest that the cooperative approach is working as it is idealized: a compliance promotion strategy. Under this theory, firms consider the cooperative environment not as an opportunity to violate laws with low consequences or impunity but as an opportunity to collaborate with government and work towards consistent compliance. Given BC's reports on compliance rates, and other provinces demonstrating a similar enforcement approach, this alternative seems unlikely, but since we do not have data on other provinces' compliance rates, it is possible. More data and research on compliance rates and enforcement is necessary to determine whether general deterrence is functioning in Canada.

Regardless of all of these intersecting and interacting factors within the collective "cooperative approach," it is necessary to add a caveat that this research cannot ascribe the intentions or reasons behind why jurisdictions take the cooperative approach. It could be the product of successful corporate lobbyists, a neoliberal approach to governance, or even explicit instructions from Ministries to target minor offenses (rather than undertake larger-scale prosecutions) as Girard, Day, and Snider (2010) posit. Or it could be that governments simply do not have the resources to be anything but cooperative. Budgets for environmental ministries/departments have been repeatedly cut since the 1990s, with provincial budgets experiencing a 28% decline from 1993 to 2012 (more, if inflation is taken into account) (Boyd 2015). Systems are such that the enforcement actions that might actually be expensive for and deter polluters are similarly expensive for enforcement agencies to levy, which might discourage agencies from pursuing those kinds of actions (e.g., prosecutions seeking court convictions). As Girard, Day, and Snider point out, warnings and letters are cheaper to administer than other penalty types. It is debated as to whether firms return to compliance merely by being notified in such a way that they are out of compliance (Wilkins and MacDonald 2009; Girard, Day, and Snider 2010), but it stands to reason why resource-stressed agencies might gamble that they will and hope for the best. It is perhaps some combination of the two – a neoliberal approach to governance, plus under-resourced agencies – that contributes to the cooperative ethos. Regulatory capture (where the governing body's close relationship to regulated parties results in lax compliance and enforcement activities) may also play a role. Future research may seek to investigate this question in detail to address the root causes of a (possibly) ineffective approach to environmental enforcement.

7.3 Environmental Priorities Versus Enforcement Outcomes

There is a substantial disjunct observed between environmental priorities and enforcement outcomes. Through the subset of "high-risk offenses" and its subcategories of "criteria air contaminants," "repeat offenders," "cross-provincial repeat offenders," "NPRI-reporting facilities," "NPRI top 20 facilities," and "non-individuals," I attempted to capture what might be considered the "environmental priorities" for enforcement: the offenders and offenses that are potentially riskier to environmental and human health. On several levels, enforcement outcomes do not appear to align with environmental priorities, as demonstrated by static fines, uneven treatment by provinces, and the minority of high-risk offenses (37.3%) (against the majority of burns and individual-level enforcement actions) (Table 29).

Box 2. Contextualizing Penalties for High-risk and OMR Offenses

It is important to contextualize high-risk and OMR observations outside of the narrow lens of my dataset. Notably, how does the US (under the EPA) treat similar offenses? While it is difficult to compare offenses on truly equal grounds, we can compare the penalties levied on a few high-risk and OMR offenders from my dataset to those for the same offenders in the US.

The most comparable offenses come from Essroc Canada and Lafarge Canada. For both companies, on at least one occasion, they discharged particulates and/or dust into the atmosphere. Essroc was convicted in ON courts and fined \$550,000 between its two offenses, while Lafarge was issued a \$2,500 administrative penalty for excess particulate emissions in AB.

In the US, Essroc and Lafarge have been found guilty in court of similar offenses (although the scale of the case against them was larger – or at least more information was provided about it). Essroc was convicted and penalized \$1.7 million USD in civil penalties, required to invest \$33 million in pollution control technologies, and had to pay \$745,000 to mitigate past excess emissions. Lafarge was convicted and penalized \$5.075 million in civil penalties and also required to clean up (a dollar figure was not provided regarding the cleanup efforts) (US EPA n.d.).

Other companies, including Dow Chemical, Valero, Terra International, and Agrium have also violated ground-level, point-source air pollution laws in both countries, and received much higher fines in the US. The fines levied on these companies, plus Essroc and Lafarge, total \$658,000 in Canada. In the US, they total \$14 million. Considering these companies alone, the US has fined them over 21x more than did governments in Canada.

7.3.1 Static fines

Despite the reported criteria strategies from BC and ON to make penalties responsive to an offense's environmental damage, the static nature of fines and general applications of penalties provide evidence that penalties are not responsive across provinces. First, Figures 6 and 7 demonstrate that fines are generally flat over time and consistent across keywords. The median fine for all keywords except for Emissions and Burn is between \$2,500 and \$10,000 – a negligible difference in practice (consider the aforementioned Rio Tinto Alcan example as a proportion of revenue) – yet there are considerable differences in the environmental impacts of keywords. For example, the median fine for Excess emissions is \$2,500, and the median fine for Notification offenses is \$3,250. This means that, per these median values, a firm could get fined more for failing to notify an enforcement agency that they exceeded their permitted emissions limits than for actually exceeding their emissions limits. The difference between the median fines that provinces levied for high-risk offenses and the overall dataset is also negligible in practice, although statistically significant (Table 31). Similarly, penalty types are not responsive to the severity of violations, as previously noted by the large proportion of high-risk offenses that are issued warnings. Clearly, this narrow range of fines across keywords, coupled with liberal use of warnings, does not take into account wide disparities in the potential environmental effects of offenses.

Fines' static nature over time (Figure 10) dovetails with this point. They are static in most provinces despite an ever-increasing body of literature about the environmental and human harms of air pollution, including literature about high levels of mortality, morbidity, and inequitable exposures to pollutants for Canadians (see subsections 1.1.1 and 2.5). If fines or penalties were responsive to this information, one would expect them to increase over time, reflecting attention to the "polluter pays" principle or general deterrence. It is possible that the aforementioned fluctuations over time in BC, AB, and QC – as explained by proportional changes in offender types (AB and QC) or by a few high-dollar administrative penalties (BC) – are expressions of these provinces responding to environmental priorities. That is, perhaps AB and QC increased their "targeting" of non-individual offenders and BC implemented and administered administrative penalties, which increased the average fines in recent years as a secondary effect. Again, only enforcement agency officials in these provinces can comment on the motivations or reasons behind these trends. Overall, though, the narrow range of fines, over time and across keywords, suggests that fines are not responsive to changing information or the severity of an offense. Future research can investigate the possible reasons for this phenomenon.

7.3.2 Distribution of high-risk offenses

The distribution of high-risk offenses within the overall dataset and between provinces raises important questions about environmental priorities relative to intersections with the violations pipeline, data availability, and potentially resource-stressed enforcement agencies. First, Table 29 suggests that 37.3% of observations are high-risk offenses, with lesser proportions allocated to specific high-risk groups. Similarly, Table 30 notes significantly different proportions of observations for high-risk groups between provinces. Whether this enforcement outcome reflects environmental priorities depends on how many high-risk violations actually occur earlier in the violations pipeline, which we do not know because of poor data quality and poor monitoring/reporting from facilities. For example, we might consider AB, FD, NB, ON, and QC as successfully “targeting” high-risk offenses because a majority of observations from these provinces are high-risk, but we do not know what proportion this represents out of the true number of enforcement actions in each province or the true number of violations (that fall out of the violations pipeline). Based on the literature on emissions and facilities performance in Canada, it is dubious that high-risk offenses are as rare as this overall minority proportion of 37.3% would suggest. As a specific case, an investigation in SK found numerous exceedances of hydrogen sulfide limits from a few oil and gas facilities adversely affecting nearby families and farms, yet the firms “faced no charges or fines” (Cribb et al. 2018). This is a clear, high-risk offense, but it fell out of the violations pipeline before being enforced (and therefore does not appear in my dataset). Thus, it seems the environmental priority of enforcing high-risk offenses is not realized in enforcement outcomes, although we cannot determine the precise degree of misalignment.

The small number of NPRI top 20 companies among recorded offenders is particularly troubling in terms of the potential misalignment of environmental priorities and enforcement outcomes. As previously discussed, the NPRI top 20 group is potentially a proxy for “toxic outliers,” as defined by Collins (2011). For the NPRI top 20 group, we have a slightly better sense of the violations pipeline, as we already know that 134 facilities across provinces are responsible for a large amount of pollution (are top 20 facilities), yet only 24 of these appear in my dataset (18%). This suggests that either 82% of potential toxic outliers are compliant (policy and permits allow for these large amounts of pollution), or some portion of these 82% are noncompliant but are not being subjected to enforcement actions, which represents a large disjunction of environmental priorities and enforcement outcomes. Box 3 illustrates one such NPRI top 20 facility that does not appear in my dataset. Insofar as the NPRI top 20 companies may be the highest of the high-risk for environmental outcomes, it is particularly noteworthy that the median fine for them is a mere \$4,000 (Table 29). Only in NB were more than 10% of enforcement actions issued to NPRI top 20 offenders, which stems from NB’s repeated enforcement actions related to a pulp mill (Fraser Papers). While there are several possible explanations for why the NPRI top 20 group receives few enforcement actions, one might be that they are large businesses that can have substantial political influence within a given province (Boyd 2015).

Box 3. The cooperative approach for NPRI top 20 polluters

Glencore and Vale's Sudbury, Ontario operations are among the top 20 polluters in the province, yet the facilities do not appear in my dataset. This could be a function of the poor data quality – I could be simply missing the observations – but it is also possible that even though they are large polluters, they are operating legally under their permits and/or enforcement against their illegal activities is nonexistent. It appears the latter may be true. According to White (2018), these facilities have not met the province's sulphur dioxide standards in years, continuously receiving extensions for compliance requirements. This pattern may continue into the future, because even though Ontario recently strengthened its ambient standards limits for sulphur dioxide (effective in 2023), certain industries will not be expected to comply. As the Environment and Climate Change Minister at the time, Chris Ballard, said: "We understand there are technological limits in some industries and smelting certainly is one of those where even if they were to double or triple their pollution control investments today, our experts tell us it wouldn't perceptibly drop the sulphur dioxide emissions. [...] We're after continuous improvement. They will be in compliance as long as we work together" (White 2018). Thus, the Environment and Climate Change Minister's quote demonstrates that compliance is not dependent upon actually meeting the provincial standards – it is measured by cooperation with regulators. The Glencore and Vale cases underscore the point that policy is only as good as its enforcement, and even progressive updates to Ontario's (supposedly) binding ambient standards are undermined if the largest polluters are still openly allowed to circumvent those standards.

Ultimately, it seems enforcement outcomes do not align with environmental priorities, but this research does not explain why this might be true. Questions remain for future research to investigate where (if any) among the intersections of the violations pipeline, deterrence, the cooperative approach, resourcing issues, data issues, political economy, legislative or policy weaknesses, or other factors, explanations can be found for why these phenomena do not align in the dataset.

7.4 Environmental justice

One of the primary motivating questions for my research was whether there is a "double burden" for disadvantaged groups in Canada: first that they are disproportionately exposed to environmental burdens such as air pollution, and second that they are disproportionately less able to access justice and/or mitigation of that pollution through effective enforcement of air pollution laws. I hypothesize that there is such a double burden, following the work of Konisky (2013) and Spina (2015), who note that communities with more resources are better able to elicit enforcement outcomes. Because of the weaknesses exposed by the violations pipeline and the limited scope of this research, much more study will be necessary to investigate this question in depth and follow particular pollution events through the violations pipeline into environmental justice communities and enforcement actions. I provide supporting evidence from my research that may add to the discussion of the question.

The results presented have important implications for the landscape of environmental (in)justice in Canada, which necessitate further research. This study found that people in proximity to violations where enforcement actions occurred were generally whiter but more socially deprived, poorer, and more likely to be female (Table 35). It is important to emphasize that these differences are relative to cross-provincial averages for each variable, **not to a given threshold of deprivation**. For example, people in proximity to violations had generally lower incomes than the cross-provincial average, but they were not "low-income," as defined by Statistics Canada (which ranged from \$13,525 - \$54,220, depending on family size and population setting, for the 2016 Census, while the enforcement area average was \$87,238.63 [(Government of Canada 2016, Table 35)]. Some trends (particularly the lower property values and perhaps lower incomes found in enforcement areas) may be partially explained by other variables, such as a hypothesized uneven distribution of enforcement actions between rural and urban settings. With these considerations in mind, results are discussed considering other literature.

7.4.1 Comparison to the US

My research contributes to the mixed dimensions of enforcement actions and environmental justice, as mainly investigated by Konisky and a few others in the US thus far. Konisky's 2009 study, the most similar study to mine in terms of methodology, found the opposite trends for enforcement in the US compared to my results (that enforcement rates were significantly lower in poorer counties in the US). But, as he and other authors note, the shape of enforcement in the US differs depending on what is measured: what moment in the violations pipeline, what pollution law, etc. So, although my results differ from the most similar study, they overlap somewhat with other scholarship (Konisky and Reenock 2018; Konisky, Reenock, and Conley 2021; Mennis 2005). The most critical difference between related studies in the US and this study is access to data and data quality, and the subsequent quality of results. Konisky and colleagues can investigate much more detailed, nuanced, and particular aspects of enforcement across the US, and with higher degrees of accuracy and certainty, because of the relatively high data quality provided by ECHO. This allowed Konisky's 2009 study to investigate enforcement *rates* with true zeroes, evaluating the absence of enforcement as much as its presence in communities. Such data attributes are essential for investigating the double burden hypothesis, when scholars are testing whether disadvantaged, polluted communities experience decreased access to enforcement. Meanwhile, I do not measure enforcement rates, because I do not have access to the data from the violations pipeline, which would provide information about the absence of enforcement – I do not know how many violations go unenforced in Canada. As such, I cannot evaluate the double burden hypothesis in a similarly rigorous manner. Overall, because of ECHO's superior data quality, similar American studies have fewer limitations and can be interpreted more holistically, while the source data for this study is a significant limitation on its scope and applicability of results (discussed later in greater detail [subsection 7.6]). In other words, while it is worth discussing the potential differences in enforcement outcomes for EJ communities between the US and Canada, the real difference (for now at least) is between the quality of data that facilitates the study of these phenomena.

7.4.2 Comparison to other studies in Canada

Interestingly, the demographics of environmental justice communities disproportionately exposed to pollution in Canada differ somewhat from the demographics of the enforcement areas found in my study. Bearing in mind the limited scope and application of my research and the city-level scale of most Canadian pollution exposure analyses, I connect the studies to theorize possible trends in EJ communities' experience of enforcement and exposure. Previous studies in Canada have found correlations between pollution and: dwelling value (Michael Jerrett et al. 2001); social deprivation (Crouse, Ross, and Goldberg 2009); and income (Giang and Castellani 2020; Michael Jerrett et al. 2001; Crouse, Ross, and Goldberg 2009; Canadian Institute for Health 2011) – which also correlate significantly with enforcement as found in my study. Meanwhile, other research in Canada has found correlations between pollution and race (Buzzelli and Jerrett 2004; Crouse, Ross, and Goldberg 2009; Giang and Castellani 2020) and immigration status (Giang and Castellani 2020; Pinault, van Donkelaar, and Martin 2017) – which do not significantly correlate with enforcement according to my study. Overlaps suggest that for some disadvantaged communities – those with lower dwelling values, higher social deprivation rates, and lower income – they are exposed to more pollution and more industrial enforcement actions have taken place in those communities. Conversely, divergent findings suggest that other disadvantaged communities – racialized and immigrant populations – are exposed to higher pollution levels, but fewer industrial enforcement actions have occurred in those communities. Put simply, it appears the first group of EJ communities suffers the burden of pollution, while the second group suffers a “double burden” of pollution plus lack of enforcement. However, as suggested throughout this study, enforcement appears generally insufficient, so more than likely, all EJ groups affected by pollution probably are suffering a double burden; this simply proposes some are perhaps more than others.

7.4.3 The role of the public and public complaints

An important dimension of both the violations pipeline and the double burden hypothesis is the question of how enforcement agencies become aware of violations and subsequently act on them. As previously discussed, the observations in this dataset are mostly a product of inspections and public complaints, but the proportional breakdown between these groups is of vital importance for EJ. On a basic level, it is important because complaints require time, information, and other types of resources, so a reliance on complaints to drive enforcement will crucially interact with communities' access to such resources. On an elevated level, though, it

is important because it reflects which actor bears the burden of detecting noncompliance: regulators or the public. While the source data from provinces mostly did not mark the information source (whether an observation was detected through inspections or reporting versus through public complaint), nor was this a coded variable, there is evidence in the offense summaries and external literature that for at least several provinces, a sizable proportion of enforcement actions stem from public complaints.

According to BC's Compliance Inspections Report (2017), most inspections are planned (85%), rather than responsive (i.e., responding to public complaints), but as noted, most of BC's observations come from individual-level burns (which, by definition, were not detected by planned inspections, since planned inspections are for permitted facilities). This suggests that while most inspections might have been scheduled in BC, it appears the majority of actual enforcement actions may be triggered by other means, such as complaints from members of the public. We can imagine this being true for individual-level actions generally; it would be difficult for agencies to detect them in any other capacity besides complaint, or at least, I did not see evidence in the province's enforcement literature for such a mechanism. If so, it is possible that the 62.8% of enforcement actions that were issued to individuals (Table 24) were primarily detected by public complaints.

Setting individual-level actions aside, we can evaluate the summaries and source data information for how non-individual violations were detected. After reading inspection documents to garner source data and the offense summaries provided in most observations (see Appendix A), it appears 50-60% of BC's non-individual enforcement actions are a product of inspections. As such, 40-50% of non-individual enforcement actions may have been triggered by public complaints or some other driver of violation detection (again, not noted by provincial enforcement literature), in addition to the large number of individual-level enforcement actions in BC that may stem from public complaints.

In ON, offense summaries (through the news bulletins source data) often contain information about how a violation was detected, described more often from the complaint-driven side (rather than violations detected during a planned inspection). Even for chronic and large-scale pollution events, public complaint was often an initial and/or principal driver. In two of the province's bigger environmental prosecutions, one against Essroc (previously discussed in Box 2) and another against ArcelorMittal Dofasco, community members affected by the pollution were instrumental in mobilizing enforcement action (McLean and Bruser 2017). These cases took years' worth of the community members' time, over which period Essroc, in particular, continued to violate laws on hundreds more occasions and the Ministry of Environment, Conservation, and Parks continued to work with the company towards voluntary compliance (a violation of their enforcement policy and decision-making matrix, according to the Environmental Commissioner of Ontario) (Environmental Commissioner of Ontario 2012; McLean and Bruser 2017). The source data and literature do not provide enough information to determine to what extent these community members' involvement contributed to enforcement action and/or mitigating environmental damage or if voluntary compliance might have eventually been achieved. Regardless, it seems to have taken public pressure in some measure to alert the Ministry to these facilities' chronic and significant noncompliance, drive the Ministry to act on it, or both.

For other provinces, explicit information regarding violation detection is less available. It is reasonable to assume that Monitoring, Order, or Notification violations (3.7% of observations – Table 23) would be difficult for the public to observe, so these were probably detected via reporting or inspections. For all other keywords, it is difficult to know whether an enforcement officer observed the violation during a planned inspection, while reviewing a facility's self-submitted report, or if a member of the public alerted the agency to pollution, and a given keyword was discovered as a result.

Ultimately, it is not possible within the scope of this research to determine precisely how many enforcement actions were a product of public complaints or agencies' due diligence. However, between the large proportion of individual-level enforcement actions (which may be challenging to detect in any manner besides public complaint) and information from BC and ON's source data, enforcement literature, and other sources, it appears that high numbers of enforcement actions are instigated because of public complaints. While this could signal positive government behaviors – that agencies are indeed responding to complaints – it could also signal that there is a undue reliance on members of the public to detect violations. If the latter is true, it is a misplacement of responsibility; it is the mandate of enforcement agencies to be the primary actors in detecting and enforcing environmental crimes – not the public. Insofar as disadvantaged groups may be less able to file

these types of complaints, this misplacement of responsibility is additionally problematic and supports the notion that the hypothesized double burden may be occurring.

7.4.4 Comparison to observed EJ sites

Finally, some evidence can be considered regarding environmental and EJ priorities in well-known sites of environmental injustice. Sarnia is a city in ON that has been studied relatively extensively for the inequitable pollution exposures and health outcomes therein. Approximately 40% of Canada's chemical industry is concentrated in the area, likely contributing to the myriad health issues observed nearby, experienced by the people of the Aamjiwnaang First Nation and others (Mackenzie, Lockridge, and Keith 2005; Larsen et al. 2020; Scott 2008). Facilities in Sarnia account for 2% of those that report to the NPRI in ON, 16% of emissions, and 26% of my observations from the province. Ten (over half) of the observations from Sarnia were issued to Shell Canada Limited, and nine of these originate from the Environmental Penalty Annual Reports (see Appendix A) as a part of the province's new ability to issue administrative penalties under Regulation 530/18. New penalties have still been low relative to the revenue of petroleum companies like Shell (\$79,000 or less). Nonetheless, they represent a more promising direction for enforcement since all of these administrative penalties were issued within ten months in 2020, showing high responsiveness to violations and willingness to use the new tool. Still, given the high concentration of facilities, the large volume of emissions, and demonstrated inequitable impacts, the conditions in Sarnia warrant increased attention to enforcement. That 26% of enforcement actions occur in the area is perhaps promising, insofar as it signals that agencies are paying attention to it, but this only contributes to improved environmental and justice outcomes if those enforcement actions serve to deter polluters from noncompliance. Because high volumes of industrial air pollution and environmental injustices are ongoing, it seems existing enforcement strategies have been inadequate.

Box 4. Imperial Oil - a Toxic Outlier in an EJ Community

One of Canada's few better-studied toxic outliers, Imperial Oil, has a facility in Sarnia. According to Ecojustice's 2018 report, it was the most highly polluting refinery for numerous criteria air contaminants as measured against US benchmarks, requiring a 98% reduction in SO₂ to meet a US benchmark, and creates the most emissions by volume of any facility in Chemical Valley (Ecojustice 2018; The Land and Refinery Project n.d.). Interestingly, Imperial Oil is a cross-provincial repeat offender, with two offenses in Sarnia and one in AB, but is not a NPRI top 20 polluter at either facility, despite these high emissions. This speaks to the limitations of the NPRI top 20 variable (if it captured toxicity and exposure, as the RSEI index from EPA does, perhaps Imperial Oil would be included in the province's top 20 by this metric), but also to the incredibly high volumes of pollutants emitted by Glencore and Vale (described in Box 3), which "outcompete" Imperial Oil for the top 20 places in ON. Imperial Oil applies for technical standards for several of its pollutants, exempting it from at least some of the general air standards in ON. In addition, over 85% of the company's emissions are calculated using computer models (rather than physically measured), raising concerns about under-reporting (The Land and Refinery Project n.d.). These factors may help to explain the few enforcement actions against the Sarnia facility (two). Excess emissions may be considered compliant under the technical standard and/or exceedances may not be detected because they are modeled rather than measured. While the two enforcement actions did carry relatively high fines (\$650,000 each), they were for the same type of infraction, committed a bit over a year apart (discharging coker gas into the atmosphere). This suggests that the fines were not sufficient to invoke specific deterrence of violating behavior generally, or even this particular violation.

Therefore, it is perhaps most clear in the case of Imperial Oil that the cooperative approach of technical standards and indirect emissions measurements are not successful strategies for environmental or environmental justice outcomes. Such enforcement strategies, coupled with weak enforcement and low fines, allow Imperial Oil to persist as a toxic outlier that disproportionately pollutes the communities of the Aamjiwnaang First Nation and others.

7.5 Comparison to other studies in Canada

As mentioned in subsection 3.4, the methods and results of my study and that of Berkley Canada (2019) and Nimonik (2010) are generally similar.

Nimonik's report found that fines were mainly flat over time, with Ontario, Alberta, Quebec, and BC being the provinces that garnered the most total dollars from fines in the study period and/or the highest median fine per offense. I find these trends in my study as well. Interestingly, even though the Nimonik study was eleven years ago (2010), the authors met similar obstacles in obtaining data. They received an almost identical response from Newfoundland and Labrador (whose public servants claimed that they do not collect data on enforcement because enforcement was not necessary in the province). They received a list of fines levied in Nova Scotia but could not obtain fine amounts, and information requests went unanswered. In other words, it seems little has changed in these departments' enforcement or transparency practices over the past decade.

The Berkley report (2019) parallels findings in this study and offers explanations for some trends. First, like Nimonik, it finds that Ontario, BC, and Alberta consistently use relatively large (compared to other Canadian jurisdictions) fines to enforce compliance. Again, this is basically consistent with the findings of my study. Second, Berkley reports fewer fines in recent years (2018-2020), which I also observed for the overall count of enforcement actions (not only fines) in my dataset. Finally, Berkley analyzes provinces' enforcement "foci" based on pollution media: reporting which media most fines (by count and dollar amount) were focused on in each province. Consistently, Ontario's enforcement actions center on air-related offenses, whereas Saskatchewan, although an "active" regulator (issuing lots of fines), tends to focus on water-related offenses (as does British Columbia). In Alberta, most fines stem from "oil and gas related exposures (e.g., releases of crude oil or migratory bird kills)" (Berkley Canada 2019).

This information about "foci" is helpful to potentially explain some of the gaps in the dataset, especially from earlier points in the violations pipeline. If enforcement agencies are under-resourced and thus have to make choices about which pollution media or which facilities they attend to, air-related enforcement actions might be categorized as a lower priority in more sparsely populated provinces, but not in more densely populated Ontario. Provinces or regions where my dataset reports lower fines, lower counts of enforcement actions, etc., may reflect those choices. It is perhaps equally possible, however, that Berkley's use of the term "focus" implies intentionality where there may be little – or at least, it is possible that intentionality might not be organized around the type of pollution. Instead, enforcement priorities might be organized around entrenched practices, long-standing permits for facilities, cooperative relationships, or other factors, but is unlikely to be completely random (Telle 2013). Only enforcement agency personnel can comment on how priorities and resources are allocated; such information is not made public.

7.6 Limitations: returning to the open data rubric and the violations pipeline

The open data rubric and the violations pipeline dovetail in important ways for considering the limitations of this study. Together, they represent part of what is unknown and unrepresented by the data. The violations pipeline demonstrates the many opportunities for pollution to avoid detection or enforcement, thus going unrepresented in my final dataset. Meanwhile, the provinces' overall grades from the open data rubric demonstrate the collectively poor and variable data quality about those few observations that do make it through the pipeline. The result is an incomplete and inconsistent picture of pollution, violations, and enforcement actions within and between provinces. Consequently, it is impossible to know whether counts or patterns in my results represent the true extent of enforcement in a province. If my results do not accurately represent reality, it is difficult to determine whether that is because of data issues, failure to detect violations, failure to enforce violations, widespread compliance, etc.

Only for a few cases, like the observations of Imperial Oil in Sarnia, do we have a more complete picture of the pollution, its disproportionate effects on communities, and how enforcement (failed to) address the problem – a fuller sense of the violations pipeline. It is worth re-emphasizing that for such rare observations in Canada, knowledge like this is painstakingly gathered by activists, journalists, NGOs, and academics, compiled over several sources. In the US, these kinds of insights and analyses are based on data that is publicly available from ECHO. Just as it is a question of whose responsibility it is to detect violations (community members through public complaint or enforcement officers), it is a question of whose responsibility it should be to compile and publish this kind of information.

Ultimately, the lack of information about the violations pipeline and disjunct data availabilities frustrate explanations for trends in enforcement and render me unable to answer the core question: "Is enforcement 'working' in Canada?". My results should only be interpreted as trends in a given direction, within the bounds

of my dataset; supporting the notions that data quality is poor, governments employ a cooperative approach, enforcement outcomes do not reflect environmental priorities, and that there are inequities in EJ metrics between enforcement areas and provincial averages. The results should not be interpreted as defining any degree to which those conclusions may be accurate beyond the extent of my dataset, which, as demonstrated, suffers from gaps and poor data quality. Furthermore, these suggested trends do not sufficiently speak to whether enforcement is “working” in Canada: whether enforcement deters violations and how the landscape of pollution and population health is impacted by it. Again, these are functions of the unknown violations pipeline.

While the sources of gaps and where observations fell off in the violations pipeline cannot be known within the scope of this study, thinking about where gaps occur can help illustrate where root problems may exist. The following four extremes represent hypotheticals, where different concepts are either totally complete/present or totally missing:

Table 36. Scenarios for outcomes of missingness

Scenario name	Complete/present	Missing	(Harmful) Pollution	Explanation/Outcome
Weak Enforcement	Data	Enforcement	Exists	Suppose my dataset is nearly complete and represents the majority of enforcement actions against point-source, ground-level air pollution in the jurisdictions studied. In that case, enforcement rates appear exceedingly low, especially for offenses of interest. Consider, for example, that for the entire study period of 20 years, the federal government of Canada successfully prosecuted one case, while BC enforced 1000 burn offenses.
Poor Data	Enforcement	Data	Exists	Suppose my dataset is nowhere near complete, and there are many multitudes more enforcement actions to be found across provinces. In that case, government transparency and regard for the community right to know is lower than previously discussed. However, this is potentially positive for environmental outcomes, depending on how this unknown enforcement is allocated (if it is going towards high-risk offenses).
Permission-to-pollute Government	Data and enforcement	(Sufficiently strong) Policy	Exists	Suppose both my dataset and enforcement are complete (most if not all noncompliance is enforced). In that case, an explanation for gaps in my dataset is that air pollution policy is permissive. There is little, if any, pollution proscribed as “noncompliant,” and therefore, there are few violations to enforce. However, this is environmentally problematic, as pollution continues and is unabated by policy.
Responsible Emitters	Data and enforcement	(Sufficiently strong) Policy	Does not exist	Suppose both my dataset and enforcement are complete. In that case, another possible explanation is that policy is missing, but that policy is not necessary to manage air pollution because (harmful) air pollution does not exist. That is, policy-makers do not need to manage emitters because emitters intrinsically or for non-regulatory reasons manage their own emissions and ensure they only emit “healthy” levels of pollutants.

Through the literature and my results, I believe some combination of the first three scenarios to be most likely – that enforcement itself, data about enforcement, and sufficiently strong policy are all missing to some degree. To what degree they are missing – and therefore exactly how low enforcement rates are, how lacking is government transparency and regard for the community right to know, and how much of the pollution we experience is actually illegal – I cannot determine. Future research, and future improvements in government data availability, may serve to answer these questions.

7.7 Comparison to the US

Many of the key comparisons between my dataset and the US have already been discussed in context, notably the relative strengths of the EPA's ECHO database and how its comparatively high quality has facilitated the community right to know and numerous academic studies, including the work of Konisky and colleagues. In Box 2, I compared the penalties issued to a few companies in Canada and the US, noting substantially higher fines were issued to these companies in the US. I continue that discussion of differing penalties here, alongside one of federal coordination. Finally, the limitations of using the US as a model are outlined.

As noted in Box 2, for just a few prosecutions of point-source air pollution offenses in the US, the EPA levied fines totaling \$14 million USD in civil penalties (much more if including other types of penalties). Taking only the civil penalties from the EPA's eight most recent point-source air pollution prosecutions into account, occurring between December 2019 and January 2021, these fines total over \$17 million USD. Compared to my dataset, where the fines total \$16,277,516 CAD across 2,217 observations, the EPA is clearly willing and able to secure far more dollars per enforcement action than jurisdictions in Canada. Since the average fine for non-individuals in my dataset is \$28,525.97 (Table 29) and the average fine for these eight non-individual offenders in the US is \$2.15 million, the EPA has fined this group on average 75x more than jurisdictions in Canada. While the CAA fines are much higher than those in Canada, it remains necessary to put them into the context of the revenues of violators. Dow Inc. was fined \$3 million USD in 2021, which was mentioned in Box 2 and was added to the aforementioned total \$17 million USD calculation. This \$3 million USD fine amounted to 0.007% of their 2020 revenue, proportional to a \$439.35 CAD fine for the median-income Canadian (Dow Inc. n.d.; S. C. Government of Canada 2021). So, this is a somewhat notable proportional increase, but again, it should be examined whether even the higher fines in the US deter noncompliance relative to whatever gains Dow (and others) may attain by polluting.

Another notable strength of the US approach is its ability to coordinate enforcement across state lines. Many of the cases mentioned in Box 2 and among the eight most recent point-source prosecutions were not violations based on single-facility pollution events, but involved noncompliance across the parent company and its facilities in multiple states. As Galli, Robertson and Collins (2019) point out, examining firms at the company level rather than the facility level is instrumental for detecting systematic noncompliance and pollution trends. Because Canada has delegated environmental enforcement to provinces, which appear to be mostly siloed in their approach, Canadian governments are missing the opportunity to coordinate effective enforcement in such a way. The presence of cross-provincial offenders suggests a utility for a stronger federal approach, or at least, increased coordination among provinces, in order to address firms that violate laws in multiple provinces. OMR offenders like those that are cross-provincial offenders and also NPRI top 20 polluters (Table 32) present a further incentive for this coordination since these polluters are theoretically toxic outliers. Enforcement agencies may already internally collaborate on specific enforcement actions; however, I saw no evidence of this. It appears that the primary focus of cross-province coordination is the AQMS.

Cross-state coordination, higher fines, and even improved data are perhaps just manifestations of the core strengths of the American treatment of air pollution: regulated under the comprehensive and binding CAA, enforced with a direct approach, and administered by the federal EPA. As noted previously, each of these core strengths is fundamentally different from their Canadian counterparts. In Canada, there is no such federal Clean Air Act, the ECCC is much weaker than the EPA, and as the results of this study have further supported, the enforcement approach appears to be cooperative. We cannot establish causality between any of these foundational features and enforcement outcomes, especially on the Canadian side, where we have less data, but it is worth considering insofar as Canadian governments may want to improve their enforcement performance and look to American models to do so. Still, the ongoing problems in the US with environmental injustice,

incomplete data (although better than Canada's), low compliance, and more indicate that governments and future research may study strategies adopted in other jurisdictions to further improve upon the enforcement model.

7.8 Recommendations

In this section, recommendations are offered for improvements to enforcement strategies with respect to policy systems and enforcement resources. Further research opportunities are also suggested.

Konisky et al. (2021) make the point that enforcement agencies “possess the necessary levers [to] set priorities, invest resources, and adjust stringency,” which grants them a significant degree of power over how enforcement strategies are made to align with environmental priorities. Many potentially impactful adjustments can be made within the scope of existing policies and existing or moderately increased budgets. A few are described as follows:

1. Make “monitoring” and “reporting” mutually inclusive. As hinted by the separate nature of the “Notification” and “Monitoring” keywords, it is true in at least BC and AB, and possibly other provinces as well (although not enough information about enforcement is provided) that in many cases, companies are required to monitor their emissions, but not report them to regulators. Monitored data is essentially just for the company's own information purposes. For example, in BC's sawmill regulations, only 39% of authorizations/permits include a requirement to report the monitoring data to enforcement agencies regularly (British Columbia Ministry of Environment and Climate Change n.d.). Rewriting permits when they are renewed to increase this proportion to 100% - all monitoring data must be submitted to regulators – could be a relatively simple fix to increase the number of violations detected by enforcement agencies, although this data is still self-reported by firms.
2. Conduct random inspections (instead of, or in addition to, planned inspections). As Zou (2021) notes, scheduled inspections give firms the opportunity to “game the system” and intentionally save higher-polluting operations or behaviors for days where firms are not inspected and/or monitored. Random inspections will help to observe firms on an “average” operational day over the long term and have a better chance at identifying noncompliance where it may exist.
3. Increase administrative penalties. While some agencies are bound by low maximums for how much a penalty for a given offense can be – and changing this limit is a policy question – agencies generally should use this tool more frequently. By design, it is supposed to be less onerous than court prosecutions, yet in most provinces, they are not used as often as is possible. This tool/approach offers an opportunity to levy at least more fines for violations, although these financial penalties may not be sufficiently high to achieve deterrence.
4. Standardize the information shared about enforcement actions, including basic elements of the event: namely, the “who, what, when, where, and what was done about it” of a violation. Enforcement agencies should consider the following format for reporting, some parts of which may require additional resources, but the basic format should be accessible with minimal investment. This should be delivered tabularly but also described in summaries for cohesiveness. The following is a very basic iteration but would vastly improve many, many observations currently in government datasets. This recommendation could be further enhanced with additional features, which will be outlined in the next section.
 - a. X noncompliant event occurred (releasing Y quantity of Z pollutant into the atmosphere where applicable). The violation occurred at lat, lon, in the town of B, Province, on C date. By allowing it to occur, D party is in violation of E policy/permit, which outlines F terms. Accordingly, G enforcement action was taken on H date.
5. Focus on high-risk offenses, especially toxic outliers (Alm 2014; Collins 2012; Collins, Munoz, and JaJa 2016; Collins 2011). Depending on resources, certain high-risk groups can be selected, such as repeat offenders, cross-provincial offenders, facilities near vulnerable communities, etc. Toxic outliers should undoubtedly be included and an object of focus. “Focusing” here means allocating enforcement resources and adjusting the enforcement approach. A higher frequency of inspections (that are random, not planned) should be allocated to these facilities. When found to be

noncompliant, they should receive more “direct” enforcement strategies – fewer warnings and letters, more orders, tickets, and administrative penalties (prosecutions are preferred but require more resources). As Cohen notes, not all compliance is equal in terms of environmental outcomes, so where the cooperative approach is allowed to persist, it should be reserved for noncompliance that has less of an effect on environmental outcomes (such as submitting reports slightly late).

Other changes, namely those that increase enforcement outright and improve data collection and sharing, will require increasing resources for enforcement but can still operate within existing policy systems. Some of these are described as follows:

1. Continuously monitor facilities. One of the key methods for detecting violations (without relying on facilities self-reporting or calculating [rather than directly measuring] emissions) is to implement continuous monitoring systems which automatically report emissions to enforcement agencies (Giles 2020). While firms should be responsible for the costs of installing and running the systems, agency resources will be needed to review the data from these systems and enforce violations accordingly. Depending on resources available, enforcement agencies could stratify priorities for continuous monitoring, such as toxic outliers or other high-risk groups.
2. Create a Canadian ECHO, or alternatively, publish and improve NEMISIS and provincial datasets. Ideally, perhaps as a part of the AQMS, the federal government would coordinate and publish all enforcement data from across the provinces in a standardized and usable format, like ECHO. Alternatively, all datasets currently behind FOIPOP barriers should be published, and all datasets (including those currently public) should be improved according to the data rubric. Such improvements must intersect with the NPRI data so that enforcement data is connected to emissions. Suggestions are offered below for reporting observations in a standardized way with additional justice and public interpretation measures.
 - a. X air pollution event occurred, releasing Y quantity of Z pollutant into the atmosphere (**insert links to information from local knowledge holders about pollution events where applicable, peer-reviewed studies, and public communications about health effects of said pollutant**). The violation occurred at lat, lon, in the town of B, Province, on C date, **which is near J vulnerable communities (links to an EJSCREEN-type system and resources from and for those communities where applicable)**. By allowing it to occur, D party is in violation of E policy/permit, which outlines F terms (insert links to the section of the Act or permit). **D party has violated F terms on K occasions in the past (insert links to past violations)**. Accordingly, G enforcement action was issued on H date (**links to a legend describing different types of enforcement actions and what they are typically used for, etc.**).
3. Transition to a direct approach for enforcement. Many of the aforementioned recommendations are perhaps suggestive of a shift towards a more direct approach for enforcement, but it is worth saying on its own. Insofar as counterparts who employ a more direct approach like the US have witnessed greater improvements in pollution reductions (Harrison 1995), and the cooperative approach seems to be failing to specifically or generally deter violators in my dataset, it is worth considering what a more direct enforcement model would look like in Canada. This would likely be most effective under a more aggressive application of CEPA, but provinces may independently increase fines and apply stronger enforcement actions while decreasing their use of warnings and letters in order to signal a new approach.

All of the above recommendations work within the existing policy systems, starting from the premise that compliance with existing policies is sufficient to meet environmental goals: “if every facility is meeting its obligations and following the rules, we have a good chance of achieving clean air and reducing our risk of exposure. If they aren’t, we don’t.” (Giles 2020). Giles said this of the US and American policies, but I am skeptical of this being accurate in the Canadian context based on the violations pipeline and the “permission-to-pollute government” scenario (subsection 7.6). Given the lack of binding air quality standards in Canada (and notable industry exemptions in places they do exist, like Ontario), it is theoretically possible to enforce most noncompliant pollution, achieve high specific and general deterrence against noncompliance, and yet still, have

a significant air pollution problem, because arguably, too much pollution is permitted under extant laws. If this is true, then improved enforcement can deliver environmental gains but is intrinsically limited to the extent of the policy it enforces. As such, enforcement cannot make up for poor policy, and thus policy reform is the most important tool for improving compliance and environmental outcomes. A few policy recommendations are offered:

1. Minimum enforcement actions. Implementing minimum “sentences” or enforcement actions for various offenses may be an effective strategy to strengthen the cooperative approach systematically. For example, it could be a part of legislation or regulations (not just within provinces’ flexible enforcement guidelines) that repeat offenders receive a limited number of warnings or letters before more severe enforcement action is taken. To extend this idea further, certain violations or thresholds of violations could have automatic penalties associated with them. As another example, Excess emissions violations where the emissions limit was exceeded by 50% or more automatically receives an administrative penalty. Having such rules included in laws or regulations, rather than flexible enforcement guidelines, is critical for their implementation.
2. Strengthen CEPA, including the right to a clean and healthy environment. While it can be argued that the core potential of CEPA already exists and simply has not been realized (Wilkins and MacDonald 2009), it seems that an update that builds compliance and human rights into the policy intrinsically is a preferred route. First and foremost, the CAAQS must be made legally binding, with adequate policy infrastructures to support it. Per Giles’ (2020) suggestions, an update to CEPA should include rules that make compliance (with binding CAAQS and other rules) the default, like continuous monitoring and requirements for best available control technologies. Per Fitzgerald and Spencer (2020) and Boyd (2015), the right to a clean and healthy environment should be included in CEPA (although this is less powerful than a constitutional right to the same). This right would impose obligations on the federal government to protect human rights from pollution, give people the power to interact with enforcement and pollution in a more just way, with the standing to take legal action, rather than the current system of the public being burdened with detecting violations and then agitating for agencies to act on them, but having little real recourse through this process.
3. Strengthen ECCC or establish an independent agency for investigating and enforcing environmental laws and regulations. As discussed, the EPA is an essential agency for administering and enforcing the CAA. If CEPA is expected to be a stand-in for a CAA equivalent (another suggestion might be for Canada to create its own CAA, which may be necessary if CEPA cannot be sufficiently bolstered and expanded as proposed), it needs an effective, powerful agency to enforce it and deliver data about its administration. ECCC could play a role similar to the EPA if its jurisdiction and resources are significantly expanded.
4. Create an office dedicated to EJ. This could flow from proposed legislation to address environmental racism in Canada³⁰ if passed and would ideally maintain a database not only of environmental racism in Canada as proposed in Bill C-230 but also a database of how that racism interacts with enforcement actions and violations. Such a database should be created and maintained in collaboration with communities, towards just, open data.

Finally, recommendations for future research have been posited throughout, but I will offer the most logical next steps, in my view:

1. Integrating my results with pollution data. One of the most critical missing pieces from my research, and therefore next steps, is to compare the landscape of enforcement actions to the landscape of where emissions are actually occurring. This will help provide additional information about the violations pipeline and assist in evaluating deterrence and environmental outcomes. Doing so is possible through three primary avenues:

³⁰ Bill C-230 proposed the increased documentation, identification, and monitoring of EJ issues in Canada, alongside improving participation of EJ community members in decision-making (Lee and McLeod-Kilmurray 2021)

- a. Add the emissions data from facilities that report to the NPRI to my dataset. This would connect emissions data to enforcement data and in a limited way, make my dataset more like ECHO. For the corporate operations in my dataset that report to the NPRI, the emissions history of each of those facilities could be added, which would allow for much more comprehensive research and analysis. However, this is limited to a small subset of my dataset (Table 29) and only includes self-reported emissions – not cumulative emissions across facilities, where pollution is distributed by wind, waterflows, etc.
 - b. Compare enforcement data to air quality monitoring and modeling data. This is a more time-intensive approach but yields more complete results in that it considers the distribution of pollution resulting from emissions and can include a much broader subset of the dataset (not only NPRI reporting facilities), depending on the methodology.
 - c. Incorporate information on the toxicity of emissions to assist in identifying priority targets for increased enforcement, as is routinely done in the US (in the form of RSEI models).
2. Conduct interviews. This research is missing the perspectives from several stakeholders and could be bolstered with such qualitative research. These may include interviews with community members (to investigate the role of the public in driving enforcement actions, how pollution and enforcement are experienced [or not] in different areas, etc.); with business representatives (about their perspectives on the compliance landscape, how the threat of enforcement actions impacts their operational decision-making, what their relationship looks like with relevant enforcement agencies); and/or with public servants (about how resourcing and enforcement priorities are allocated within a given agency, why, etc.).
3. More analysis with environmental justice. Many dimensions are possible with environmental justice, including comparing EJ communities' toxicity analysis and exposures to enforcement actions, or the severity of enforcement actions in EJ communities as Mennis (2005) did, examining the rural/urban divide of my results as mentioned, and more. Further analysis is possible within my dataset (without necessarily requiring more data collection), such as considering the breakdown of provinces, keywords, offender types, etc., against EJ variables.

7.9 Conclusion

This study successfully addressed its research questions, which could, and should, be expanded upon by further research.

First, to RQ1, “How do enforcement data availability and quality vary between and within provinces?” I found that data varies widely but is consistent across jurisdictions in Canada in that it is low quality, incomplete and for the most part very difficult to access. These critical shortcomings violate the community right to know. The weaknesses of data in Canada are especially pronounced compared to the US EPA’s ECHO system, the strengths of which have contributed to the robust studies of Konisky and colleagues, which serve as the foundation and inspiration for this work. Several recommendations are offered for improving Canadian data systems towards just, open data.

For RQ2, “What are the demonstrated models of enforcement? How do they vary across jurisdictions, time, or other factors?” I found that jurisdictions appear to consistently apply a cooperative enforcement model, with some variation over time and between jurisdictions, but practically speaking, this variation was negligible. This was demonstrated by enforcement agencies consistently issuing low (or no) fines (despite the ability to issue higher ones), rare court convictions, frequent use of low-level penalty types, and a seeming lack of escalating enforcement actions for repeat offenders. Previous literature suggests that the cooperative approach to enforcement is less effective for environmental outcomes compared to more direct models (Harrison 1995; 1998; Harrison and Antweiler 2003). Because of the extensive data weaknesses emphasized by the violations pipeline, I cannot connect pollution data to enforcement data. Therefore, it is not possible to assess whether/how the cooperative approach I observed impacts pollution outcomes, unlike this previous literature. Future research may address this gap.

To RQ3, “What types of violations or offenders appear to be prioritized for enforcement action in Canada?” I found that the majority of enforcement actions observed have been issued to individual-level offenders and burning violations. Because of the small scale of these types of offenses, I generally assume that

they are a lower risk for environmental and human health. By contrast, high-risk offenses (those committed by repeat offenders, reporters to the NPRI, facilities in the top 20 most polluting in each province by volume, cross-provincial offenders, and those emitting criteria air contaminants) comprise a minority of offenses. This apparent focus of enforcement actions against low-risk offenses represents a misalignment of enforcement outcomes with environmental priorities. Again, because of the data shortcomings reflected by the violations pipeline, I cannot determine whether this malalignment is also reflected in environmental *outcomes* (rather than just priorities).

Finally, to RQ4, “How are the sociodemographic characteristics of areas in which enforcement actions occur different from the provincial averages of those characteristics?” I found that patterns in enforcement within my dataset do reflect environmental justice variables, but in somewhat different ways than similar studies in the US (Konisky 2009) and not all EJ groups were represented. Namely, areas where enforcement actions occurred appear generally whiter but more socially deprived, poorer, and had higher proportions of females. Insofar as the communities’ experiences of enforcement observed in this study may be different from experiences of exposure, the double burden hypothesis may be supported. However, this is uncertain, as I cannot determine where enforcement actions are *not* occurring, which is important to investigate within the double burden hypothesis. Accordingly, my research should be expanded upon with additional data from the violations pipeline and facilities’ performance records. Additionally, I discuss the substantial role of public complaints and enforcement in known EJ communities like Sarnia, ON as concerns for EJ in this study. Ample opportunities exist to expand the environmental justice dimensions of this research and should be explored.

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Appendices

Appendix A Data sources

A.1 Jurisdictions with publicly available databases/datasets

British Columbia

Source type: publicly available database, supplemental materials to search database

Source format: tabular (HTML) (supplemental long-form PDF files)

Enforcement date range: 2006-present

Information included in observations: offender name, date, general location, a summary of the offense, type of enforcement action taken, issuing agency, applicable legislation, penalty details, and documents attached (a PDF file of the offense, for example).

Penalty types included: Administrative Penalty, Court Conviction, Information Order, Pollution Abatement Order, Pollution Prevention Order, Restorative Justice, Ticket, Warning (additional processing required to access Administrative Penalties and Warnings)

British Columbia (BC)'s Ministry of Environment and Climate Change Strategy manages the Natural Resources Compliance and Enforcement Database (NRCED). Variables can be searched through advanced filters by keyword, date, offender type (company or individual), type of enforcement action, and the relevant act or regulation(s). The database is updated in nearly real-time, with the most recent posted enforcement action typically occurring less than a week prior. The current NRCED platform does not allow for CSV downloads of search output, so I contacted the NRCED's data manager, who sent me a CSV version, upon which I then performed the operations described in subsection 3.1.2.1.

After filtering output from NRCED (per subsection 3.1.2.1), it became clear that the NRCED yielded extremely low counts of administrative penalties and warnings, relative to other types of enforcement actions. Per contacting the data manager of the NRCED again, they provided additional inspections data CSV files (from 2017-2020, in addition to some posted on a separate web page from 2015 and 2016) and suggested using the record numbers contained in the inspections data to search observations within the NRCED; effectively cross-referencing observations identified by inspections data as air-pollution-relevant, with the greater details found in the NRCED. In other words, the NRCED does have the raw data about AMPs and Warnings, but they are not marked as such in the NRCED (they are marked instead as "inspections"), which made them impossible to find or filter out via the processes described in subsection 3.1.2.1; they were only discoverable by cross-referencing CSV files from the data manager. Our undergraduate staff member, Sophie Thornton, read the inspections PDF files attached to each of these observations in the NRCED, extracted the sections marked as "out of compliance," and copied them into the "summary" section of each newfound administrative penalty and warning observation. I then performed the coding operations described in subsection 3.1.3.

Alberta

Source type: publicly available datasets (Prosecutions, Orders, and Enforcement Actions Quarterly Reports [EAQRs])

Source format:

Prosecutions: long-form (HTML and court document PDFs)

Orders: long-form (PDF)

EAQRs: tabular (PDF)

Enforcement date range:

Prosecutions: 2015-2021

Orders: 2012-2020

EAQRs: 2002 – present

Information included in observations:

Prosecutions: description of the offense, offender's name, offense and court dates, Acts allegedly contravened, and links to court documents and news articles

Orders: varied depending on the order, but usually contained: offender name, date, a summary of the offense, issuing agency, applicable legislation, and terms of the order

EAQRs: offender's name, the municipality and legal land description, decision date, legislation, summary of the offense, and penalty type

Penalty types included: Administrative Penalty, Court Conviction, Enforcement Order, Environmental Protection Order, Open Court Proceeding, Ticket, Warning

Alberta (AB)'s Ministry of Environment and Parks manages a database of Enforcement Actions Quarterly Reports (EAQRs), Orders, and Prosecutions. These can be found through the "Environmental compliance enforcement" branch of the Environment section of the Government's website.

Both open court proceedings and closed prosecutions are posted on this site. I saved information about prosecutions formatted as text on the website or in court document PDFs and later processed it per subsection 3.1.2.2.

Orders and EAQRs are hosted on the Government's Open Data portal, which houses data and files across ministries. In the case of the Orders, the enforcement date ranges from 2012-2020. The attached PDFs on Order postings were Order documents issued to offenders. Accordingly, I clicked on and read all orders with the "environmental protection order" title and all where the Environmental Protection and Enhancement Act was the relevant act - avoiding those where the Water Act or Order to Vacate was in the title or the tagged Act, for example. I saved the PDFs from Orders and later processed them per subsection 3.1.2.2. Meanwhile, EAQRs have been compiled since 2002.. EAQRs were available as tabularly formatted PDFs. I manually copied the data from these into Excel documents, which were later further cleaned and analyzed per subsection 3.1.2.1.

Quebec

Source type: publicly available datasets (Register of Convictions and Administrative Monetary Penalties Register [AMPS])

Source format: tabular (ASP)

Enforcement date range:

Register of Convictions: 2009 – present

AMPS: 2012 – present

Information included in observations:

Register of Convictions: enforcement date, offense date, municipality affected, administrative region, name of the offender, offender's address and municipality (this is not necessarily where the offense occurred), fine imposed, prosecution costs, law/regulation and article, a summary of the offense, and additional comments

AMPS: enforcement date, offense date, municipality affected, administrative region, name of the offender, offender's address and municipality (this is not necessarily where the offense occurred), administrative penalty imposed, prosecution costs, law/regulation and article, a summary of the offense, and additional comments

Penalty types included: Fine (Register of Convictions [different types of convictions, i.e., tickets or court convictions, are not marked]) and Administrative Penalty (AMPS)

Quebec (QC)'s Ministry of the Environment and the Fight against Climate Change manages a series of Public Registers. The Registers provide information on the implementation, activities, monitoring, status, and more related to the Environmental Quality Act, the Pesticides Act, the Dam Safety Act, or the Natural Heritage Conservation Law. For the purposes of this research, I utilized two registers to search for data: the Register of Convictions and the Administrative Monetary Penalties Register (AMPS). All Registers can be found through the Government of Quebec's website. I used Google Translate and DeepL to translate web pages from French to English when text was only presented in French.

The Register of Convictions publishes information on convictions for violations of the four aforementioned Acts and Laws, plus the Endangered or Vulnerable Species Act. The enforcement date ranges from November 4, 2011 - present, with weekly updates to the register itself, plus hyperlinked PDFs to conviction information from May 5, 2009 - November 3, 2011. The register has a simple and advanced

search/filter tool, allowing one to search by the name of the offender, municipality where the offense was committed, administrative region, date range, law, and statement of offense number, although these filters occasionally did not function properly during my research. The Register is published as an ASP (Active Server Page), which I saved as a series of PDFs in their English translations for my usage.

The Administrative Monetary Penalties Register (AMPS) publishes information on the administrative penalties imposed by the regional directors of the Center de Contrôle Environnement du Québec (CCEQ). The register's enforcement date ranges from February 1, 2012 - present and is updated monthly. There is a similar simple and advanced search/filter tool as in the Register of Convictions, but the AMPS features the addition of a keyword search within the "Comments" column of the register. Again, the AMPS is published as an ASP, which I saved as a series of PDFs in their English translations. I processed the PDFs from both registers per the processes in subsection 3.1.2.1.

New Brunswick

Source type: publicly available dataset

Source format: tabular (HTML)

Enforcement date range: 1999-2013

Information included in observations: offender name, general location, enforcement date, and a summary of the offense, and in the cases of Administrative Penalties and Court Convictions, the offense date and fine imposed

Penalty types included: Administrative Penalty, Court Conviction, Order

New Brunswick (NB)'s Ministry of the Environment and Department of Environment and Local Government manages a collection of web pages within the Government of New Brunswick's main website, including information about guidelines, various dimensions of air quality and emissions in NB, NB's Clean Air Act (1997), and more. Within the Clean Air Act sections of the website, there is a Public Register Information page, which includes a link to the administrative penalties, court convictions, and orders issued to offenders within the province, tabularly formatted across HTML pages. Some offense summaries were not sufficiently detailed and required contacting NB public servants for more information. Public servants were able to clarify these observations and also provide a few additional, more recent observations since the website has not been updated since 2013. Data was processed per subsection 3.1.2.1.

Federal

Source type: publicly available dataset

Source format: tabular (CSV and HTML)

Enforcement date range: 2006-2021

Information included in observations: specific location, act, section, offense date, enforcement date, offender name, offense summary, penalty type, fine imposed

Penalty types included: court convictions

The Environmental Offenders Registry is a database of **convictions of corporations**³¹ that violated federal environmental laws, managed by three federal departments: Environment and Climate Change Canada (ECCC), Fisheries and Oceans Canada, and the Impact Assessment Agency of Canada. Users can export the full database to an Excel file or use it online with various filters by keyword, Act, Regulation, sector or industry, province/territory, nature of the offense, and date range. I filtered by date range (2000-2020) and by Act

³¹ Critically, the Environmental Offenders Registry only houses convictions of corporations - no lesser enforcement actions like administrative penalties, warnings, tickets, etc. Instead, these lesser actions are aggregated by instrument under CEPA and compiled in the CEPA Annual Reports, which date from 2001-2020. In the "Enforcement Activities" section of these reports, there are tabular summaries of the inspections, investigations, enforcement measures, prosecutions, tickets, and Environmental Protection Alternative Measures (EPAMs) carried out under each instrument for that year. Because the enforcement actions are aggregated at the instrument level, I was not able to add them to my dataset.

(Canadian Environmental Protection Act), then by keywords listed in Table 2, and extracted relevant observations according to subsection 3.1.2.1.

A.2 Jurisdictions without publicly available databases/datasets

Ontario

Source type: alternative sources (Newsroom, Environmental Penalty Annual Report, CanLII)

Source format:

Newsroom: long-form (HTML)

Environmental Penalty Annual Report: tabular (CSV)

CanLII: long-form (HTML)

Enforcement date range:

Newsroom: 2011-2020

Environmental Penalty Annual Report: 2011-2020

CanLII: wide range, but only included observations from 2000-2012

Information included in observations: varies widely amongst observations but generally includes offense date, enforcement date, offender name, and offense summary

Penalty types included:

Newsroom: Court Conviction, Order, multiple

Environmental Penalty Annual Report: Administrative Penalty

CanLII: Court Conviction

While relevant data sources exist in Ontario, they are protected by FOIPOP and have projected lengthy turn-around times for FOIPOP requests. To avoid unattainable FOIPOP requests but still acquire data, I garnered observations from alternative sources. My main source was the Newsroom platform on the Ontario government website (published outside of the Catalogue), particularly the subsection of Bulletins and Court Bulletins. Second, I used the Environmental Penalty Annual Report (2020), posted on the government's Open Data Catalogue. Finally, I supplemented these by using CanLII.org (the Canadian Legal Information Institute), a database of legal cases, legislation, and commentary from across Canada, to find additional observations. I communicated with multiple public servants in the Ontario government in an attempt to garner more data, with limited success.

To utilize the government news releases, I used the Newsroom website and its site filters to filter Bulletins and Court Bulletins pertaining to the Environment, Conservation, and Parks Ministry. I read all of the postings from the filtered page with "Environmental Management Act" or "O. Reg. 419/05" in the title or with similar keywords because these are the key law and regulation governing air pollution in ON. After reading the document, if the violation was relevant, I saved the news report as a PDF and later coded it as described in subsection 3.1.2.2.

The Environmental Penalty Annual Reports detail the administrative penalties collected from select industrial facilities for certain types of environmental law violations. Prior to July 1, 2019, the scope of Environmental Penalties was quite limited and did not contain any (directly) air-pollution-relevant violations (mostly water and land pollution). However, "starting on July 1st, 2019 environmental penalties could also be issued to petroleum facilities for violations of sulphur dioxide air limit exceedances, after amendments were made to O. Reg. 530/18 (Air Pollution - Discharge of Sulphur Dioxide from Petroleum Facilities) and O. Reg 222/07 (Environmental Penalties). The first year that environmental penalties were issued for these violations was in 2020" (personal correspondence). Accordingly, I extracted additional observations from the 2020 Environmental Penalty Annual Report using the process described in subsection 3.1.2.1.

Within the Ontario segment of the CanLII database, I used several search terms to filter legal cases that might pertain to enforcement actions on air pollution laws. These included "Environmental Protection Act," "emissions," "air," "gas," "dust," "nitrogen," "carbon," "sulphur," "particulate," or "pm." I sorted results by relevance (which counts the number of times any combination of these terms appears in a document and the

highest counts appear first) and read those that occurred in the time frame of this study: 2000-2020³². Several were already counted by the News bulletins, and thus I did not re-record those observations, but I did find some from before 2011 (not captured by the News Bulletins) and downloaded those legal documents as PDFs. I coded them as observations per the process described in subsection 3.1.2.2.

Saskatchewan

Source type: alternative sources (FOIPOP request, News and Media reports)

Source format:

FOIPOP: tabular (multiple PDFs)

News reports: long-form (HTML)

Enforcement date range:

FOIPOP: 2001-2018

News reports: 2015

Information included in observations: offense date, enforcement date, act, section, fine imposed, offense summary, offender name, general location

Penalty types included: Court Conviction, Fine, Long-form Information

The Government of Saskatchewan has a News and Media platform similar to the Ontario platform, with the ability to filter by ministry, year, and month. Filtering by the Ministry of Environment, I used webpage search functions to search the keywords enumerated in Table 2 for releases that may be relevant. Through this process, I was able to find two observations, which I saved as PDFs and later processed per subsection 3.1.2.2. Because of this dearth of data, I contacted several public servants in Saskatchewan through phone and email to ask where I could find the appropriate information, who eventually directed me towards submitting a FOIPOP request.

I submitted the FOIPOP request on November 24, 2020, and received the information back on March 2, 2021. My contacts in the government emailed me twice during that time to extend the time allowance for returning the request. Upon receipt, the response letter described the request as “partially granted.” As will be described in Chapter 4, the scope of the information received was quite limited³³. Because of the delay with which I received the information, relative to the timeline of my overall project, I judged that there was not enough time to appeal the request and ask for additional information. Further, there were several errors and unexplained abbreviations in the data I did receive, which required extensive further correspondence with public servants to clarify their meaning. I processed the FOIPOP observations with clarified information from public servants per subsection 3.1.2.1.

Nova Scotia

Source type: alternative sources (compiled by public servant)

Source format: tabular (CSV)

Enforcement date range: 2009-2020

Information included in observations: general location, act, section, offense summary, enforcement date, fine imposed (plus administrative categories like whether offender paid and records number)

Penalty types included: Ticket

³² I undertook a similar process for NB, NS, and SK, in an attempt to supplement data that suffers from obvious incompleteness, but I did so in those provinces more briefly, and thus did not find any additional observations there. With more time, it would probably be possible to find at least a few more observations from every province using CanLII, but it is a heavily time-intensive method to search for data, with relatively low return on investment.

³³ In an attempt to supplement the data, I tried to look into court documents from courts across the province, which would require another information request to obtain, albeit with a purportedly shorter return time. However, the format of the request was that users needed to provide the specific names of organizations or individuals to search for court documents about them (a blanket search about air pollution-related violations, where I do not yet know the offenders' identities, which I sought to do, would be impossible for this type of request). I also searched for court documents in Nova Scotia and Manitoba, with similar obstacles and outcomes.

The Ministry of Environment in Nova Scotia manages a small database of Compliance and Enforcement Actions on its website, but due to its insufficient detail about infractions, I could not use this resource. Accordingly, I contacted public servants, who directed me to other avenues to acquire data, including two different types of information requests, a FOIPOP application and an Environmental Registry search, which turned out to be prohibitively time-intensive and expensive options³⁴. Finally, a public servant generously compiled a spreadsheet of enforcement actions against individuals, which they sent to me for free. This spreadsheet accounts for all of my observations from Nova Scotia. I processed these observations per subsection 3.1.2.3.

Prince Edward Island

Source type: alternative sources (compiled by public servant)

Source format: tabular (PDF)

Enforcement date range: 2011-2020

Information included in observations: offense date, act, offender type, general location, penalty type, fine imposed, offense summary

Penalty types included: Fine, Long-form Information, Warning, NA

The Department of Environment, Energy, and Climate Action at Prince Edward Island does not have information online about its enforcement actions related to the environment, including air pollution. I contacted multiple public servants to ask where to find data, and one ably responded to my inquiries by sending me a dataset relevant to my request. I exported the original PDF format into a CSV file, then processed it according to subsection 3.1.2.3.

Newfoundland and Labrador and Manitoba

For both Newfoundland and Labrador and Manitoba, I could not obtain any enforcement action data, as these provinces do not maintain (public) records of this data.

In Newfoundland and Labrador, The Office of the High Sheriff manages a Judgment Enforcement Registry, a registry of court orders from across the province, but it did not provide any information relevant to point-source air pollution. To find data elsewhere, I contacted provincial public servants. One said they were “not aware of any registry or centralized location of enforcement action records related to air pollution,” and the Department of Environment, Climate Change and Municipalities “would have minimal, if any, records on enforcement actions for the larger industrial operations as it has generally been our Department’s view that such actions have not been necessary. Air quality surrounding such facilities are typically compliant with our ambient air standards, and when exceedances occur, they tend to be in areas of low public occupancy (e.g., facility fenceline) and thus do not pose a high immediate threat to public health. In those cases, our Department has taken a cooperative approach with the facilities to ensure that they develop and implement actions over time so as to progress towards full compliance” (personal correspondence). They gave me the contact information of the department tasked with less significant sources of air pollution, such as backyard burning, Digital Government and Service NL, but that contact did not return my emails. Hence, although I do not have any observations for Newfoundland and Labrador, we do have a glimpse into their enforcement approach that may help explain that absence.

For Manitoba, I could not find a database or alternative data sources of any kind on the Government of Manitoba’s website. They did not have a relevant dedicated database or set of raw documents posted anywhere on government websites, and FOIPOP return times were expected to be lengthy due to delays onset by the

³⁴ For each type of request, it is on a per-facility basis, and the two retrieve different types of records. Accordingly, I searched the companies that have reported to the NPRI in Nova Scotia from 2000-2020 in order to compile a list of facilities to submit for such a request, totaling 180 facilities. As one of my public servant contacts later told me, however, I would need to write a separate application for each of these facilities, for each type of request. For the FOIPOP request, doing so would total \$900 and for the Environmental Registry search, this would total \$4,770. Considering the significant monetary and time investments required to write each application, with no guarantee of returns of relevant observations, I decided against submitting these requests.

COVID-19 pandemic. Public servants did not respond to inquiries via phone or email. As a result, no enforcement data is presented from Manitoba.

Appendix B Intercoder reliability quality checks

Quality checks were conducted using a 15% subset of the total data for the province, which I randomly selected through a random number generator corresponding to observations' ID number.

The primary coder started by coding some variables in QC, AB, and NB, but because of high error rates, only some of the variables he coded were kept in the final dataset (specific locations in all three provinces and the number of violations in QC). Their error rate with several variables was unacceptably high (27%) but acceptably low with coding specific locations ($\leq 10\%$) and for coding the number of violations in QC ($\leq 10\%$). I recoded all variables with the high error rate. I determined that 10% was an "acceptably low" error rate, especially for locations, because of the difficulty of finding some locations (as described in *specific_location* below). It also took the most time to code locations of any of the variables; thus, accepting some errors was necessary for me to prioritize analysis. During the analysis and later usage, I detected and fixed several of the remaining errors that I had not earlier as part of the quality checks, resulting in me validating all of the remaining NB observations. Still, I am not sure I caught all of the errors in QC and AB, and thus some of their errors with locations may remain in QC and AB.

Similarly, we worked with a secondary coder through an undergraduate research class, and they coded some of the locations for Ontario (approximately 35 observations). Through my quality check of their locations (15%; 5 observations), their error rate was acceptably low (0%), and thus these locations were kept.