THE EVOLUTION OF WESTERN NORTH DAKOTA'S LANDSCAPE DURING THE 2008 BAKKEN BOOM

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Abstract

The western half of the rural state of North Dakota, located in the northern U.S. Great Plains, sits atop the Bakken oil formation, a sandwich-like structure consisting of two layers of shale with an oil-rich layer of dolomite in between. The development of hydraulic fracturing ("fracking") technologies led to a boom in the region from 2008 to 2014, during which residents expressed concern about the changes the landscape was undergoing. This thesis describes those changes. Chapter 1 begins by defining landscape as a socially produced space whose territorial configuration (the arrangement of structures within the physical environment) and semiotic configuration (the meaning people make of those structures) operate in dialectical tension with each other. It emphasizes the idea of roughness, borrowed from Milton Santos, who proposes the term to describe how people's interpretations of a site lead them to interact with and alter its structures, reshaping them in ways that, in turn, affect their subsequent interactions. Chapter 2 uses techniques of spatial data analysis, including kernel density estimation and variations of Ripley's *K* function, to describe the evolution of the territorial configuration of Williams County, near the centre of the Bakken, from the region's first boom in the 1950s to its most recent boom in 2008. It argues that settler conceptions of time and space as homogeneous, translated into policies and laws implemented by the U.S. government, created patterns that influenced choices about well placement during the 2008 boom. Chapter 3 uses techniques of text mining to describe the ways people made sense of these changes, as expressed in letters to the editor published in the *Williston Herald*, the region's largest newspaper, during and after the 2008 boom. It argues that the semiotic roughness, observable in expressions of conflicting opinions, smoothed out over the course of the boom, as routine set in and people grew more optimistic. In their concern for changes over time, both chapters describe different dimensions of the region's roughness, further synthesized in chapter 4, which concludes by asking how the region's territorial configuration might be read differently, if settler scholars and residents reimagine their relationship to time, space, and the landscape of the Bakken.

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Acknowledgments

There are many reasons to undertake a master's degree, but the most rewarding, I think, is curiosity. I have had the unusual pleasure of taking courses and earning a degree at a university where I am also a professor, and I am grateful. I want to thank:

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Preface: Why North Dakota?

I have spent a lot of time pondering this photograph, which I took in 2018. It shows a parcel of land about forty kilometres east of Williston, North Dakota, three hours by car from the geographic centre of North America.

It is a paradoxical picture, at least for me. The bottom right corner is dominated by a sign exclaiming "DANGER: AUTHORIZED PERSONNEL ONLY," while the print on the other signs is generally too small to read, except for words like *danger*, *caution*, *notice*, and *Whiting Oil & Gas Corp*.

What makes it paradoxical is that the signs, for all their sound and fury, do not apply to me or my family. They are at the top of a hill leading to pasture-land owned by my parents, held in common with uncles and aunts and a family friend (or their kids, as the members of my parents' generation pass away). I have spent my life wandering these hills, the surface rights to which my family bought in 1978, shortly after I was born. The signs are there because at the bottom of the hill there is a well, drilled (if memory serves) in 2016. (I include a picture of the well in chapter 2, figure 2.2.) Whiting Oil & Gas leases the mineral rights, which my family does not own, and the signs warn trespassers away. My family cannot prevent Whiting Oil & Gas from drilling, but neither can Whiting Oil & Gas keep us from wandering The Land (a place of such importance that my family capitalizes its name).

I have written about these signs before (Conway 2022, 2024) because they are paradoxical in more ways than one. Nowhere feels more like home than The Land. Sitting in my Ottawa basement, I can conjure up its summertime sweet-clover perfume or the cool, damp air down in the coulees, the tiny wooded draws between the rolling hills that were full of ash trees when I was a kid (before they were wiped out by ash borers about a decade ago).

Over time, though, my relationship with The Land has grown uneasy. I recognize that my family can lay claim to The Land only because it was taken from someone else. The signs in the photo create clear boundaries – beyond this point you may not pass! – but there are other signs that say "keep out," if you know how to read them.

Look closely, for instance, and you can see Lake Sakakawea, a silver triangle on the horizon, sandwiched between the earth and the sky. It is clearer in this photo, which I took in 2022:

The lake was created when the Missouri River was dammed in the 1940s, flooding the Fort Berthold Reservation, home to the MHA Nation, two hundred kilometres downstream. Now the lake is used for recreation in the summer. There is a restaurant on its western edge that makes juneberry pie that I go out of my way each summer to eat at least once.

Lake Sakakawea is a sign of exclusion, not too different from the warning signs in my photos. It exists because of a series of acts of displacement that happened before my birth – the Fort Laramie Treaty of 1851, the Homestead Act of 1862, the Pick-Sloan Missouri Basin Program in the 1940s – but whose effects are still very current. If they were merely past events, the signs in my photos would not be there. In fact, those events are preconditions for the presence of those signs now, the foundation on which the laws of land ownership in the United States are built. (It is worth noting that Lake Sakakawea was named after the Shoshone woman who served as a guide to Meriwether Lewis and William Clark, whose survey expedition was one of the first steps in the U.S. government's appropriation of the land.)

Another sign of exclusion is the crested wheatgrass (*Agropyron cristatum*) that covers the hills in my photos. It is the golden-hued grass in the foreground of my 2022 photo, to the left of the signs. It is a species well suited to ranching, introduced to prevent erosion after the native prairie grasses were removed. (And I am allergic to its pollen like nothing else!) In that respect, it, too, can be read as a sign, this time of settler presence, which is of a piece with the treaties, laws, and programs implemented by the U.S. government to encourage settlement of the American West.

The questions I raise in this thesis have their roots in the ambivalence I feel with respect to The Land, to North Dakota, to my decision a decade ago to emigrate to Canada – a lifetime spent asking, what is home? I understand at a gut-level the dismay people expressed about the effects of the 2008 Bakken boom on the region's landscape, even if my training helps me step back and ask what exactly was the nature of those changes and, more importantly, what were their conditions of possibility in the first place.

1. Introduction: Oil and North Dakota's Landscape

1.1. Problem statement: Western North Dakota's (lost) landscape

Beginning in 2008, the U.S. state of North Dakota, located in the centre of North America, experienced an oil boom during which cities and towns doubled or tripled in size. As the rest of the country entered a recession, advances in hydraulic fracturing ("fracking") and directional drilling allowed North Dakota to exploit the oil play known as the Bakken formation, which lay under the northwestern quadrant of the state, spilling into Montana to the west and Saskatchewan and Manitoba to the north (figure 1.1). It was not North Dakota's first boom (in fact, it was the third), but it was the biggest. Bakken oil is "tight," trapped in impermeable shale deposits difficult to reach with conventional drilling technology. Fracking, or the process of injecting a slurry of water, sand, and chemicals into shafts drilled horizontally through the oil-bearing shale layer about 2,500 metres below the surface (USGS 2013a), made extraction much easier and, while oil prices were high, very profitable. The boom lasted until 2014, when the price of oil fell too low for new wells to be profitable, although extraction did not slow as much as it did after earlier booms.

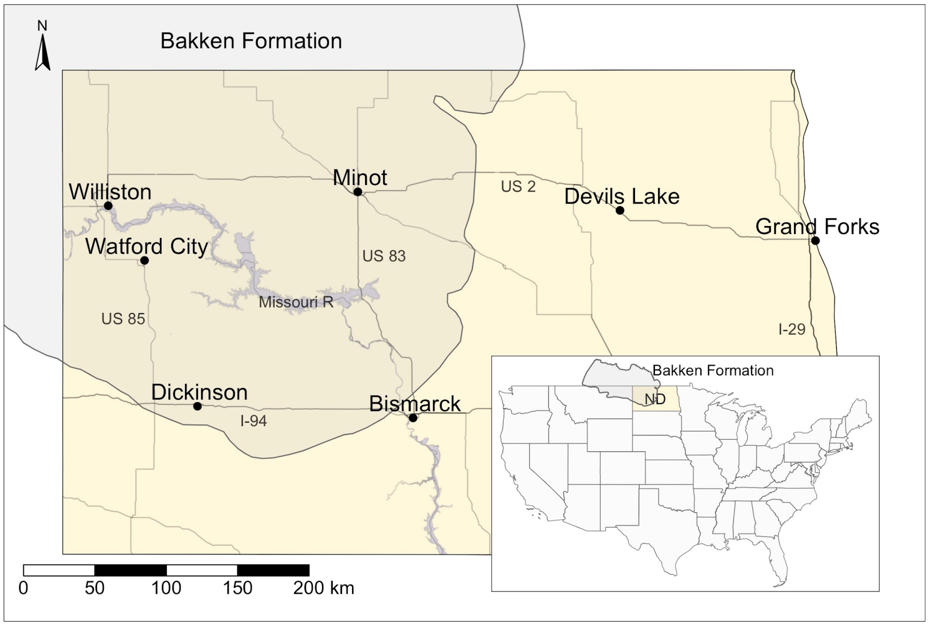

Figure 1.1. Location of the Bakken Formation in northwestern North Dakota. The economic centre of the 2008 oil boom was Williston, in Williams County. Data sources: NDIC Oil and Gas Division (2020), North Dakota GIS Hub (2020, 2023), U.S. Census Bureau (2018, 2023), USGS (2013b)

Many of the region's residents welcomed the economic development that accompanied the boom, but many thought that a place they loved was being lost. The region's largest newspaper, the *Williston Herald*, regularly published elegiac letters to the editor, whose authors worried about the destruction of the environment and the loss of their neighbours. As one wrote:

> The core of our towns is being lost because the locals simply don't want to live here anymore.
>
> They are leaving because the home they knew and loved is no more.
>
> They are leaving because they have lost their cherished lifestyle, their peace of mind, their safety – they have lost their western North Dakota.
>
> Those who had a connection to the land and loved it for all its natural beauty will understand what I'm talking about.

> I have discovered that many people from other areas do not relate to our fondness for solitude, wide open spaces, waving grass on rolling prairie hills and the quiet still darkness punctured by a coyote's howl, the hoot of a great horned owl or the whistling wings overhead from flocks of migrating ducks. (S. Ventsch, 2012)

Such sentiments were grounded in a contradictory sense of the landscape, however. On the one hand, letter-writers were nostalgic for a landscape that they thought was being lost. On the other, the landscape they evoked, with its "waving grass on rolling prairie hills" and its "quiet still darkness," reflected an ideal that was more myth than reality. Although the oil industry did in fact alter the landscape, it was not pristine before the boom, having been shaped by a century and a half of European settlement and large-scale agriculture, not to mention booms in the 1950s and 1980s.

What exactly, then, was the nature of the landscape during the 2008 boom, and how did it change? More to the point, how did residents themselves, as they interpreted the landscape and its contradictions and acted on their interpretations, influence those changes? These are the broad questions I ask in this thesis (questions that I reformulate more narrowly at the end of this chapter), focusing on Williams County and the town of Williston, from 2008 (the beginning of the boom) to 2019 (five years after the boom ended but while its impact could still be felt). In this introductory chapter, I describe the social context of the 2008 boom (sec. 1.2), which I then frame through the theoretical lens of the temporalization of space (sec. 1.3). My analysis itself is quantitative and interpretive, examining the landscape's evolving configuration and people's interpretation of it (sec. 1.4). I conclude by describing the blind spots of my theoretical framework, including its anthropocentrism and its settler epistemology, and the limitations of my method (sec. 1.5).

1.2. Social context: North Dakota's oil booms

Although geologists were aware of the presence of oil in North Dakota as early as 1916, the first successful well was not drilled until April 1951 (Robinson 1966, 458). The discovery of oil prompted the first boom, which lasted until 1954. Brad Rundquist and Greg Vandeberg characterize it, appropriately enough, as the "discovery boom." The second boom, which Rundquist and Vandeberg call the "oil price boom," took place in the 1980s, following the OPEC oil embargo of the 1970s. The 2008 boom – the "technology boom" – was the third (Rundquist and Vandeberg 2020, 81–3) (table 1.1).

Table 1.1. The proximate causes, spatial distributions, and magnitudes of North Dakota's three oil booms. Source: Ruddell and Ray (2020, 272) and Rundquist and Vandeberg (2020, 81–3)

Years	1951–1954	1981–1986	2008–2014
Proximate cause	"Discovery boom"	"Oil price boom"	"Technology boom"
Spatial distribution	2 counties	4 counties	17 counties
Magnitude	Minor	Minor	Major

To be sure, the beginning and end dates of the most recent boom are open to interpretation. With respect to the beginning, the United States entered a recession in 2008, at which point the contrast between North Dakota's economy and that of the rest of the country was stark, even if oil production had begun to increase by 2006. With respect to the end, the price of oil dipped below the break-even point of US$85 a gallon in 2014 (Maugeri 2013, 14), even if the number of active wells continued to increase (figure 1.2).

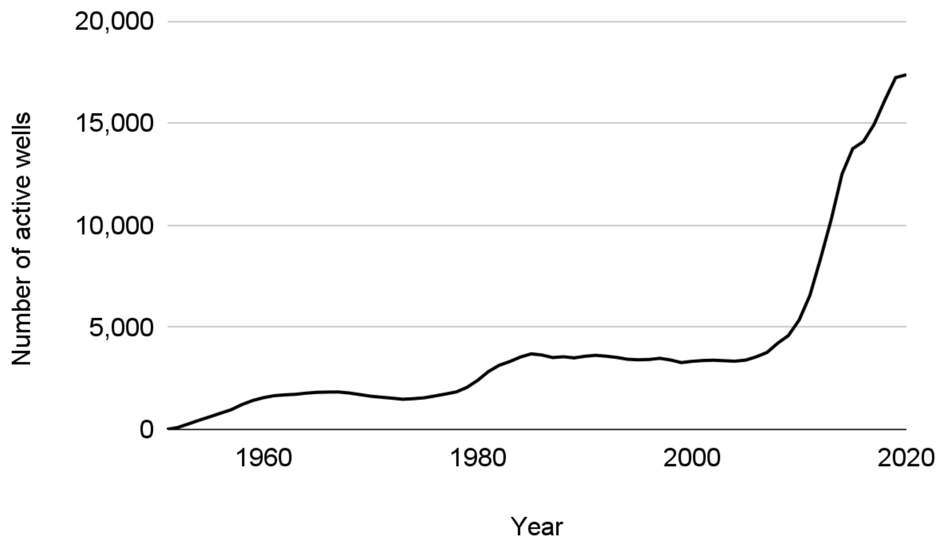

Figure 1.2. Number of active wells in North Dakota, 1951–2020. Data source: North Dakota Department of Mineral Resources (2023)

As table 1.1 and figure 1.2 suggest, the scale of the 2008 boom was dramatically bigger than the two that preceded it. The 1950s boom was limited to two counties – Williams (of which Williston is the seat) and Mountrail – while that of the 1980s extended to four. The effects of the 2008 boom were much more widely felt. Positively, within one hundred miles of the Bakken, wages increased, although not as much as within the Bakken region itself, and within two hundred miles, unemployment decreased (Batbold and Grunewald 2013). Negatively, the challenges associated with extraction booms, such as crime, decreased property values, and decreased educational attainment, were also spread widely across the state (Lauer, Harkness, and Vengosh 2016).

The amount of research about each boom has been proportional to its size. Although the first and second booms were relatively well studied (e.g., Campbell et al. 1958; Bluemle 2001), the third was one of the most studied phenomena in the state's history. Leaving aside popular and journalistic accounts, prominent scholarly books describe the social and artistic dimensions of the boom (Caraher and Conway 2016), the challenges of workforce housing (Caraher and Weber 2017), patterns of crime and law enforcement (Ruddell 2017), historical continuities and discontinuities between the 1951 and 2008 booms (Conway 2020b), and the settler-colonial dimensions of Bakken oil extraction (Estes 2019; Thomas and Braun 2023). By and large, the story they tell follows familiar contours, first identified in the boomtown literature of the 1970s (Cortese and Jones 1977; Little 1977): the Bakken region experienced growth more rapid than its infrastructure could support, to say nothing of the region's civic and social institutions. Housing prices exploded, and for a short while in 2014, rent was higher in Williston than anywhere else in the country (McCormick 2014). Residents' access to healthcare services and law enforcement decreased (Archbold 2015; Becker 2020), while various forms of violence, especially sexual violence, increased (Jayasundara, Legerski, and Davis 2018). By some counts, the absolute rate of violence increased as much as 20 percent, but because of scant record-keeping practices before the boom, it is hard to determine whether the increase was proportional to the influx of new residents. Nevertheless, although such an increase "may not be statistically significant, [… such a] change has a substantial impact on the operations of the police, courts, and corrections" (Ruddell 2017, 48), not to mention people's perceptions of their community.

The pace of growth during the 2008 boom resulted from a conjuncture of factors including the organization of the oil industry in the Bakken and the technological nature of fracked wells. In the first instance, the Bakken had proportionately more independent operators than most oil plays. Because they were often undercapitalized, they took on more debt than larger operators, forcing them to drill quickly in order to finance their operations (Braun 2023). In the second, fracked wells have a short half-life, losing as much as 50 percent of their capacity each year, the only oil released coming from the microfissures created by the fracking process. In contrast, conventionally drilled wells, in which oil continuously migrates toward the well shaft, lose capacity at a rate of 5 to 8 percent a year (Maugeri 2013, 1–3; Braun 2023, 127). Consequently, oil companies had to drill about ninety new wells a month just to hold production steady, the number of active wells ballooning from about 4,200 in 2008 to more than 12,500 in 2014 (Maugeri 2013; North Dakota Department of Mineral Resources 2023).

In other words, the transformations residents saw were very real, even if the landscape for which letter-writers pined was fundamentally contradictory, as I contend. As extraction increased, for instance, so did spills of "produced water," the brine that flowed back out of fracked wells (Konkel 2016; Lauer, Harkness, and Vengosh 2016). Likewise, the size of the average fragment (or "area surrounded by human structures") on public lands shrank, leading to increased run-off, sedimentation, and dust, in addition to chemical, noise, and light pollution (Howden et al. 2019, 526–8).

Longtime residents who remembered the 1980s boom also remembered the bust that followed, and they were anxious that the downturn would leave them in worse shape than they had been in prior to the boom (Young 2016). Their concern, however, illustrated a fundamental problem underlying research about the Bakken (and boomtowns more broadly), namely its teleology: boomtown stories tend to presume their own ending, namely the bust (Brown, Dorins, and Krannich 2005; Braun 2023). Not only is the story familiar, but so are its characters, each portrayed as a victim: longtime residents as victims of changes they cannot control, newcomers as victims of the circumstances they want to escape. This myopia obscures an important dimension of the boomtown experience, namely the agency people exercise as they navigate through it. In short, it focuses on the second part of Marx's famous maxim from the *Eighteenth Brumaire* at the expense of the first five words: "Man makes his own history, but he does not make it out of whole cloth; he does not make it out of conditions chosen by himself, but out of such as he finds close at hand" (1919, 9).

It is precisely this focus on agency, linked dialectically to the broader forces affecting people's lives, to which I turn in this thesis. My focus is necessarily narrow: returning to the theme raised by the letter to the editor cited above, the focus is the construction and evolution of the region's landscape during and immediately following the boom.

1.3. Theoretical framework: The temporalization of space

Concern for how people shape their environment while the environment shapes them has marked human geography since its inception (see, e.g., Vidal de la Blache 1902; Vidal de la Blache and Martonne 1922). However, critical geographers working in a materialist or Marxist framework began turning their attention to this dialectical process only in the 1960s (Soja 1989, chap. 1). They asked about the nature of *social* space, generating a dialogue of publications in French (Santos 1971; Lefebvre 1974, published in English as Lefebvre 1991), Brazilian Portuguese (Santos 1978, published in English as Santos 2021a; Santos 2006 [1996], published in English as Santos 2021b), and finally English (Soja 1989; Harvey 2006).

By social space, these theorists mean a set of lived relations positioning people first with respect to each other, mediated by their relationship to the surrounding environment, and second with respect to their surrounding environment, mediated by their relationships to other people. They oppose the concept to absolute or "Cartesian" space, upon which a three-dimensional grid can be imposed to allow an observer to locate any given point along an x-, y-, and z-axis (Lefebvre 1991, 1–3; Harvey 2006, 121). In the context of North American modernity, characterized by ever increasing levels of abstraction (Giddens 1990), Cartesian space is one necessary abstraction among others, underpinning technologies such as geographic information system (GIS) mapping software and the satellites that make it possible (although such technologies postdate the development of these theories).

That abstraction, however, is also its greatest weakness, if the goal is to account for people's lived experiences, because it transforms the study of space into one of the "sciences that philosophers deem 'pure'" – along the model of mathematics – "precisely because they have purged them of dialectical moments" (Lefebvre 1991, 13). It is in those dialectical moments that lived experience becomes meaningful: people interpret their environment as they navigate through it, or better yet, *in order to* navigate through it. At a phenomenological level, their experience of distance does not necessarily correspond to the square root of the sum of the squares of the distances between two points plotted along a coordinate system. My home in Ottawa, Ontario, for instance, feels closer to my parents' home in Williston, North Dakota, than the 2,400 kilometres separating us might suggest because I am emotionally connected to both. As the letter to the editor quoted in the introduction suggests, it was at this phenomenological level that residents of North Dakota perceived changes in the landscape they worried they were losing.

How does the idea of social space help us understand the evolving landscape in western North Dakota between 2009 and 2019? It draws attention to the relationship between meaning-making, territorial configuration, and the passage of time (sec. 1.3.1) by providing metaphors derived from processes of geomorphological change (sec. 1.3.2), which help explain the dialectical processes of change (secs. 1.3.3–4).

1.3.1. Critical approaches to space and landscape

To see space as social is to see the landscape as "*le milieu et le résultat tangible des échanges matériels et sensibles de l'être humain avec le monde environnant*" ("the setting and tangible result of the perceptible, material exchanges of humans with the surrounding world") (Besse 2018, 53, my translation). Landscape consists in "a set of forms that, in a given moment, express the legacies of successive localized relations between humans and nature" (Santos 2021b, 62), reflecting the way that the "mode of production that creates fixed spatial forms [...] can disappear without the fixed forms themselves disappearing. The moment crystallizes [...] as the memory of a present that is past" (Santos 2021a, 104, paraphrasing Henri Lefebvre and Irvin Morgenstern).

In concrete terms, people arrive at a site, and their interpretation of it is guided among other things by what they think about it before they arrive and by the choices made (or not made) by prior visitors, reflected in the structures they left in place. Paul Ricœur describes this precomprehension as *prefiguration* (2016, 33). Newcomers act on their interpretations, building on or altering the site (or leaving it untouched). These structures also remain, even if the people do not. Characterized by different degrees of permanence, they stand or they crumble, shaping the interpretations – and by way those interpretations, the actions – of the people who come later and shape the site themselves. Ricœur characterizes the second and third steps as *configuration* and *refiguration* (2016, 34–8).

Milton Santos calls the observable results of the first part of this dialectic a site's *territorial configuration*, or the "set of natural and artificial elements that physically characterize a given area" (Santos 2021b, 62). I am calling the second part its *semiotic configuration*, which, like its territorial counterpart, is characterized by temporal relations of mutual influence. This idea can be further broken down as a function of the person who is acting as an interpreter and their position of power relative to other interpreters. First there are "scientists, planners, urbanists, technocratic subdividers and social engineers" who produce *representations of space*, by Henri Lefebvre's (1991, 38) account. They exercise forms of official or State power. Then there are those who "*live*" space "through its associated images and symbols," who are "'inhabitants' and 'users'" of a *representational spaces*, again by Lefebvre's account, spaces that are "the dominated – and hence passively experienced – space which the imagination seeks to change and appropriate" (1991, 39, original emphasis). Representations of space and representational spaces operate in tension with a society's *spatial practice*, which "secretes that society's space" and which "is revealed through the deciphering of its space" (1991, 38). In this respect, the dialectical relationship out of which social space emerges is not dyadic, based on "oppositions, contrasts or antagonisms," but triadic, moving between "the perceived, the conceived, and the lived" (1991, 39). As such, it allows for a wider range of possible actions.

Carola Hein draws these categories together in her concept of the "petroleumscape," or the "layered physical and social landscape" – linked inextricably to oil – "that reinforces itself over time through human action and connects urban and rural spaces, culture and nature, materials and intangible practices" (2022, 3). Its spatial practices are industrial, administrative, and infrastructural (among others), supported by representations of space within corporate and popular media, or artistic and popular culture. Its representational spaces are those of citizen response (2022, 9).

These models highlight the temporal dimension of space and, more to the point, of the territorial configuration of a given landscape, such as in western North Dakota. Landscape is always emergent, never fully realized but always evolving as people interpret and act upon it.

1.3.2. Flow, sediment/accumulation, and roughness

Santos provides a useful metaphorical vocabulary for observing this temporalization of space, derived from Jean Tricart's work on geomorphology (Santos 1971, chap. 9). For Tricart, two factors influence the shape of riverbeds, for example, namely the flow of water and the accumulation of sediment (Tricart 1960). In their interaction – when the current deposits sediment, the flow slows down, and when flow increases, it carries sediment away – they produce the riverbed's *roughness* ("rugosité" or, in Santos's Portuguese, "rugosidade"). Santos expands the idea of "roughness" beyond specific geomorphological features to space itself: "*les flux qui traversent l'espace ne le vivifient pas seulement, ils sont également responsables de nouvelles rugosités, dans le sens qu'ils facilitent ou rendent difficiles des accumulations ou des appauvrissements*" ("the flows that cross through space not only animate it, they also create new points of roughness, in the sense that they facilitate or hinder accumulations or depletions") (Santos 1971, 75, my translation; see also Santos 2021b, 34). Rather than water, he is concerned with flows of capital and labour, especially as capital flows shape the division of labour, causing people to alter their environment. The metaphorical roughness resulting from the interaction between these forces is "that which remains from the past as form, as built space, landscape, what is left over from the process of suppression, accumulation, and superposition, that with which things replace themselves and accumulate in all places" (Santos 2021b, 89).

1.3.3. Sign structure and "word memory"

I contend that something analogous happens in language, as the evolution of natural languages suggests. Phonological change, for instance, can occur when one generation of speakers starts dropping unaccented syllables from words, to give one example, and those speakers' children, hearing this pronunciation, adopt it and pass it on to their own children. Similarly, morphological change can occur as more and more people apply regular rules to irregular words, for instance substituting regular verb forms for irregular forms, such as *proved* for *proven* as the past participle of *to prove* (McWhorter 2001). Unaccented syllables and irregular verb forms are rough, so to speak, in that they hinder the flow of speech, much as sedimentation hinders the flow of a river, and flow increases – in speech as in a river – when the resistance they provide is overcome.

For the purposes of understanding the production of space and landscape in western North Dakota, it is useful to consider the mechanics of this change at a semantic level (in this section) and the resulting relationship between semiotic and territorial configurations (in the next section). (*Semantics* refers to words' meanings, while *semiotics* refers to the capacity for and development of meaning itself.) I am adopting Charles Peirce's notion of a *sign*, which he describes as having three parts. First is the *representamen*, which "stands to somebody for something in some respect or capacity" (1940, 99). Representamens can take any form, but the most recognizable is that of a printed or spoken word. They function by "creat[ing] in the mind of that person an equivalent sign, or perhaps a more developed sign," which Peirce calls the sign's *interpretant* (1940, 99). Expressed differently, when people read a word or hear it spoken (or encounter any other type of representamen), that word prompts them to think of something else. That "something else" is the interpretant. Because people use signs in real-world contexts, words (and other representamens) also have an ostensive function: they point to a thing, which for Peirce is the *object*, the third component of a sign (1940, 99).

The power of Peirce's semiotic system lies in the way it reveals the concatenation of signs. When a representamen evokes an interpretant, that interpretant itself evokes further interpretants, which evoke still others, creating a chain of associations. Consider the letter to the editor quoted in the introduction. Its author was responding to a series of articles about the good and bad dimensions of the Bakken oil boom. Those articles, in particular words such as *good* and *bad* and *boom*, brought to mind the lifestyle she felt was being lost, which evoked the area's natural beauty, which prompted her to think of the solitude, open spaces, and animals she associated with those spaces. The words *good*, *bad*, and *boom* were first-order representamens, and the endangered lifestyle a first-order interpretant. But that lifestyle also operated as a sign, becoming a second-order representamen by evoking the area's natural beauty, a second-order interpretant, which itself then became a third-order representamen, evoking third-order interpretants such as solitude and open spaces. Although the letter does not reflect the next links in the author's chain of associations, they no doubt existed. Signs operate in a network defined by these associations, which can be viewed only ever incompletely (Conway 2023, chap. 2).

The idea of roughness is useful for explaining how these associations come to be. As words circulate, they acquire what Ginette Michaud (1998) calls "word memory" by accumulating associations, both for individuals and for broader communities. As people talk (or communicate more broadly), they must take into account how the words they choose have been used in prior situations, for instance as they consider, in light of what they know about their conversation partner, what type of reactions their word choices are likely to provoke. Even within the bounds of a single conversation, a word acquires new associations related to the conversation itself, as one speaker takes into account what the other has just said. These changes are usually imperceptible, but not always. (Consider the new associations I have worked to attribute to the word *rough* over the course of this chapter.) Over time, some changes come to characterize the lexicons of larger speech communities, as individuals come to share new associations. (Consider the evolution of *climate change* over the past decade as it has become both more accepted and more polarizing.) The same mechanisms that bring about phonological or morphological change also bring about semantic change (Conway 2020a, chap. 1).

The relationship between the set of associations a speaker takes into account when putting thoughts into words and the evolving set of associations growing out of interactions between speakers produces a site's semiotic configuration. The roughness of this configuration is observable in the resistance speakers encounter when using certain words, especially those whose meanings are contested. The word *landscape* in western North Dakota was one such word. For some people, it evoked a chain of associations like that of the letter to the editor cited in the introduction. For others, it evoked a chain of associations related to other dimensions of the boom, such as housing or economic development. In either case, it was not a word over which speakers could easily pass, as others were likely to challenge their assertions. It was, simply put, rough.

1.3.4. Dynamic relation between territorial and semiotic configurations

The twin concepts of territorial and semiotic configurations make it possible to describe "the living environment of unstable compositions" constituting the landscape in which people were immersed in western North Dakota during the 2008 Bakken oil boom (Besse 2018, 12). Each configuration is characterized by a dialectic of stasis and movement, or of received structures or ideas and action.

Importantly, the territorial and semiotic configurations are also linked to each other in a relationship of mutual influence. The natural environment is imbued with signs, as people interpret the flora, the fauna, the topography, and so on, in relation to their sense of place. So is the built environment, as people create structures to express ideas following identifiable semiotic codes. In short, people interpret their environment even as they alter it, and their alterations in turn shape their interpretations. Sometimes they draw on conventional texts, ranging from architectural textbooks to religious texts prescribing the arrangement of objects in space (Duncan and Duncan 1988). Sometimes they imagine a site itself as a text, reading the marks prior inhabitants have left as indices of their actions (Conway 2024). What matters, I contend, is that this theoretical framework makes it possible to see the agency people exercise in an oil boom, which has largely been erased in the broader literature on boomtown phenomena.

1.4. Method: Quantitative and interpretive approaches to landscape

Observing how residents exercised their agency over the course of the 2008 Bakken oil boom requires two related sets of data, corresponding to the landscape's territorial and semiotic dimensions. In the first instance, I focus in this thesis on the forces shaping oil companies' decisions about where to drill, using data from the North Dakota Industrial Commision's Oil and Gas Division. In the second, I use a corpus of letters to the editor published by the *Williston Herald* between 2009 and 2019.

Observing how residents exercised their agency also requires analytical tools that reveal the changing configurations over time, making possible a synthetic analysis of the interactions between the meanings people made of the changes they saw and their consequent actions. For the territorial analysis, I use techniques of point pattern analysis to describe relationships between well placement and features of the surrounding environment. For the semiotic analysis, I use techniques of text mining to identify patterns of language use symptomatic of the chains of associations described above.

In this way, I refine the broad questions I posed in this chapter's opening paragraphs. To wit:

- How have geological factors and socio-political factors related to land use influenced the location of oil wells in Williams County, North Dakota, during its three oil booms?

- How did usage patterns of key terms related to landscape evolve in letters to the editor published by the *Williston Herald* between 2009 and 2019?

These questions draw attention to the ways that residents of the Bakken were not *outside* the landscape but were in fact *part* of it: their actions reverberated in ways that affected them, too (Besse 2018). They also emphasize different spatial practices. The question related to the region's territorial configuration focuses on official representations of space, while the question related to its semiotic configuration focuses on residents' representational spaces. In this way, they lead to an examination of a more profound relationship between the territorial and semiotic changes and the social and political events occurring during the Bakken's various booms.

1.4.1. Territorial configuration

The nostalgia some people felt for a lost landscape obscured the ways that the region's territorial configuration had already been shaped by the oil industry and, more broadly, the project of settlement it continued. To describe that configuration, I create a series of maps in chapter 2 showing where wells were drilled in Williams County during the region's three oil booms in the 1950s, the 1980s, and then starting in 2008. My data come largely from North Dakota state agencies. Using the spatstat package in R (Baddeley and Turner 2005), I calculate kernel density estimations describing where wells have been drilled. I also use Monte Carlo statistical techniques and variations of Ripley's *K* function to calculate the likelihood that wells' locations in relation to other wells, to geographic features such as roads, or to wastewater spills would be produced by a process of random point generation.

Such a process, I contend, would be unlikely to produce the observed point patterns. The statistical analyses demonstrate significant relationships, but they offer no explanations for how or why they developed. For that reason, I focus on historical government policies and the interpretations of space shaping them. The statistical relationships suggest the plausibility of the historical explanations to the degree that they are consonant with the logic of causality those explanations employ.

These maps and calculations show the relationship between spatial practices and dominant/official representations of space, but they also help contextualize the nostalgia people expressed for a landscape they saw as lost, addressed in chapter 3.

1.4.2. Semiotic configuration

In 2019, as part of a related project, I compiled a corpus of letters to the editor archived on the website of the *Williston Herald* (www.willistonherald.com). Using three search engines (Google, Bing, and the *Herald* website's own search function), I found and copied every letter with at least one of three key words, namely *Bakken*, *oil*, and *boom*. My corpus included 132 letters published between 2009 and 2019. Most authors were from North Dakota, but not all, although not every letter indicated where its author lived. I worked with a research assistant to code the letters, noting the presence of any mention of a series of themes. We identified themes collaboratively and iteratively, refining our initial list as we read and reread the letters. In the end, the three most common themes were jobs (46 letters), the environment (44), and housing (43). Other common themes were infrastructure (39 letters), taxes (37), and the state government (36).

For this thesis, I continue this analysis by zooming out, so to speak. I use text mining to engage in a form of "distant reading," where the goal is to understand the letters as a system (Moretti 2000), in conjunction with closer readings of individual letters, as in the example in the introduction. Specifically, I use the tidyverse and tidytext packages in R (Wickham et al. 2019; Silge and Robinson 2016, 2017) alongside the KH Coder software package (Higuchi 2016, 2017) to perform two types of analysis. First is co-occurrence analysis, which maps the pairs of words that occur together in individual letters (my unit of analysis). Although it is impossible to know the string of associations that a sign evokes for an individual or a social group directly, co-occurrence analysis provides a way to make inferences, based on the assumption that writers crafted their letters to reflect the associations they made (and that they wanted others to make, too) (Mercier 2019). Second is correspondence analysis, which provides a visual representation of the evolving ways letter-writers talked about the boom, making it possible to see how terms occurred at different rates over the course decade I examine.

Letters to the editor produce a useful corpus, but not without certain caveats, the most important of which is that for this project, it is impossible to know how many letters the *Williston Herald* published using the collection techniques described above. All that can be discovered is how many it archived and made available on its website. My conclusions will thus have no predictive value because I cannot determine the nature of my sample. Instead, the value of this analysis derives from the qualities that define letters to the editor as a genre. First, they are spontaneous and reflect people's priorities, revealing the issues that writers found important enough to take the effort to address. Second, they are public, meaning they engage in a broader discourse beyond the letter-writers' own private worlds. Third, following from their publicness, their purpose is persuasion, meaning their authors sought to influence others. In all three respects, they reflect residents' representational spaces, where they attempted to influence the course of the boom and the decisions made by civic and political leaders.

1.5. Conclusion: The Bakken petroleumscape

To describe the Bakken landscape as it has been shaped – in both its territorial and its semiotic configurations – by oil, I return in the concluding chapter to the relations of mutual mediation to which the ideas of the production of space (broadly speaking) or the petroleumscape (narrowly speaking) draw attention. Government representatives and business leaders made choices that shaped the landscape, following a discourse that intersected with (but did not subsume) that of citizens, who made choices of their own. The forms of mediation were not tidy: members of these groups were allies in some cases, adversaries in others. My goal is to account for that messiness.

This messiness, however, reveals the limitations of my approach. At a conceptual level, the dimensions of the territorial and semiotic configurations on which I focus are artificially extracted parts of a Heraclitan flux whose dynamism exceeds the descriptive power of language. This problem is as ancient as Western philosophy itself, as Socrates laments at the end of Plato's *Cratylus*: if the world as we come to know it is constantly changing, he says,

> can we correctly say of it first that it is *this*, and then that it is *such and such*? Or, at the very instant we are speaking, isn't it inevitably and immediately becoming a different thing and altering and no longer being as it was? (Plato, *Cratylus* 439e)

Besse (2018), Santos (2021b), and even Vidal de la Blache (Vidal de la Blache and de Martonne 1922) make this argument from a more properly geographic perspective.

More narrowly, the very idea of the production of space, rooted in a Marxist materialist perspective (especially in Lefebvre 1991), is anthropocentric. As Besse observes, "*Toute action sur l'espace n'est pas de l'ordre de la production [humaine]*" ("Not every action upon space is of the order of [human] production") (2018, 110, my translation). We must not lose sight of actions – and actors – outside the human realm (Latour 1991; Maran 2020).

Finally, with respect to the specifics of my research questions: much as they are anthropocentric, they also derive from a settler epistemology. For example, in the chapter on the Bakken's semiotic configuration, Indigenous perspectives are mentioned in only one letter to the editor, and only one letter-writer self-identifies as Indigenous (although others might have been), despite the dramatic impact that the Bakken boom had on the Mandan-Hidatsa-Arikara (MHA) Nation and the Standing Rock Sioux Reservation (Cross 2011; Estes 2019). Furthermore, my epistemology is rooted in a settler view of the world, apparent among other places in its linear notion of time. An epistemology grounded in relationships, as described by Indigenous scholars such as Margaret Kovach (2021) and Shawn Wilson (2008), would look for temporal circularity and continuity in addition to change.

To be sure, the settler epistemology and anthropocentrism are inextricably linked, and I return to their critiques my conclusion, not to overcome them but to use the resistance they provide to think beyond the limits of my research design and, I hope, gain a more textured understanding of the changing landscape in the Bakken region during the 2008 fracking boom.

2. Territorial Configuration of the Bakken Landscape

2.1. Introduction: North Dakota's oil fields

This chapter asks:

- How have geological factors and socio-political factors related to land use influenced the location of oil wells in Williams County, North Dakota, during its three oil booms?

Williams County is in the northwestern corner of North Dakota, and it was the site of the first successful well in 1951 and at the centre of the subsequent booms in the 1980s and early 2000s. I am using well placement as a proxy observation for the larger question of landscape, which in chapter 1 I defined (among other ways) by quoting Milton Santos, for whom it consists in "a set of forms that, in a given moment, express the legacies of successive localized relations between humans and nature" (Santos 2021b, 62), reflecting the way that the "mode of production that creates fixed spatial forms [...] can disappear without the fixed forms themselves disappearing. The moment crystallizes [...] as the memory of a present that is past" (Santos 2021a, 104).

Why landscape? It is a central point of identification for many North Dakotans, at least in a certain idealized form: "North Dakota's wide-open space is perhaps the defining characteristic of this most rural and agricultural state," writes Owen Anderson (2009, 716). East of the Missouri River, which runs diagonally through the western half of North Dakota (see figure 1.1 in chapter 1), that space is filled with farms and occasional cities, rarely larger than 50,000 people. West of the Missouri, it is filled with ranches and even smaller cities. Anderson goes on to add, however, that "in certain locations, energy is also a defining characteristic" (2009, 716). North Dakota is the world's largest producer of lignite coal, and it produces large amounts of corn for ethanol. The Garrison Dam, on the

Missouri River northwest of the capital city Bismarck, produces hydro-electric power, while over the wide open spaces blows a never-ending wind that has made the state a leading wind-power producer (Anderson 2009; U.S. Energy Information Administration 2023). But because of the publicity created by the 2008 Bakken boom, it is oil that "will keep North Dakota in the energy spotlight for the foreseeable future" (Anderson 2009, 719).

To understand the meaning that people attached to landscape during the boom (the focus of chapter 3), it is first necessary to understand the nature of the physical landscape and its changes. Broadly speaking, the Bakken is in the American West (between the 100th meridian and the Pacific Coast mountain ranges), a region characterized by an arid climate, "spatial expansiveness," and a settlement pattern of "pockets of extensive urban and suburban land" separated by vast distances (Haggerty et al. 2018, 619). It has many natural resources, vast amounts of which are owned and managed by the federal government. People living in the region, especially those in settler communities, face the challenge of "accommodating conflicting social values about the region's natural resources and their appropriate uses," as well as that of "protecting vulnerable ecosystems unique to the region" (2018, 620).

Of those resources, unconventional oil and gas (UOG) deposits have proven to be among the most profitable. Although there is a high degree of variability between plays (or fields shaped by the same geological forces), they typically involve rich source rocks with low permeability and porosity, factors that prevent oil and gas from migrating (Haggerty et al. 2018). Hence the utility of hydraulic fracturing and its related technologies (Maugeri 2013). These technologies have had an observable impact on the physical environment, leading to the loss of arable land, strain on water supplies, and increased land use fragmentation. Researchers estimate, for instance, that these technologies contributed to the loss of about 10 million metric tons of biomass across central North America between 2000 and 2012, equivalent to about 120 million bushels of wheat, or 6 percent of the region's wheat production in 2013. More than half of the UOG extraction occurred in water-stressed regions, while the increased land use fragmentation reflected the expansion of UOG production onto agricultural lands (Allred et al. 2015). Reactions by residents of affected areas have included feelings of environmental distress or nostalgia for a lost sense of home (Elser et al. 2020). These broad-scale patterns are observable more narrowly in North Dakota, too. The landscape is increasingly industrialized, as William Caraher and Bret Weber describe in their guidebook to the Bakken (Caraher and Weber 2017). Indeed, Julia Haggerty and her co-authors contend that the changes local residents have experienced might be better described as an *infrastructure* boom than as an oil boom (Haggerty et al. 2018). Residents of the region also express anxiety about the changes they experience, related not only to landscape but also to crime, access to healthcare, and general quality of life (Fernando and Cooley 2016b).

This chapter approaches the territorial configuration of space in the Bakken through the lens of roughness, a term Santos proposes to describe how people's interpretation of a site leads them to interact with and alter a region's physical environment, reshaping it in ways that, in turn, affect their subsequent interactions (Santos 1971, 2021a, 2021b). In this chapter, I understand *interpretation* narrowly: it relates to the information people gather and the observations they make that help them decide how to act. More specifically, I examine the representations of space made by people exercising forms of official or State power (Lefebvre 1991). (I treat interpretation more broadly in chapter 3, where I look at residents' representational spaces.) Interpretation's counterpart is *action*, or the implementation of their decisions. In North Dakota, the dialectic between interpretation and action has taken this general shape: at the end of the nineteenth century, as settlers began to arrive in large numbers, the U.S. government enacted laws that reflected a conception of space as empty, something on which to impose a grid dividing it into regular segments. State and federal courts rendered decisions reflecting and strengthening this sense of space. These laws and rulings provided the framework for constructing the state's road system, among other things, which in turn influenced where oil companies drilled wells as much as a century later, actions that further shaped residents' interpretations of the boom (the subject of chapter 3).

This chapter proceeds by examining this dialectic and its effects. In line with my research question, I contend that two sets of factors influenced where wells were spudded (that is, started) during the three booms that have taken place in western North Dakota. The first factors are geological: drills are spudded where there is oil, which also affects land use (secs. 2.2–2.3.1). The second set of factors are cultural and political, reflections of settler interpretations of space. The rule of capture, or the idea that landowners take possession of petroleum resources at the point where they drill a well, has influenced the density of well placement (sec. 2.3.2). The legacy of the Homestead Act of 1862, visible in the roads following township lines established when the federal government divided up the west to give to settlers, has influenced how wells are arranged because they follow those roads (sec. 2.3.3). These factors influence each other, and their effects are observable in further effects of the oil extraction process, such as wastewater or brine spills, whose relationship to well sites, I show, is one of spatial attraction (sec. 2.4). The environmental damage wastewater spills represent becomes a catalyst for the broader set of interpretations of the 2008 boom expressed in the letters to the editor published in the *Williston Herald* explored in chapter 3.

2.2. Williams County: Geology and ecoregions

Two sets of factors have shaped the spatial distribution of oil wells in Williams County, the first geological, the second political. To understand the configuration of the county's landscape, the question to ask (suggested by Haggerty et al. 2018) is, how does what is below the ground affect what is above?

With respect to the region's physical geography, Williams County sits on top of not one but three oil-bearing formations, of which the Bakken is the best known. The first to form was the Devonian-age Three Forks formation, which formed about 370 million years ago and lies below the Bakken. It is as much as 75 metres thick, in the eastern part of McKenzie County (directly south of Williams County). The last to form was the Mississipian-age Lodgepole Formation, which lies above the Bakken and formed less than 360 million years ago. It is as much as 750 metres thick, again in eastern McKenzie County. The Bakken lies in the middle. It was originally a sea in a tropical climate, when what is now Williams County was located closer to the equator, about 360 million years ago. Over time, the sea's shallow marine sediments, rich in oxygen, gave way through erosion and tectonic shift to terrestrial sediments created in the anoxic conditions conducive to the production of oil and gas. The marine sediments became the Bakken Formation's lower level of black shale, while the terrestrial sediments became its oil-bearing level, which was in turn covered by black shale, creating the sandwich-like structure that fracking technology was developed to tap (Bluemle 2016; Rundquist and Vandeberg 2020).

Above ground, the state of North Dakota is located in the northern part of the U.S. Great Plains (a level 1 ecoregion), divided between the Temperate Prairies in the east and the West-Central Semi-Arid Prairies in the west (level 2) (U.S. Environmental Protection Agency 2006). Within the state's boundaries exist four level 3 ecoregions. In the east, a strip of land about 100 kilometres wide, running north and south parallel to the Red River, belongs to the Lake Agassiz Plains (ecoregion 9.2.2, following the nomenclature of the U.S. Environmental Protection Agency) (U.S. Environmental Protection Agency 1997, 2006; Omernik and Griffith 2014). The region to its west belongs to the Northern Glaciated Plains (ecoregion 9.2.1), the western boundaries of which run in a diagonal line roughly bisecting the state, from the northwest to the centre-south, parallel to (and about 100 to 150 kilometres to the east of) the Missouri River. The area west of that boundary to just before the river itself belongs to the Northwestern Glaciated Plains (ecoregion 9.3.1). The remaining section of the state, its southwest quadrant, is part of the Northwestern Great Plains (ecoregion 9.3.3).

Williams County falls within the third and fourth of these ecoregions. It contains five distinct level 4 ecoregions (figure 2.1), the first four of which – the Collapsed Glacial Outwash (9.3.1.42b), Missouri Coteau Slope (9.3.1.42c), Northern Missouri Coteau (9.3.1.42d), the Glaciated Dark Brown Prairie (9.3.1.42i) subregions – all belong to the Northwestern Glaciated Plains. These regions tend to have an irregular topography with a relatively high concentration of wetlands. The Missouri Coteau Slope and the Glaciated Dark Brown Prairie predominate in Williams County. Land in the first is used largely for farming, but less so in the second, which is characterized by drier conditions and by a "well-defined drainage system" (Bryce et al. 1998).

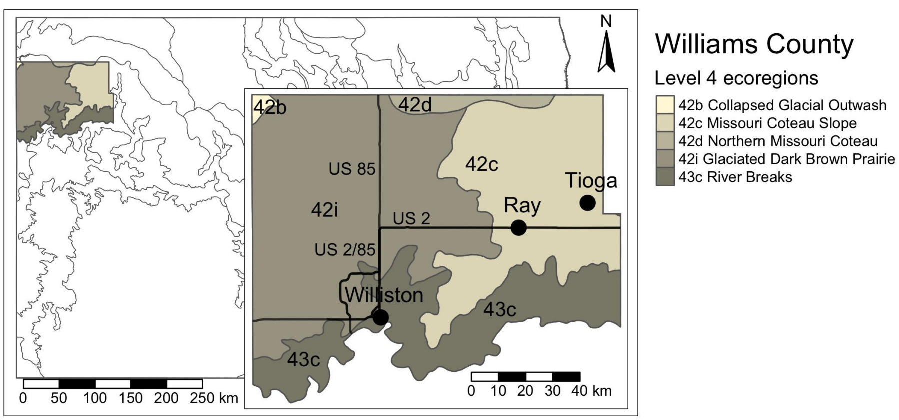

Figure 2.1. Level 4 ecoregions in Williams County, in the context of the state of North Dakota. Data sources: U.S. Environmental Protection Agency (2012), North Dakota GIS Hub (2002, 2020, 2023), U.S. Census Bureau (2023)

The fifth level 4 ecoregion, the River Breaks subregion (9.3.3.43c), belongs to the Northwestern Great Plains. It takes the form of a narrow ribbon a kilometre or two wide on either side of the Missouri River (which forms the southern border of Williams County) and its tributaries (Bailey 2016; Bryce et al. 1998; U.S. Environmental Protection Agency 1997). Its climate is semi-arid, and its topography is characterized by wooded draws and ravines (called "coulees" by local residents), which include ash and elm trees. On the slopes of the ravines grow juniper, juneberry bushes, and chokecherry trees. Grasses grow in the uplands, including crested wheatgrass and related prairie grasses (figure 2.2). Historically the land was either agricultural (typically cattle ranching) or uncultivated (Bryce et al. 1998), although as figures 2.3–5 below show, it now has a very high concentration of oil wells.

Figure 2.2. A well pad in the River Breaks subregion (9.3.3.43c), about forty kilometres east of Williston, North Dakota (August 2022)

This subregion, as the name suggests, is dominated by the Missouri River and its tributaries. The Missouri River flows east and south, joining the Mississippi River in St. Louis, Missouri. In 1953, the U.S. Army Corps of Engineers built the Garrison Dam near Riverdale, North Dakota, about 100 kilometres upstream from Bismarck, the state capital, creating Lake Sakakawea, which is about 290 kilometres long and covers about 1,200 square kilometres of land. The Garrison Dam was part of the Pick-Sloan Missouri Basin Program, authorized by the 1944 Flood Control Act, prior to which the

Missouri River flooded regularly. In the time since, the dams created by the program, of which Garrison is the biggest, have helped the Corps control the flooding, although occasional floods still occur. The most recent took place in 2011 in Bismarck. On a smaller scale, the ravines and wooded draws often have small, usually temporary streams or creeks.

The geologic and land use-related dimensions of Williams County are important in two ways. First, with respect to geology, the thickest part of the Bakken lies southeast of Tioga, near the Nesson Anticline, which was the focus of drilling in the 1950s, in part because its oil was accessible through pre-fracking technologies. Second, with respect to land use, one important consequence of drilling (as I write in sec. 2.4) has been the proliferation of wastewater spills, which threaten the sources of water throughout the region.

2.3. Well locations

2.3.1. Geological factors

To see the effect of the underlying geologic formations, consider figure 2.3, a map representing the wells spudded between 1951 and 1979, from the beginning of North Dakota's first boom to the end of its first bust, indicating the density of wells per 100 square kilometres (based on a kernel density estimation function) (Baddeley and Turner 2005; O'Sullivan and Unwin 2010). The wells are concentrated in a north-south line whose centre is Tioga, in the eastern part of the county. These wells trace the line of the Nesson Anticline, the "most important oil trap," according to researchers writing in 1958, on which "most of the producing wells [were] located" (Wills, Talbot, Kelley, and Campbell 2020, 11). (Most of the wells in the western and central part of the county were spudded in the 1960s and 1970s.)

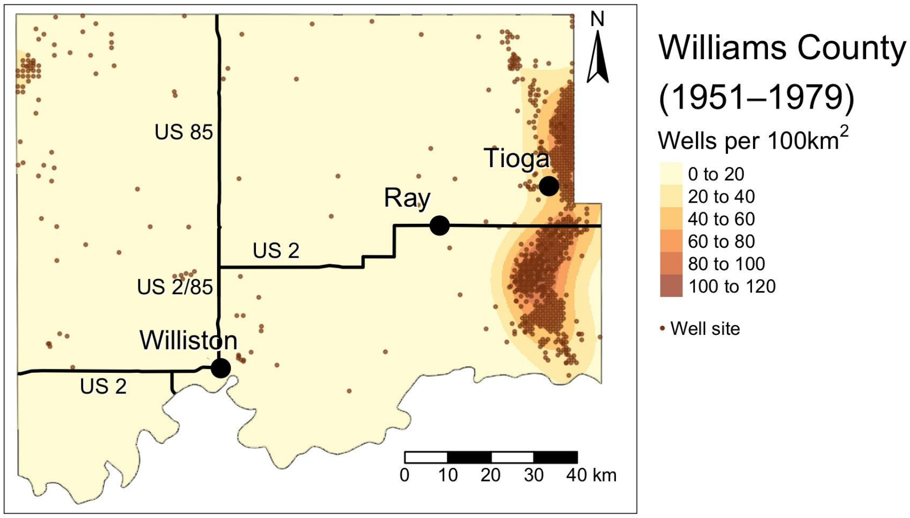

Figure 2.3. Location and density of sites of all wells spudded between 1951 and 1979 in Williams County, North Dakota (kernel density estimation, σ = 5km). Note that the highway alignment is that of the 1950s. Data sources: USGS (1957), North Dakota GIS Hub (2002, 2023), U.S. Census Bureau (2023), NDIC Oil and Gas Division (2024b)

This pattern was repeated, even as well sites came to cover more of the county, during the boom that began in about 1980, as seen in figure 2.4.[1] This map shows the wells spudded from the beginning of the region's second boom to the end of its second bust. Most of the drilling in these years took place between 1981 and 1986 (see chapter 1, figure 1.2); the wells spudded between 1986 and 2007 had only a limited impact on the region (Ruddell and Ray 2020).

[1] Figures 2.3–5 also show the realignment of U.S. highways in the region, often to make travel easier during times of increased traffic, such as oil booms.

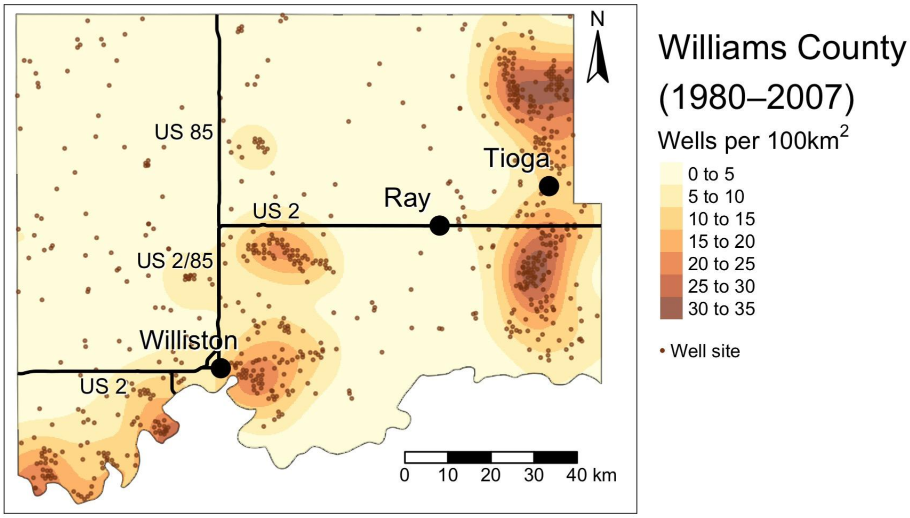

Figure 2.4. Location and density of sites of all wells spudded between 1980 and 2007 in Williams County, North Dakota (kernel density estimation, σ = 5km). Data sources: North Dakota GIS Hub (2002, 2023), U.S. Census Bureau (2023), NDIC Oil and Gas Division (2024b)

The patterns characterizing the 1980s boom resemble those of the 1950s, especially with respect to the Nesson Anticline. They also show an expansion into the areas surrounding Williston, although in all locations, the well density is relatively low compared to the high level of clustering in the eastern part of the county in the 1950s. In contrast, figure 2.5, which shows all the wells drilled between 2008 and 2019 – from the beginning of the third boom to well into the third bust, which is ongoing – not only reproduces the patterns of drilling apparent in earlier maps, but also the density of the region’s first boom, now extended across more of the county.

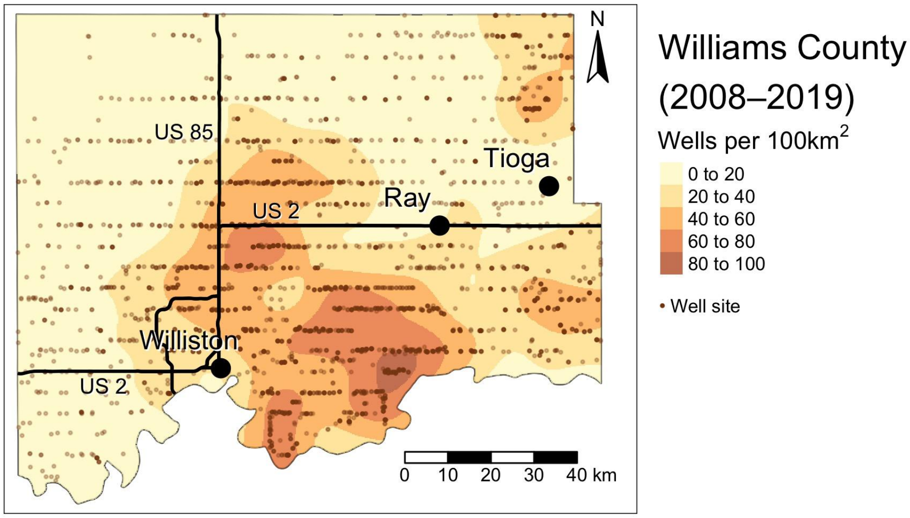

Figure 2.5. Placement and density of sites of all wells spudded between 2008 and 2019 in Williams County, North Dakota (kernel density estimation, σ = 5km). Data sources: North Dakota GIS Hub (2002, 2023), U.S. Census Bureau (2023), NDIC Oil and Gas Division (2024b)

Geology's role in this process is clear: oil companies drilled wells where they thought they were likely to find oil. But geology was not the only factor influencing their choices. In particular, it cannot explain certain aspects of well density and arrangement.

2.3.2. Rule of capture and well density

Other important factors influencing well density and arrangement were social and political, related to land use policy. They have been shaped by the U.S. government's historical approach to settlement, which followed a logic whose roots can be traced back to the European project of modernity, in particular to Enlightenment notions of rationalization (in the sense both of overcoming superstition and of making systems efficient). Although the literature on European modernity is too vast to summarize here (see, *inter alia*, Giddens 1990; Habermas 1983, 1991; Weber 1946), its central point is simple enough: predictability, achieved through abstraction, makes work more efficient and, with respect to economic development, allows industry to flourish. One key abstraction concerns time, which in (Western) modernity takes the form of "'homogeneous, empty time,' in which simultaneity is, as it were, transverse, cross-time, marked not by prefiguring and fulfilment, but by temporal coincidence, and measured by clock and calendar" (Anderson 1991, 24, paraphrasing Walter Benjamin). A second concerns space, which is treated as "a preexisting, immovable, continuous, and unchanging framework" (Harvey 2005, 5). Space and time in this sense are both homogeneous, the first divisible into discrete units measured in kilometres or miles, the second divisible into minutes, hours, and days.

The effects of this conception of space and time are observable in nineteenth century court decisions and laws setting policy for distributing land to settlers. These policies reflect their architects' interpretations of space, and their implementation shaped the way that settlers altered the physical landscape. More to the point, they influenced choices about where to locate wells in Williams County during its different oil booms. The first policy (the subject of this section) was codified as the rule of capture, and the second (the subject of sec. 2.3.3) as the Homestead Act.

The rule of capture describes the idea that landowners own the oil and gas they produce by drilling on their land, even if the reservoir from which they draw extends under their neighbour's land, too. The idea was given its definitive form in an 1889 decision rendered by the Pennsylvania Supreme Court in the case Westmoreland v. Dewitt. Creating an analogy with wild game, to which the "rule of capture" applied, the court wrote:

> In common with animals, and unlike other minerals, [water, oil, and gas] have the power and the tendency to escape without the volition of the owner. Their "fugitive and wandering existence within the limits of a particular tract is uncertain," as said by Chief Justice Agnew [...]. They belong to the owner of the land, and are part of it, so long as they are on or in it, and are subject to his control; but when they escape, and go into other land, or come under another's control, the title of the former owner is gone.

> Possession of the land, therefore, is not necessarily possession of the gas. If an adjoining, or even a distant, owner, drills his own land, and taps your gas so that it comes into his well and under his control, it is no longer yours, but his. (Westmoreland etc. N. Gas Co. v. Ira DeWitt et al., at 249–50)

Courts enforced the rule of capture when landowners brought suits against their neighbours, arguing that their neighbours, by capturing a shared resource, had deprived them of its use. Some early rulings, such as one decided by the Pennsylvania Supreme Court in 1893, went so far as to assert that "a mineral owner has a property interest in the gas which allows him to do with it as he pleases, even if he wastes the gas and diminishes the common source of supply" (Kramer 2015, 304).

In other words, the effects of the neighbour's actions were felt at a distance, linked through a chain of actions that the parties involved all took for granted. In this way, the idea of rule of capture relied on notions of cause and effect across (homogeneous) space and (simultaneous) time, translating the predictability of cause and effect into the predictability of land use, where what mattered was not an individual's identity as such – it was abstracted from the process – but their status as a landowner.[2] Although the precedent has been reinterpreted in the intervening years (Kramer and Anderson 2005), its guiding principle remains the same, especially in the incentive it produces to drill: "a mineral owner must drill and produce, or he risks losing the minerals to his neighbors' wells located on adjacent lands" (Kramer 2015, 303). In fact, applying the rule of capture to petroleum has encouraged landowners to drill as quickly and extract as much as they can, lest the deposits under their land be

[2] For a competing conception of space and time, consider the arguments made by Native leaders fighting the construction of pipelines in North Dakota, New Brunswick, and elsewhere, in the 2010s. These leaders often evoked a sense of space where relationships were strengthened by proximity and where time was circular rather than linear, characterized by a history, such as that of settler land grabs, that repeated itself. For an example of these arguments, see Archambault (2016); for a comparative analysis of settler and Native discourses of time and space, see Conway and Duguay (2019). I also discuss competing notions of space and time in chapter 4.

taken by their neighbours, a fact that led to an overproduction of oil in the first half of the twentieth century (Huber 2013, 45).

The impact on well placement has been a densification of wells, although this densification is impossible to quantify. Instead, it is suggested by the efforts by the state government to encourage the conservation of oil as a natural resource, one of three "bedrock principles" of regulation meant to counteract the effects of the rule of capture (the other two being the prevention of waste and the protection of correlative rights) (Kramer 2015, 296). In the 1950s, North Dakota's Industrial Commission enforced spacing rules, which established a minimum distance between wells within pools (or multiple tracts joined together). The Commission's spacing order stated that there should be "one well to 80 acres in order to drain efficiently, all of the recoverable oil from the sand pool, assure orderly and uniform development and avoid the drilling of unnecessary wells, and prevent waste in a manner that will protect correlative rights" (quoted in Talbot 2020, 118). Although the laws have evolved, the state's current Oil and Gas Conservation Act follows the same logic, placing "primary reliance on spacing and pooling to moderate the rule of capture," according to David Pierce, and although its "provisions on unitization" – or the consolidation of interests of mineral rights-holders laying claim to a shared supply – "are better than in many states [...] the statute still contemplates a passive role for the state regulatory commission" (Pierce 2009, 767; cf. Kramer 2015).

Currently, oil spacing units are larger than in the 1950s, generally 1,280 acres or 2 square miles (about 520 hectares or 5.2 square kilometres), although as figure 2.5 shows, density is greater in some regions where spacing units are decided on a case-by-case basis. The size of contemporary spacing units is the equivalent of two sections as defined by the Homestead Act, the topic of the next section (NDIC Oil and Gas Division 2024a). In that respect, spacing-related policy has also influenced the arrangement of wells, in particular, their alignment along the roads that run in neat parallel lines through North Dakota's townships.

2.3.3. Homestead Act, roads, and the arrangement of wells

Congress passed the Homestead Act in 1862 to encourage settlers from eastern states and from Europe to move to the American West. The act divided the West into townships made up of thirty-six sections, each of which was one square mile (about 2.6 square kilometres). Settlers could apply for 160 acres (65 hectares), or a quarter section, and if they lived on the land for five years and made improvements, they could "prove up" and acquire the title.[3]

The Homestead Act showed evidence of having been influenced by the same notion of homogeneous space as the rule of capture. For its authors, one section was no different from another: the land was an empty space upon which surveyors imposed a grid. (Of course, for settlers living there, each section presented different challenges, depending on its soil, proximity to sources of water, and so on.) Evidence of this interpretation of space is clear in maps of North Dakota even today: the state is crisscrossed at one-mile intervals by roads running north and south or east and west, following section lines. In Williams County, the sections themselves are visible in the 6-by-6 checker-boards contained within each township (figure 2.6).

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[3] As I write in the preface, in 1978, my parents bought part of a quarter section of land that had been homesteaded in the early twentieth century and "proven up" in 1913. I took the photo in figure 2.2 standing on a hill on that land.

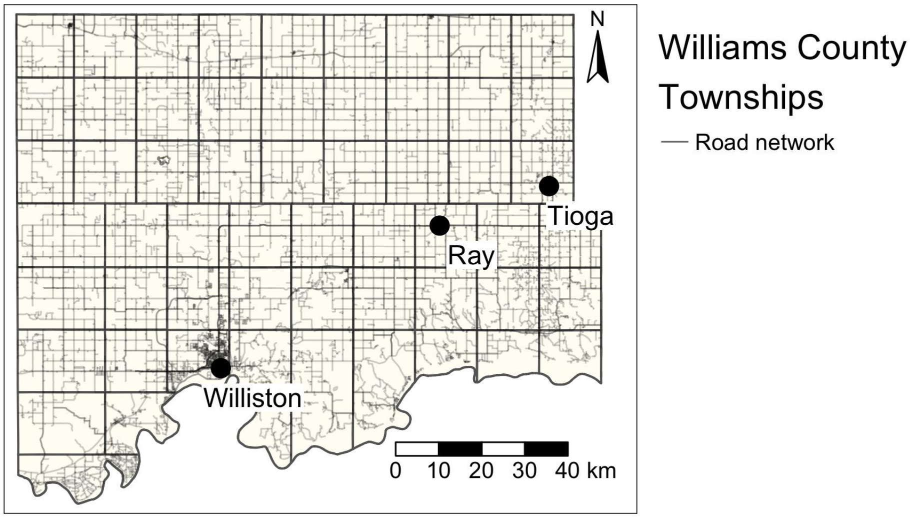

Figure 2.6. Williams County road network (indicated by light lines) in relation to the townships created by the *Homestead Act* of 1862 (indicated by heavy lines). Data sources: North Dakota GIS Hub (2002, 2007, 2023); U.S. Census Bureau (2021, 2023)

This arrangement helps explain a striking feature of the map showing the location of wells drilled between 2008 and 2019 (figure 2.5), namely the way they line up in tidy rows from east to west across the county. In short, they follow the roads (figure 2.7). This pattern results from "a series of proactive steps" taken by North Dakota to minimize the damaging ecological effects of energy development: "For example, the state has begun to focus development along energy corridors, which are spaced 6.4 km apart (the current length of laterals is approximately 3.2 km), with pads constructed on either side of the main service/access road" (Preston and Kim 2016, 1517).

To demonstrate the significance of this relationship, I analyzed well locations by using a Monte Carlo technique, simulating 99 point patterns within Williams County to compare to the observed well locations. I examined wells spudded between January 1, 2008, and December 31, 2019, following my density analysis above. Between these dates, 3,134 wells were spudded; thus each of my simulated point patterns also included 3,134 points. I calculated the mean distances from each simulated point to the nearest road, values that I compared to the mean distance of the observed points to the nearest road (about 290 metres). The result was clear: the *p*-value for a one-tailed test (to determine whether the observed mean distance was less than the simulated mean distances) was 0.01, suggesting that a random process of point generation would be unlikely to generate locations of wells as close to roads as those observed in Williams County. In other words, the proximity of wells to roads was not coincidental. (See appendix 1 for a full account of this process.)

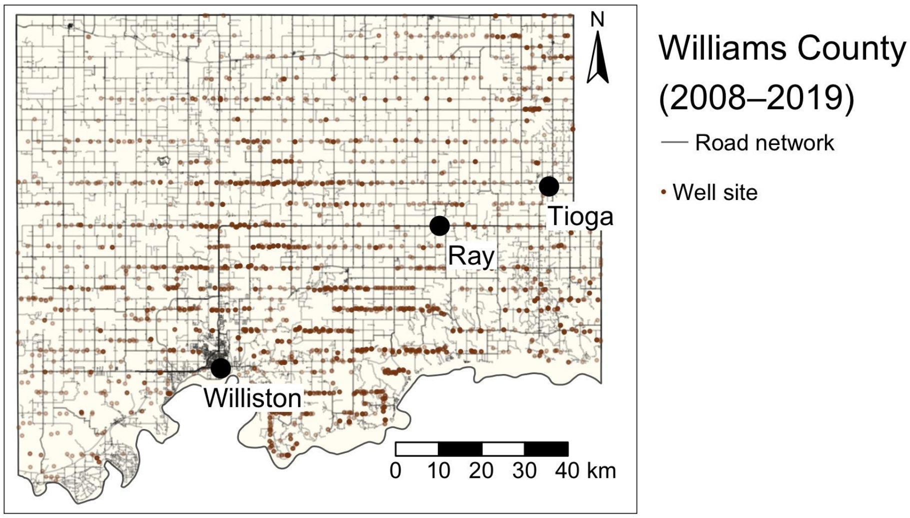

Figure 2.7. Sites of wells spudded between 2008 and 2019 in relation to roads in Williams County. Sources: North Dakota GIS Hub (2002, 2023); NDIC Oil and Gas Division (2024b); U.S. Census Bureau (2021, 2023)

Thus in the case of the Homestead Act, the link between interpretations of space as homogeneous and the placement of wells is fairly direct. The act imposed a grid on North Dakota in the form of townships. The state built roads to serve those townships, roads that passed between individual sections. The location of those roads shaped oil companies' choices about where to spud wells: even a century after the Homestead Act, the lines that surveyors drew influenced the ways people built on and altered the territorial configuration of the landscape they encountered.

2.4. Consequences of well spacing: Spatial distribution of brine spills

At least three factors, then, have contributed to where oil wells have been spudded in Williams County, North Dakota: the region's underlying geology, the density encouraged by the rule of capture, and the alignment resulting from the road grid following the lines initially established by the 1862 Homestead Act. How has the configuration of wells influenced the surrounding environment? To answer that question, I turn here to wastewater spills.

As fracking has increased, the demand for water has also increased. Although drilling companies are required to safely dispose of used fracking water (referred to as produced water, wastewater, or brine), “as much as 5% of all oil and gas wastewater is accidentally or illegally released into the environment” (Konkel 2016, A231). The map in figure 2.8 shows the location of spills between December 2013 and July 2019 (North Dakota Brine Spills 2022). The density pattern is remarkably similar to that of the 2008 boom (figure 2.5), and the spills are arranged in similar lines, following roads east-to-west across the county.

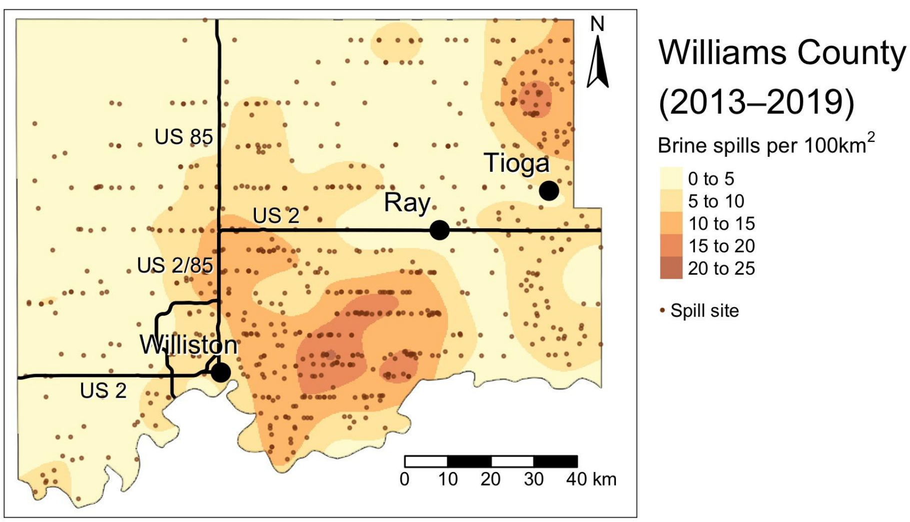

Figure 2.8. Density of brine and wastewater spill sites, December 2013–July 2019, in Williams County, North Dakota (kernel density estimation, σ = 5km). Data sources: North Dakota GIS Hub (2002, 2023), U.S. Census Bureau (2023), North Dakota Brine Spills (2022)

The increased water use was observable in three ways. First, the amount of water consumed for fracking (to create the slurry of chemicals and proppants used to release oil) rose from 2.9 billion to 16 billion litres between 2008 and 2012, to say nothing of the water consumed by the roughly 22,000 people who came to Williams County to work (between 2.4 billion and 4.9 billion litres in 2012, depending on the estimate) (Horner et al. 2016, 3278–9). Second, and in parallel to the water used for fracking, the amount of wastewater increased between 2008 and 2012, from 2.5 million to 8.7 million litres per well in the first year of operations (Horner et al. 2016, 3280). By 2016, North Dakota's 9,700 active wells were producing 119 billion litres of wastewater in total (Lauer et al. 2016, 5389).

The third increase – that of spills – follows from these two. Between 2007 and 2014, the rise in spills was directly proportional to the rise in oil wells (Lauer, Harkness, and Vengosh 2016, 5396). Not only were there more spills, but they also appeared to be bigger (although their volume was often hard to gauge because it went unreported) (Wirfs-Brock 2015). These patterns all suggest a relationship of spatial attraction between oil wells and spills, as do the visual similarities between the well and spill density maps (figures 2.5 and 2.8).

A cross-*K* test, based on Ripley's *K* function, confirms this relationship (Dixon 2013; O'Sullivan and Unwin 2010). To be precise, using the spatstat library in R, I tested all of the spill sites in relation to the wells spudded between 2008 and 2019 (again using the same subset of wells I used for the density analysis of the 2008 boom in sec. 2.3.1) (Baddeley and Turner 2005). I also tested individual years, from 2014 to 2018, the years with the most complete spill data. I compared each year's spill sites to the sites of wells spudded in the previous *two* years (for example, comparing 2014 spills to wells spudded in 2013 and 2014), given that wastewater is typically produced during or immediately after fracking and that fracked wells have a half-life of about a year, making the two first years their most productive (Maugeri 2013). I tested for significance using a Monte Carlo technique. For each set of observed data, I generated an envelope with 199 simulations, to which I appended my observed $\widehat{K}_{12}$ values. Using this envelope, I applied a one-tailed DCLF (Diggle-Cressie-Loosmore-Ford) goodness-of-fit test, examining whether the observed values were greater than the simulated values, which would indicate spatial attraction (Baddeley et al., 2014). (See appendix 2 for a full account of this process.) In every test but one, the *p*-values were 0.005, well below the threshold (α =

0.05) for rejecting the null hypothesis, according to which the relationship between well sites and spills would be one of spatial independence. The one divergent result was for spills observed in 2017, of which there were only three. However, they represented only about 0.5 percent of the overall total (N = 699).

This relationship raises questions about the impact of oil drilling on the environment, not only directly but also indirectly, through wastewater spills. It is difficult to assess the risk of spills because the chemical composition of the slurry drilling companies use is proprietary information (Konkel 2016, A231), but the ecological aftereffects are clear. Wastewater's high salinity kills plant life and reduces the soil's permeability, and "higher chloride concentrations in a wetland are associated with higher numbers of wells nearby" (Konkel 2016, A234). Remediation has "historically focused on restoring surface soils by reversing the effects of excess salts" (Konkel 2016, A234), but the process can be ecologically disruptive. In this respect, the high density of wells (and spills) in the Missouri Coteau Slope and River Breaks ecoregions is significant. These regions contain wetlands and border the Missouri River, the region's defining water feature. Wastewater spills pose a particular threat, especially in the agricultural sections of the Missouri Coteau Slope.

2.5. Conclusion: The territorial and semiotic configuration of the Bakken

This chapter has described the back-and-forth forms of influence between the "fixed spatial forms" of the Bakken landscape – its physical and built characteristics – and the ways people have interpreted them (Santos 2021a, 104). The region's underlying geology shaped where oil companies drilled wells, but so did nineteenth-century ideas that the American West was made up of empty space that could be divided in a grid-like manner or that landowners staked a claim to the minerals over which their land sat by drilling a well. The effects of the implementation of these ideas lingered long after the architects of the Homestead Act or rule of capture had passed away.

In this respect, the region's roughness, to return to Santos (2021a, 2021b), is visible in the density and arrangement of the wells in the oil fields of Williams County. They are a result not only of geology but also, to no less a degree, of the circulation and accumulation of capital, as encouraged by the laws and policies shaping the historical and ongoing settlement of the American West. In other words, they embody the representations of space created by "scientists, planners, urbanists, technocratic subdividers and social engineers," people who exercise forms of official or State power (Lefebvre 1991, 38). They are, however, only one moment in that dialectic of accumulation, as the oilfields in turn exert an influence on the Bakken (and the broader region) through secondary effects such as wastewater spills.

The mutual influence between the territorial and semiotic configurations of the Bakken landscape raises further questions about *residents'* interpretation of space. The maps throughout this chapter show the degree to which the landscape for which they were nostalgic, as cited in the opening paragraphs of chapter 1, was coloured by their nostalgia. The "prairie idyll" they mourned as lost "to widespread drilling and disruption" was very much a *settler* landscape (Thomas and Braun 2023, xii). The structures of earlier booms predated the 2008 boom by decades, while the conceptual grids imposed on the land predated the 2008 boom by more than a century. People's nostalgic comments reflected an increased density of activity, but not a fundamentally new situation.

At the same time, residents' concerns were tied up in a network of concerns about housing, jobs, and access to social services: increased industrialization was just one problem among others that were all symptoms of the boom itself. These were the concerns of "space as directly *lived* through its associated images and symbols [...] the dominated – and hence passively experienced – space which the imagination seeks to change and appropriate" (Lefebvre 1991, 39). They evoked a wider range of responses than what I have considered in this chapter, which has been narrowly focused on factors influencing where oil companies drilled wells. It is to that broader sense of interpretation that I turn in the next chapter.

3. Semiotic Configuration of the Bakken Landscape

3.1. Introduction: The meaning of North Dakota's landscape

This chapter asks:

- How did usage patterns of key terms related to landscape evolve in letters to the editor published by the *Williston Herald* between 2009 and 2019?

This question, however, presupposes several others. How does landscape relate to meaning, especially in light of the last chapter's discussion of the Bakken's territorial configuration? What value is there in looking at letters to the editor, and what do we find when we do? In this introductory section, I answer the first question (about landscape and meaning), leaving the second (about letters to the *Williston Herald*) for the rest of the chapter.

With respect to the meaning of *landscape*, in chapter 1, I cite Jean-Marc Besse, for whom landscape is "*le milieu et le résultat tangible des échanges matériels et sensibles de l'être humain avec le monde environnant*" ("the setting and tangible result of the perceptible, material exchanges of humans with the surrounding world") (2018, 53, my translation). It is defined, he says, by the conceptual tensions where these exchanges take place. The term itself operates in a semantic field linking nature, territory, vision, and ambiance, where each idea is shaped by forces pulling and pushing it in different directions. *Nature*, for instance, pulls between the exterior world-as-object and the interior world of people's experience. *Territory* pulls between the idea of a place over which people exercise power and a place where people dwell. *Vision* pulls between sight (and other senses) and broader affective phenomena, a category that Besse extends with the idea of *ambiance*, on the one hand characterized by "*l'ensemble des gestes habituels par lesquels nous agissons dans le monde*" ("the set of ordinary gestures through which we act in the world"), on the other by a space's "tonality" or "rhythm" to which people can attune themselves (2018, 11–29, my translation). John Wiley offers a similar (but simpler) assessment: the tensions of landscape, he says, operate between "proximity and distance, body and mind, sensuous immersion and detached observation" (2007, 1).

Semiosis, or the capacity of signs to evoke other signs, is at the heart of these tensions, the means by which their components pull against each other. Thus the question of meaning, in particular *contested* meaning, is central, so much so that semiotics is one of two major discourses characterizing landscape studies, the other being ecological (Cosgrove 2003). The precedents of this discourse reach as far back as Paul Vidal de la Blache (1911), who a century ago encouraged geographers to "read" the features of physical landscape as an index of human interaction with the environment. And its importance continues. Timo Maran's (2020) ecosemiotics, for instance, arrives at a point similar to Vidal de la Blache's but expands the range of actors beyond humans.

The bulk of work on semiotics, however, began in the 1960s, the quantity and range of work increasing in the 1980s and 90s (Lindström, Palang, and Kull 2019). During this time, scholars focused on texts about landscapes or on landscapes-as-texts. One important book, *The Iconography of Landscape*, published in 1988, drew on the techniques of art history to interpret visual representations of landscapes (Cosgrove and Daniels 1988). An even more influential approach derived from a reinterpretation of structural linguistics, following precepts set out by Ferdinand de Saussure in his *Cours de linguistique générale* (1995; see Lindström, Panang, and Kull 2019). James Duncan and Nancy Duncan, for instance, draw on structuralist and poststructuralist scholars to describe how landscapes are "constructed on the basis of a set of texts, how they are read, and how they act as a mediating influence, shaping behavior in the image of the text" (1988, 120). By the 1990s and 2000s, scholars' concerns expanded to include the ways discursive power operates in the production of landscape understood not (merely) as a set of topographical features but as a field of meaning constituted by discourse itself (Matless 1992; Duncan and Duncan 2003).

The vastness of this literature stands in contrast to the sparseness of the literature about the particular landscape I am concerned with, namely North Dakota's. On the one hand, during the 2008 Bakken oil boom, memoirists and public intellectuals published a handful of books describing what the land meant to them and how it was changing. Lisa Westberg Peters (2014), for instance, wrote about her ambivalence as an environmentalist who inherited mineral rights in the heart of oil country, while Clay Jenkinson warned of the

> wholesale industrialization of the landscape of western North Dakota [… marked by] oil pads on virtually every other section of some parts of the state until you can walk from Minot to Wolf Point, Montana, or Medicine Hat, Alberta, at midnight by following the methane flares. (2012, 320)

On the other hand, it is unclear how widely their interpretations were shared or the degree to which others saw the changes differently. Hence my focus in this chapter. I examine all of the letters to the editor about the Bakken boom published between March 2009 and February 2019 and archived on the website of the *Williston Herald*, the newspaper serving the largest town in the region. Broadly speaking, my approach is that of "distant reading" as described by Franco Moretti, who argues that when researchers focus on patterns that emerge across multiple texts, distance becomes "*a condition of knowledge*: it allows you to focus on units that are much smaller or much larger than the text: devices, themes, tropes" (2000, 57, original emphasis) – or, in my case, collective meanings. More narrowly, I am building on work by Felix Fernando and Dennis Cooley, who also examine letters to the editor published in the *Herald* (Fernando 2016; Fernando and Cooley 2016a, 2016b). Although their focus – quality of life – is different from mine, they reach conclusions that point to residents' widespread concern about the landscape. They write that one of the most frequently mentioned factors influencing quality of life was the "serenity and tranquility of the surrounding environment" (Fernando 2016, 34), whose loss was observable in the "noise, increased traffic on rural roads, dust, and rapid pace of change" (Fernando and Cooley 2016b, 1102).

At the level of theory, my concerns are rooted in phenomenology, a subset of semiotic research that focuses on how the meanings people attribute to a landscape "are generated in the phenomenal world and in respect to the corporeality of the person who dwells in a landscape" (Lindström, Panang, and Kull 2019, 80). As outlined in chapter 1, I examine the contestation of meaning through a Marxist lens, while my semiotics, in contrast to the structuralism of the 1980s and 90s, derives from the work of Charles Peirce.

To examine my corpus, I use tools of discourse analysis, combining manual coding and text mining, a form of natural language processing that identifies patterns within and across a corpus (Jain, Murty, and Flynn 1999; Saldaña 2013). Through an iterative series of steps, I identify the themes structuring how letter-writers interpreted their relation to the landscape, as well as clusters of words reflecting – or so I contend – the ideas that they associated with the landscape's different dimensions. The patterns I identify reveal the representational spaces of residents, as opposed to the representations of space advanced by people in positions of authority or power, as described in chapter 2. Letter-writers negotiated their relationship to the landscape in more complex ways than personal accounts by memoirists and public intellectuals would suggest. They were concerned with more than just the "natural" environment (where *nature* was itself a complicated term), writing also of wells, buildings, roads, and other infrastructure, whose value they weighed against that of the jobs the boom created. Although some rehearsed narratives of decline and environmental degradation, many saw change as necessary, even beneficial.

The rest of this chapter continues with an overview of letters to the editor as an object of study (sec. 3.2) followed by a description of the *Herald* corpus and a guide to its analysis (secs. 3.2.1–3).

Then it proceeds by working from a wide to a narrow description of the patterns emerging from the letters (sec. 3.3), looking first at relationships among broad topics covered (sec. 3.3.1), then at patterns of word usage among those topics (secs. 3.3.2–3). These sections describe the discursive fabric on which the threads of landscape pull. The final sections describe the threads themselves, treating contention as a manifestation of roughness (as theorized by Milton Santos) and focusing on what letter-writers said about jobs and economic development, about the environment, and about housing in relation to changes they were observing in the landscape (secs. 3.3.4–6). The trend over the ten years examined here was one of levelling-out – letter-writers addressed a wider range of topics in 2009 than in 2019, and from a wider range of perspectives. By 2019, jobs and economic development emerged as the primary concerns, while questions of landscape, prominent in 2009, were relegated to the background. I conclude by returning to a theme running through chapters 1 and 2, that of the petroleumscape and the production of social space (sec. 3.4). The expanded range of interpretation results from the larger group of interpreters playing a more diverse set of social roles, illustrating the complex interplay between official discourses ("representations of space"), citizen discourses ("representations of space"), and the spatial practices out of which landscape grows (Lefebvre 1991).

3.2. Letters to the editor as object of study

As objects of study, letters to the editor occupy a distinct place in the field of communication. On the one hand, they provide one of the rare sites where non-professionals can express their opinions to a relatively large audience. As I write in chapter 1, they reflect the priorities of writers who adopt a public mode of address in an effort to persuade readers. Certainly other venues exist, such as social media platforms or news website comment sections, but they are not invested with the same institutional authority as letters to the editor, whose history in North America reaches back at least to the beginning of the twentieth century (Cavanagh and Steel 2019).

On the other hand, letters to the editor are not a "straightforward representation of public opinion" but are instead "carefully crafted and curated products of editorial processes" (Wahl-Jorgensen 2019, viii). Indeed, their authority derives in no small part from this selection process, in contrast, for instance, to unmoderated online comment sections. Editors typically choose letters as a function of their relevance, their brevity, their capacity to capture readers' attention, and the authority of their authors, however they might establish it (Wahl-Jorgenson 2002). In the case of the *Williston Herald*, managing editor Jacob Brooks explained that his main criterion was "local interest" – letters either had to be by local authors or, if the author was from somewhere else, had to be about matters of local concern. The best letters, he said, "are brief and to the point" and "present a clear point of view and back their point of view with documented examples." In this way, the *Herald* could "make sure our community has a voice" (Brooks 2012). Letters might have gone through a selection process, but it was one designed to uphold ideals of balance (Brooks 2011; Wahl-Jorgensen 2019).

Consequently, as objects of study, letters to the editor reveal something particular about public meaning. Their authors are not representative of a community at large, nor is their content representative of the broader discourse.[1] Instead, they simultaneously constitute and make manifest a range of meanings that serve as shared points of reference, albeit ones that are often contested. Words' meanings expand as letter-writers take into account the way that

> a word presents itself not as an item of vocabulary but as a word that has been used in a wide variety of utterances by co-speaker A, co-speaker B, co-speaker C and so on, and has been variously used in the speaker's own utterances. (Vološinov 1986, 70)

They respond to each other and anticipate each other's responses in turn, crafting their letters to "parry objections that [they] foresee" and "make all kinds of provisos, and so forth" (Bakhtin 1986,

[1] What form would a representative sample of the broader discourse take? How could researchers even identify or observe this "broader sample," especially after ephemeral texts such as conversations in passing have been forgotten?

95). Meaning is shaped through this give-and-take, as over the course of an exchange, writers account for the evolving use of words by their ever-expanding cohort of co-speakers (Conway 2020a).

3.2.1. The Herald *corpus*

I created my corpus by using three search tools – Google, Bing, and the *Herald*'s own search bar – to find letters containing at least one of the keywords *Bakken*, *oil*, or *boom*. For Google and Bing, I used the "site:" operator to limit searches to the subdomain www.willistonherald.com/opinion/letters_to_editor. For the *Herald*'s search engine, I searched "boom letter to the editor." I performed the search in February 2019, and although I looked for letters from as far back as 2008, the first letter I found was published in March 2009. I included letters after the putative end of the boom (in 2014, when oil prices fell too low for new wells to be profitable) because the boom's effects could still be felt in the region.

This initial process yielded more than 150 letters. After deleting duplicates and letters that contained one or more keywords but did not relate to the boom, I had 132 letters, written by 115 distinct authors (some authors writing more than one letter, some letters having more than one author). They came largely from the surrounding region, but some came from as far away as Georgia, Florida, Idaho, Texas, and Arizona.

3.2.2. Analytical steps: Corpus-level coding, text mining, subcorpus-level coding

My analysis involved three steps, the first of which was manual coding. I worked with a research assistant to code letters using attribute coding (concerned with "basic descriptive information"), structural coding (concerned with "commonalities, differences, and relationships" among segments), and descriptive coding (concerned with the "basic topics" covered by a corpus) (Saldaña 2013, 70, 84, 88). We noted authors' place of residence (if given) and their general disposition toward the boom (favourable, unfavourable, or neutral).[2] Then we catalogued specific topics, starting with those we expected to find based on our knowledge of the boom and on prior research (for example, Fernando 2016), noting each letter that contained terms related to a given topic. Finally, we extrapolated topics that writers addressed without using the key words we were looking for. Our approach was iterative, some topics proving less common than expected, some proving more, the three most prominent being jobs and economic development, the environment, and housing.

My second step involved text mining. I first removed common words using a modified version of the stop_words dataset from the tidytext package in R (Silge and Robinson 2016), before reducing the remaining words to their more basic lemma forms (singular instead of plural nouns, infinitive rather than conjugated verbs, and so on).[3] I used three tools to analyze this cleaned-up corpus: first, co-occurrence analysis (to describe the observed occurrences of words appearing together in the same letter), then correspondence analysis (to calculate words' relative similarity), and finally sentiment analysis (to approximate a letter's emotional valence by imputing values to the words it contains) (Leetaru 2012; Bock 2021). I performed the co-occurrence and sentiment analyses in R (R Core Team 2022; Silge and Robinson 2016, 2017); for a detailed account of the process, see appendix 3. For the correspondence analysis, I used the application KH Coder (Higuchi 2001, 2016, 2017).

My approach reflects Peirce's idea that meaning is constituted by the associations evoked by a sign. I organized my corpus so that the overarching sign was that of the boom itself; the topics my research assistant and I identified through coding were first-order associations as well as signs in their

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[2] We classified letters as favourable if they advocated for maintaining or expanding oil extraction activities or for programs or policies, such as decreasing taxes, that were supported by the industry. We also classified them as favourable if their authors considered services (such as trash collection) as adequate or defended Williston and the region against critique. We classified them as unfavourable if they advocated for decreasing oil extraction activities, increasing taxes, or stopping bills supported by the industry, or if their authors considered services inadequate or agreed with critiques of the region.

[3] With respect to the stop word list, I removed *area*, *place*, and *problem* while adding *North*, *Dakota*, *oil*, the number *1*, and the first and last names of two politicians – Marcus Jundt and Heidi Heitkamp – who were the subject of a series of letters at specific moments over the course of the decade.

There remained 20,366 words – then transformed into 20,366 lemmas – after the removal of stop words.

own right (hence interpretants, in Peirce's term), which evoked still more associations. Although letter-writers rarely defined words in an explicit way, the meanings they made of the boom – that is, the ideas they associated with it and with jobs, the environment, housing, and so on – were observable in their assertions about what the boom *did*. Rather than say "the boom is a job-maker," they would say "the boom has created jobs" (e.g., Hamm 2012). In this way, they described the associations that different signs evoked for them. Likewise, by trying to persuade readers, they worked to evoke specific associations for others. Simply put, words appeared together in the same letter because writers were drawing links between them, links that co-occurrence and correspondence analyses bring to light. In J.R. Firth's pithy turn of phrase, "You shall know a word by the company it keeps" (1968, 179; regarding text mining, see Leydesdorff and Welbers 2011).

Other tools are necessary, however, to interpret these links, which are inherently polysemic because words can be used together in multiple, contradictory ways (Leetaru 2012, chap. 4). Sentiment analysis, which reveals affective relationships between words, is one such tool (Hu and Liu 2004; Mohammed and Turney 2013; Nielson 2011). Another – the third step in my analysis – involves a more focused round of coding. Here I created three sub-corpora consisting of the letters mentioning jobs, housing, and the environment, coding them to highlight ideas related to landscape. I looked for mentions of any "portion of the earth's surface that can be viewed from one spot" (Cresswell 2004, 10), a heuristically useful definition of *landscape*. I classified the values writers attributed to the landscape as *functional* (expressing the idea that changes will be useful or serve a purpose), *cognitive* (expressing how people interpreted the landscape, identifiable by the framework they employed), or *affective* (expressing either an emotional attachment to or an aesthetic judgment of the landscape) (Fernando and Cooley 2016a).

3.2.3. The value of discourse analysis

Discourse analysis is an art requiring creativity and a craft requiring practice, but it is not a science. As an "exploratory problem-solving technique without specific formulas or algorithms to follow" (Saldaña 2013, 8), its value is heuristic and interpretive, but not predictive. It demonstrates rigour through the rules the researcher establishes for data gathering and analysis. In the first instance, as the researcher builds a corpus, are criteria for including or excluding texts unambiguous? In the second, can categories be operationalized in ways that allow different researchers to classify texts in similar ways (Saldaña 2013, 35)? In this respect discourse analysis is inductive and hermeneutic, relying on the plausibility of its explanations: to what degree are they internally consistent, linking the various parts of a corpus to each other, and to what degree are they externally compelling, accounting for the complex ways the corpus relates to the larger discursive world (Saldaña 2013, 39; Conway 2023, 58–71; cf. Ricœur 1972)?

It would be a mistake, then, to read too deeply into the numerical values produced in the process of text mining. What matters are the patterns that the analyses reveal, placed in the context of the meanings gleaned from the manual coding that organized my text mining strategies and that explains the connections text mining brings to light.

3.3. The meanings of landscape during the boom

To understand the meaning letter-writers attributed to different aspects of the boom, it is useful to consider, first, the broad patterns that emerge from the first round of manual coding (sec. 3.3.1) and from the co-occurrence analyses (sec. 3.3.2), then the patterns that emerge over time, revealed by correspondence analysis (sec. 3.3.3), which provides a clearer interpretive structure related to roughness (sec. 3.3.4–6), as defined in chapter 1.

3.3.1. Manual coding: Topic map and cross-tabulation

As mentioned in sec. 3.2.2, the first round of manual coding revealed jobs and economic development, the environment, and housing as the three most commonly mentioned topics. Others included infrastructure, taxes, the local, state, and federal governments, crime, traffic, and the anticipated duration of the boom. Figure 3.1 shows the links between topics appearing together in at least ten letters.

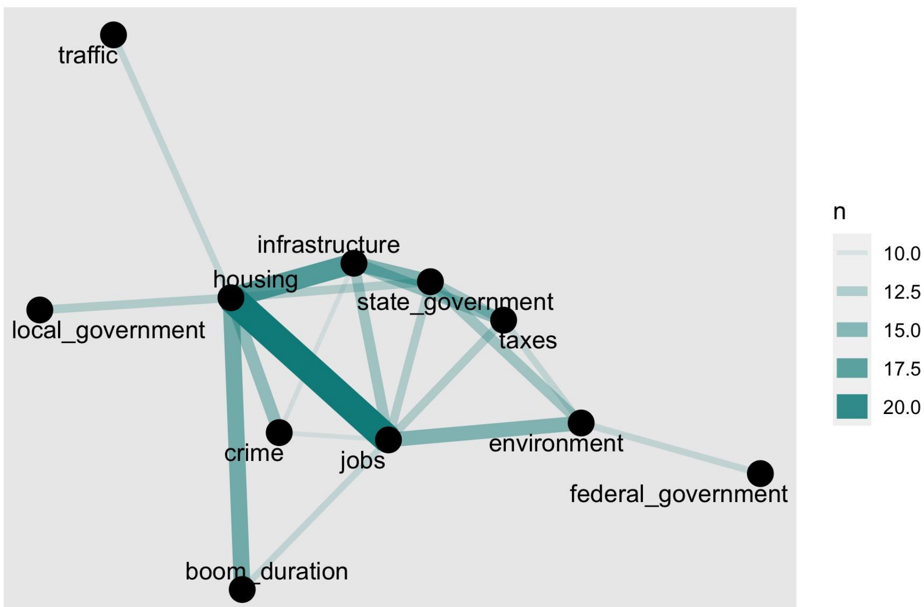

Figure 3.1. Co-occurrence map of hand-coded topics in *Williston Herald* letters about the Bakken boom, March 26, 2009–February 12, 2019 (minimum 10 co-occurrence pairs)

Two interesting patterns emerge among the three most frequent topics. First, frequency itself did not necessarily imply centrality, if centrality is measured by the number of edges connecting topics to other nodes. By this measure, jobs and housing, each with seven edges, were equally central, while the environment had only four. The topics clustered around housing (especially traffic and infrastructure) and around jobs (especially housing and infrastructure) were also more closely related to landscape than those clustered around the environment, which was linked to the state and federal levels of government and to jobs and taxes, rather than to topics related more directly to landscape.

Second, letters that mentioned jobs tended to be favourably disposed toward the boom, while those that mentioned the environment or housing tended to be unfavourably disposed. However, those that mentioned jobs *also* frequently mentioned housing and the environment, and vice versa (table 3.1). This contradiction suggests that letter-writers gave (and responded to) counter arguments that they anticipated. I will return to this contradiction in sections 3.3.3–6.

Table 3.1. Letters to the editor related to the Bakken oil boom, published in the *Williston Herald* between March 26, 2009, and February 12, 2019, cross-tabulated by topic and frequency

As a group, letters that mentioned:	… tended to adopt a disposition toward the boom that was:	… and also to mention:
Jobs and economic development (n=46)	Very favourable (29 favourable, 14 unfavourable, 3 neutral)	Housing (n=22) Environment (n=15) Infrastructure and services (n=13)
Environment (n=44)	Very unfavourable (16 favourable, 25 unfavourable, 3 neutral)	Jobs, economic development (n=15) State government, bills, and laws (n=13) Taxes, funding, revenue (n=11)
Housing (n=43)	Somewhat unfavourable (16 favourable, 19 unfavourable, 8 neutral)	Jobs, economic development (n=22) Infrastructure and services (n=18) Boom duration (n=16)

3.3.2. Co-occurrence analyses and semantic maps

To create semantic maps related to the top three topics, I began by identifying the three most frequent lemmas corresponding more or less exclusively to a given topic.[4] For instance, although *Williston* and *people* are the two most frequent lemmas overall, they are present in discussions of all of the topics we identified. In contrast, *water*, the third most frequent lemma, is related more closely to the

[4] Section A3.3.1 in appendix 1 lists the most frequent lemmas in the corpus.

environment (one of the top three topics) than to jobs or housing (the other two). For jobs and economic development, the top three lemmas were *industry*, *pay*, and *job*; for the environment, they were *water*, *gas*, and *land*; and for housing, they were *house*, *home*, and *build*.[5] Then for each topic, I created maps of lemma pairs that included at least one of the three lemmas.

Figure 3.2 shows the map generated by the three most frequent lemmas associated with jobs and economic development, namely *industry*, *pay*, and *job*.

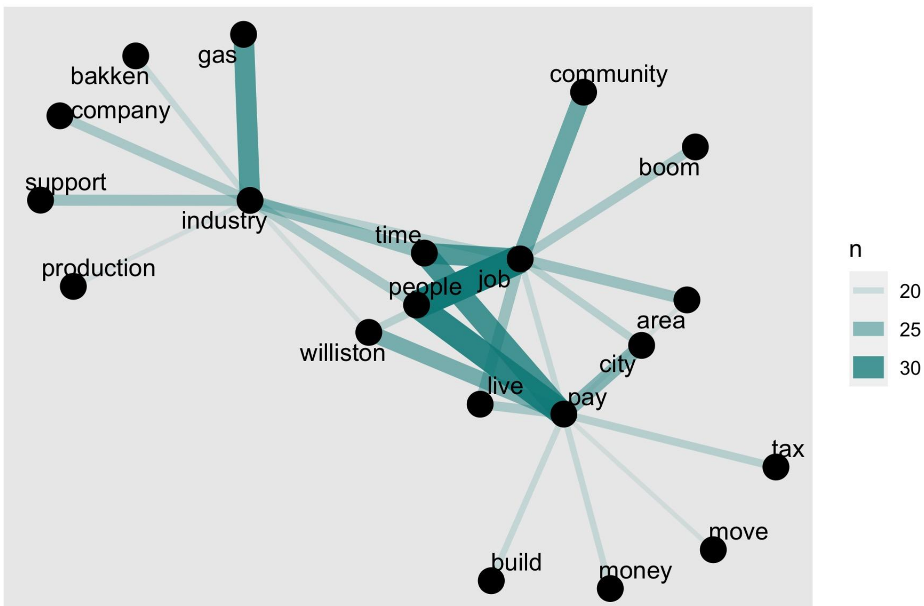

Figure 3.2. Co-occurrence map related to jobs and economic development, showing all lemma pairs that include *industry*, *pay*, and *job* (minimum 19 co-occurrence pairs)

The clusters around the three most frequent lemmas are relatively distinct, although some lemmas (*time*, *people*, and *Williston*) are shared by all three. The clusters themselves are suggestive of different dimensions of people's concerns. Those around *pay*, especially *tax*, *move*, and *build* (which are not in any other clusters) along with *live*, *city*, and *area*, relate largely to the lives of workers, who

[5] The choice of relevant lemmas is one place where coding's heuristic – and decidedly non-objective – qualities are clear. I could potentially have chosen other lemmas (*build*, for instance, also relates to infrastructure), but these were the ones that I found through an iterative process of refinement. In short, they revealed relationships similar to those I observed elsewhere, each analysis providing complementary parts of my broader interpretation.

had to move to the region and wanted homes to be built. Those around *job*, in contrast, especially *community* and *boom*, along with *live*, *city*, and *area* relate to the impact on the region. Finally, those around *industry*, especially *gas*, *production*, and *company*, relate (not surprisingly) to the role of oil companies themselves. The correspondence analysis in sec. 3.3.3 supports this interpretation: a shift in emphasis over time, as we will see, from the concerns of workers to those of the community and finally of industry is reflected in these clusters.

Figure 3.3 shows the map generated by the three most frequent lemmas associated with the environment, namely *water*, *gas*, and *land*.

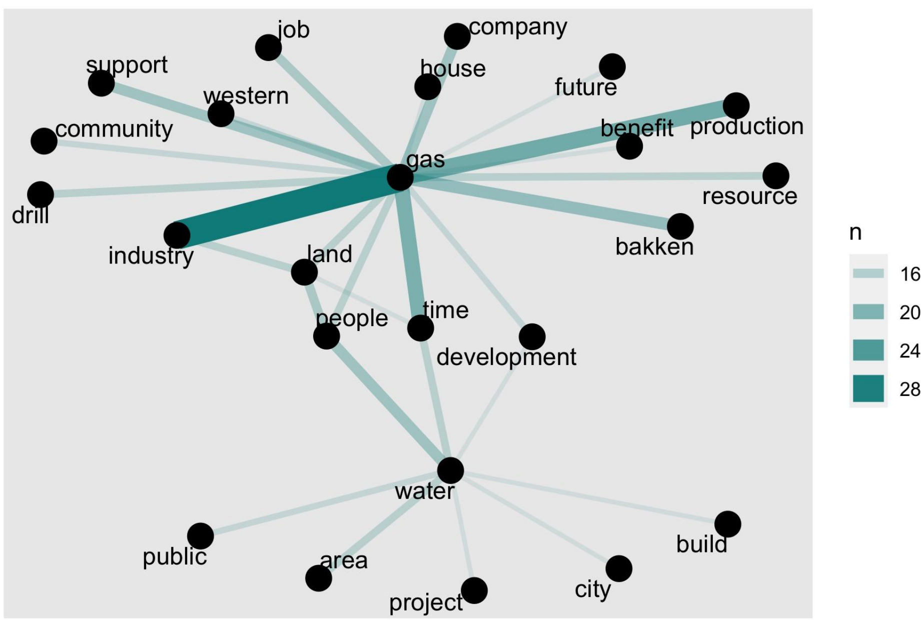

Figure 3.3. Co-occurrence map related to the environment, showing all lemma pairs that include *water*, *gas*, or *land* (minimum 13 co-occurrence pairs)

Two of the clusters in this semantic map are relatively distinct, namely those around *gas* and *water*. However, the third lemma, *land*, is completely subsumed within the *gas* cluster. Interestingly, both the map relating to jobs and the map relating to the environment have an edge linking *gas* and *industry*, a pair that occurs frequently in both fields and suggests paths of associations linking the topics of jobs and the environment. *Bakken*, *company*, and *production*, for example, link to *industry* in the jobs map. *Industry* links to *gas*, which in turn links to *drill*, *community*, and *future* in the environment map (not to mention *Bakken*, *company*, and *production*!). As I write below (secs. 3.3.3–6), the patterns with which these terms appear are indicative of the competing values letter-writers associated with them, manifest in their efforts to anticipate and respond to counter-arguments.

Figure 3.4 shows the map generated by the three most frequent lemmas associated with housing, namely *house*, *home*, and *build*.

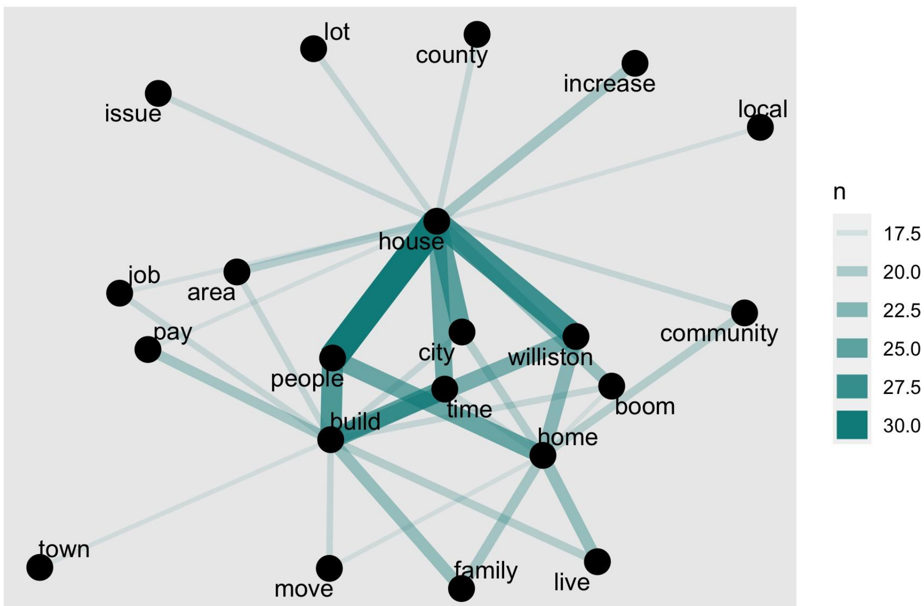

Figure 3.4. Co-occurrence map related to housing, showing all lemma pairs that include *house*, *home*, or *build* (minimum 18 co-occurrence pairs)

The clusters in this semantic map are less distinct than those in the other two. The clusters surrounding *home* and *build* overlap considerably (and the two lemmas themselves appear together in a number of pairs just below the minimum threshold I used to make this map). The cluster around *house* is more distinct, however, and includes five lemmas not included elsewhere (*issue*, *lot*, *county*, *increase*, and *local*). In contrast, the cluster around *build* has only one distinct lemma (*town*), while that around *home* has none. The edge linking *pay* and *build* appears in both the job- and the housing-related semantic maps.

Taken together, these maps suggest a number of meaning-related tensions. The competing interests within the region are clear – workers coming to the region, the people already there, and oil companies all found value in different dimensions of the boom. The maps also suggest that letter-writers associated different types of value with different terms. In the housing map, for instance, the lemmas surrounding *house* are largely functional, related to problems to be solved, while those surrounding *home* and *build* touch on affective dimensions of belonging (*family*, *live*, *community*), while *build* also includes functional, industry-related lemmas (*job*, *pay*).

How did the evolution of these associations shape the meaning that people associated with the changing landscape? That question returns us to the notion of roughness.

3.3.3. Correspondence analysis: Change over time

In chapter 1, I quoted Milton Santos's definition of "roughness," or "that which remains from the past as form, as built space, landscape, what is left over from the process of suppression, accumulation, and superposition, that with which things replace themselves and accumulate in all places" (2021b, 89). I suggested that we can understand roughness in a semiotic sense, too, as a function of "word memory," observable in "the resistance speakers encounter when using certain words, especially those whose meanings are contested" (sec. 1.3.3). What form does this resistance take? That is, where are words contested, and, in contrast, where are their meanings unremarked upon?

Roughness in this sense is already suggested by the disagreement in disposition characterizing letters, described in table 3.1, and in the conceptual tensions described above. Another form of text mining, correspondence analysis, provides a visual representation of the evolving ways letter-writers talked about the boom. Figure 3.5 maps clusters of word stems[6] in relation to three different time periods, 2009–11, 2012–14, and 2015–19.[7]

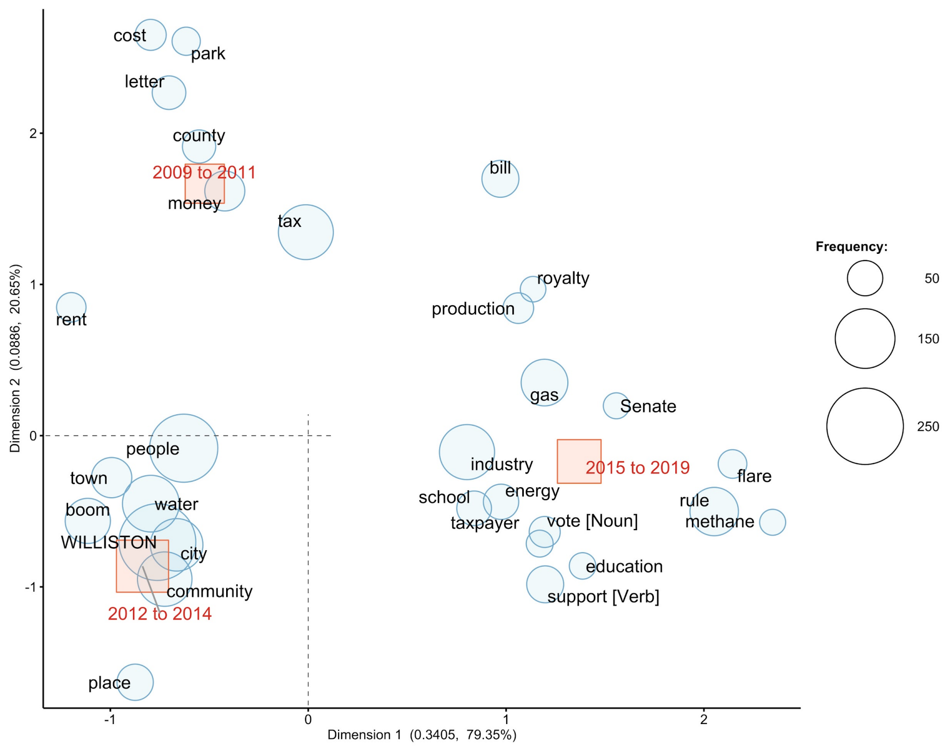

Figure 3.5. Correspondence analysis for the thirty most frequent word stems for the letters to the editor about the Bakken oil boom published in the *Williston Herald*, March 28, 2009–April 12, 2019. Source: adapted from Mercier (2020)

This analysis organizes elements by determining two dimensions (which are constructed from the data themselves and do not correspond to real-world measurements) that account for the degrees of similarity and difference between different elements. In this case, dimension 1 (along the horizontal x-axis) accounts for a little less than 80 percent of the differences, while dimension 2 (along the vertical

[6] For this analysis, I used KH Coder rather than R. It identifies word stems instead of lemmas.
[7] I established this grouping with a research assistant. Together we observed that "the limited number of letters for some years severely restricted the grouping options" (Mercier 2020, 3), leading us to test two different groupings, one with three (used here), and one with four. Three groups provided greater explanatory power than four, especially because the last year of the second group – 2014 – marked the point where oil prices fell too low for new wells were profitable. This drop provided a material interpretation of the discursive changes we observed (sec. 3.3.6).

y-axis) accounts for a little more than 20 percent (Mercier 2020, 20). This figure reveals that two thematic shifts – one major, one minor – took place between 2009 and 2019. The major shift took place between 2014 and 2015. The letters from 2009–11 and 2012–14 are grouped closely together on the left side of the x-axis (the dimension that accounts for a greater degree of difference), while those from 2015–19 are on the right. The key terms in the first two groups tend to relate to ideas of community and geography (*town*, *county*, *Williston*), while those in the final group tend to relate to industry and politics (*gas*, *revenue*, *methane*, *taxpayer*), indicating a shift in emphasis around 2014 or 2015. The minor shift took place between 2011 and 2012. The letters from 2009–11 are grouped apart from those from 2012–14 and 2015–19 on the y-axis (the dimension that accounts for a smaller degree of difference). In this case, the shift is from questions of economy in the early days of the boom (*money*, *tax*, *cost*) to community and industry later (*town*, *Williston*, *education*, *rule*, *flare*) (Mercier 2020, 20–1).

This analysis complements the co-occurrence analysis above. Consider the patterns that emerge with respect to the topic of jobs and economic development (figure 3.2). The word stems that characterize letters from 2009–11 overlap with the lemmas in the *pay* cluster (notably *money* and *tax*, which are not associated with any other cluster). Similarly, those from 2012–14 overlap with the *job* cluster (notably *community* and *boom*), and those from 2015–19 overlap with the *industry* cluster (notably *gas*, *production*, and *support*). Combined, the co-occurrence and correspondence analyses reveal a shift from 2009 to 2019: initially, letter-writers were concerned about the economy and jobs, while later they were concerned about industry and its byproducts. They related those concerns to their community, making different dimensions salient as a function of the lens – economy/jobs or industry/industry's byproducts – through which they observed it.

Specific historical events, hinted at in the co-occurrence map related to the environment (figure 3.3), support this interpretation. The two distinct clusters related to the environment – one around *water*, the other around *gas* – come largely from two specific events. Most of the letters mentioning water were about the Western Area Water Supply (WAWS) project, which was passed during the 2011 state legislative session. WAWS was (and is) a public authority supplying water from the Missouri River to the region including the Bakken, paid for in part by selling excess water to the oil industry. Private water suppliers had an ambivalent relationship to it as a competitor (Mortenson 2011, 2013), although politicians applauded the way it allowed "local entities to solve their drinking water issues through a regional solution, while having the ability to pay off debt with the sale of industrial water" (Koeser and Zubke 2013).

Most of the letters mentioning gas appeared after North Dakota sued the federal Bureau of Land Management to repeal rules meant to reduce methane production. The vote to repeal the rules took place in 2017. It failed, North Dakota senator Heidi Heitkamp providing the decisive vote. Many letter-writers, especially those voicing explicit concerns about the environment, expressed support for Heitkamp (e.g., Bird Bear 2017; S. Ventsch 2017), while representatives of the energy industry, along with their supporters, disapproved (e.g., Streyle 2017; Wald 2017).

3.3.4. Roughness in the landscape's semiotic configuration: Jobs, housing, environment

These changes over time define the roughness of the landscape's semiotic configuration. The trend was one of levelling-out: the letters showed more contention (and therefore more roughness) in 2009 than in 2019. In 2009, writers addressed a wider range of topics – all three of those described above figure prominently – than in 2019, when they focused largely on jobs and economic development. In 2009, they also invoked a wider range of values – functional (related to cause and effect), cognitive (related to identifiable interpretive frames), and affective (related to aesthetic judgments or expressions of emotion) – than in 2019, when the values they invoked were largely functional. These trends were also manifest in the increasingly positive tone of letters (see sec. 3.3.5).

Each of the three topics described above had a different relationship to the landscape. Although the most prominent topic was jobs and economic development, its relationship was indirect: it acted as a mediating factor, influencing letter-writers' relationship to the landscape by virtue of the fact that job-creation was an inescapable topic. It was, in fact, the source of the boom and thus something that influenced how people interpreted the other changes that economic development brought about. In contrast, housing represented one of the most salient aspects of the built landscape. Similarly, the environment was directly related to the landscape. In fact, for the majority of letter-writers, the environment was *synonymous* with the landscape (rather than with climate change, for instance) (see Fernando 2016; Fernando and Cooley 2016a, 2016b).

Table 3.2 provides examples of statements drawn from letters whose authors were favourably or unfavourably disposed toward the boom, broken down by the values on which they rested. I identified values heuristically: functional values were often signalled by "if-then" formulations indicating cause and effect (although the conditionality was also often implied). Cognitive values were identifiable by the interpretive frames used by letter-writers, which I have named. Affective values expressed emotion or the impact of the landscape's aesthetic qualities on the letter-writer's psychological state and were signalled by words indicating feelings or the perception of beauty (or ugliness).

Table 3.2. Examples of statements attributing functional, cognitive, and affective values to the Bakken landscape, from the subcorpus of letters addressing the topic of jobs and economic development

Value	Favourably disposed letters	Unfavourably disposed letters
Functional	"In addition to using advanced technologies, the oil and gas industry is building permanent employee housing and installing new oil, gas and water lines this summer and beyond to reduce truck traffic on the roads. Through oil and gas taxes, the industry is also responsible for $1 out of every $4 of state revenue." (Hamm 2012)	"[In an earlier story about the 'good, bad, and ugly' parts of the boom] Jobs and money emerged as the only 'good.' Among the 'bad' was lack of housing, higher prices, increased traffic, trouble keeping up with emergency calls and life-long residents being forced to move somewhere less expensive." (S. Ventsch 2012)
Cognitive	Safety frame (in the context of changes due to economic development): "While we have a lot left to do, we see what our communities can become as our cities grow and new residents join the community. [...] We'll have fewer trucks and safer roads." (Elliot 2013)	*no examples*
Affective	Aesthetic register (describing an organized tour about the impact of economic development in the Bakken): "[...] we saw the oil wells, usually four to a pad and along a section line instead of in the middle of a large farm field. The wells and storage tanks blended into the landscape as much as possible so they were not an eyesore as you drive in the area." (Bakken 2014)	Aesthetic register: "If you are currently living in the country and enjoying the peace and quiet, and oil activity moves into your area, you will be living in a perpetual construction zone." (D. Ventsch 2011)

Jobs and economic development anchored letter-writers' understanding of the changes the region was undergoing, both with respect to housing, which was in short supply, and to the environment and people's affective relationship to landscape. The values associated with jobs were largely functional, especially when writers were concerned with infrastructure, the need for which they attributed to the effects of job creation, as the quotations in table 3.2 suggest. They were less frequently affective, usually when writers raised issues related to jobs in order to introduce their more pressing concern, typically the environment. They were still less frequently cognitive. Only occasionally did letter-writers interpret job creation through a distinct lens, such as that of safety as in the quotation in table 3.2.

In this respect, letters mentioning the environment provide a useful point of contrast: they more frequently evoked affective values, especially as people worried about the loss of natural spaces (table 3.3).

Table 3.3. Examples of statements attributing functional, cognitive, and affective values to the Bakken landscape, from the subcorpus of letters addressing the topic of the environment

Value	Favourably disposed letters	Unfavourably disposed letters
Functional	"If oil exports are allowed then projects like the Dakota Access and Keystone XL pipelines will likely send North American oil to export terminals." (Wisness 2015)	"Flares at well sites have caused prairie fires in Mandaree and have threatened occupied homes." (Bird Bear 2017)
Cognitive	Safety frame: "Recent findings by the EPA stated that hydraulic fracture techniques (fracking) pose no inherent risk to the public and the environment, including groundwater." (Hovet 2015)	Religious frame: "When I attended [a] meeting […] to discuss how […] an oil waste pit was built above a drinking water well for the city of Ross, I was both inspired by our commissioner's clear mission to protect creation, and disgusted by Helm's seeming mission to protect profits for the oil industry. As a Lutheran pastor in Ross, I baptize babies with that water. My friends, neighbors and parishioners depend on that water." (Philstrom 2014)

Value	Favourably disposed letters	Unfavourably disposed letters
Affective	Aesthetic register: “As I was driving out of town Saturday, what a nice sight it was to see people cleaning out ditches. That’s not what people want to do on a beautiful Saturday, but an oil field company was doing just that. An oil field company asked their employees to donate their time and help clean up Williston.” (Horob 2012)	Aesthetic register: “There is one ugly, heart-breaking spill in North Dakota and elsewhere after the other. This dirty business will leave the involved states with dead zones and property values tanking.” (Nelson 2011)

The centrality of the environment in residents’ sense of well-being is suggested by another study of letters to the editor and readers’ online comments published in the *Williston Herald*. Fourteen percent of those letters, along with 36 percent of comments, mentioned the “serenity and tranquility of the surrounding landscape” as positive factors affecting residents’ quality of life before the Bakken boom, the only factor cited more being “low level of crime and better feeling of safety” (Fernando 2016, 35). Those percentages were higher even than those describing the positive impact of “direct or indirect job opportunities generated by increased activity” brought about by the boom, mentioned by 11 percent of letters and 27 percent of comments (2016, 38). The decline of the landscape-as-territorial-configuration – and the affective values writers associated with it – was equally marked: the authors of letters and people leaving comments cited “noise, dust, and disturbance to peacefulness,” “impacts on land, rural landscape, or biophysical environment, and concerns of pollution,” and “impacts on environment based recreation (hiking, hunting, fishing)” as top concerns related to the decline in quality of life during the boom (2016, 39–40).

Consistent with that study, letters invoking the environment in my corpus invoked affective values, rather than cognitive or functional ones, more often than letters about jobs and economic development. Usually, but not always, these letters were unfavourably disposed toward the boom.

Residents lamented what they saw as the spoiling of a natural, if not idyllic, landscape, due to the byproducts of extraction and, more dramatically, to oil spills or polluted water supplies.[8]

Finally, letters mentioning housing tended to interpret changes to the built landscape based on their function (whether the boom had prompted new housing) and, for unfavourably disposed letters, through the lens of income inequality and the affordability of rent (table 3.4).

Table 3.4. Examples of statements attributing functional, cognitive, and affective values to the Bakken landscape, from the subcorpus of letters addressing the topic of housing

Value	Favourably disposed letters	Unfavourably disposed letters
Functional	"Improved housing options [have] attracted more families to the Bakken since the downturn, which has markedly improved the quality of life in communities across the region." (Black 2017)	"I agree we need growth but at the cost of the people who've sustained this community through not only this 'oil boom' but other oil booms that have come and gone. New buildings such as apartments, single family homes are a bit different than out-of-state companies coming in and purchasing already established properties and raising the rents to double, almost triple the rent cost." (Vondell 2014)
Cognitive	*no examples*	Inequality frame: "We all know that not everybody can buy hundred-thousand-dollar homes and yet that's all we are building." (Reighard 2011)

[8] In this respect, the record of wastewater spills described in chapter 2 supported their observations.

Value	Favourably disposed letters	Unfavourably disposed letters
Affective	Aesthetic register: "If your image of a 'man camp' is a handful of ramshackle RVs sitting on a dusty lot, chances are you are more than ready to see the last of them. However, Ordinance 1026 as it currently exists will also eliminate professionally run workforce housing exemplified by operators like Target Logistics. These are unique solutions to the particular needs of an industry which moves specialist crews around the country and around the world on short notice to work long and irregular hours in a tough and dirty environment." (Olin 2015)	Emotional and aesthetic register: "[…] residents of western North Dakota are fed up with 'man camps,' unsafe communities and traffic, outrageous rental rates, and unsightly impacts to the very land which supports every aspect of life in western Dakota." (Heiser 2012)

Although housing was one aspect of the boom where people's actions – building new structures – had a clear impact on the landscape, few statements about housing related to the landscape as such. Those statements were typically functional, addressing the problems that new housing solved, but they were also often cognitive, describing the need for new housing through the lens of income and wealth inequality. In rare instances, they described aesthetic or emotional dimensions of the boom, always with respect to the aesthetic disruption caused by temporary housing or man camps (see Genareo and Filteau 2016). More common, however, were letters simply about rising rents (with no reference to new buildings), characterized by their criticism of landlords, whom many letter-writers saw as profiting at the expense of people with limited income not employed by the oil industry. As one letter exclaimed, "Greed, thy name is Williston" (Jacobson 2011).

3.3.5. Roughness in the landscape's semiotic configuration: Competing values

Here is where the contradictions of landscape outlined in this chapter's introduction become visible in this corpus, translated into tensions between competing interpretations and the values shaping them.

Not only did letter-writers address different topics, but, even more fundamentally, they appealed to different values when doing so, privileging some over others.

A close examination of individual letters shows that the values they evoked were often incommensurate. The biggest conflict was between functional values, usually associated with jobs and economic development, and affective ones, usually associated with the environment. Often, the writers evoking functional values were city boosters, either within the municipal government or the chamber of commerce, or representatives of the oil industry. Most prominent was Harold Hamm, CEO of Continental Resources, the company with the greatest number of wells during the boom's early years (see Conway 2016, 36). He tacitly acknowledged the risk to the environment when he wrote, "There will be thousands of new wells drilled in the Bakken, but that drilling activity will be spread out over the next 30 years using the most efficient and ecologically sound technology available." But he was clear that the value of jobs outweighed the risk to the environment:

> Due to the dramatic increase in tax revenues, North Dakota is making unprecedented investments in infrastructure in this region. Last year, the legislature approved $1 billion in improvements, including the expansion of highways, water treatment plants, and sewer lines in oil and gas producing counties. (Hamm 2012)

Writers concerned about the natural landscape made similar appeals but inverted their priorities. They, too, framed the choice between jobs and environment, such as one who wrote:

> Now North Dakota is joining Texas, Pennsylvania and more than 30 other states in environmental pollution and destruction of wildlife and their habitats all caused by fracturing. There is one ugly, heart-breaking spill in North Dakota and elsewhere after the other. This dirty business will leave the involved states with dead zones and property values tanking.

> The only people profiting from fracking are the oil companies, businesses in the Bakken such as motels and grocery stores and those receiving royalty payments, often from free homesteaded land. Many of these people don't even live in North Dakota. (Nelson 2011)

Another, commenting on the "North Dakota Legendary" branding campaign, which the state had run since the early 2000s, said:

> Living in a naturally legendary landscape made us who we are, and we didn't pay much attention to whether or not the State Tourism Department was, well, paying much attention to us.
>
> Life on the range of western Dakota was maybe not quite perfect with its weather vagaries and maybe too many people – but then Big Oil discovered our place and brought general chaos on a mega-scale. (Heiser 2012)

The roughness of these conflicts, however, smoothed out over the course of the decade. The correspondence analysis in section 3.3.3 hints at this process. So does an analysis of the positive and negative sentiments characterizing letter-writers' word choice. Figure 3.6 shows how, in aggregate, words' positive connotations increased across the three periods used in the correspondence analysis.

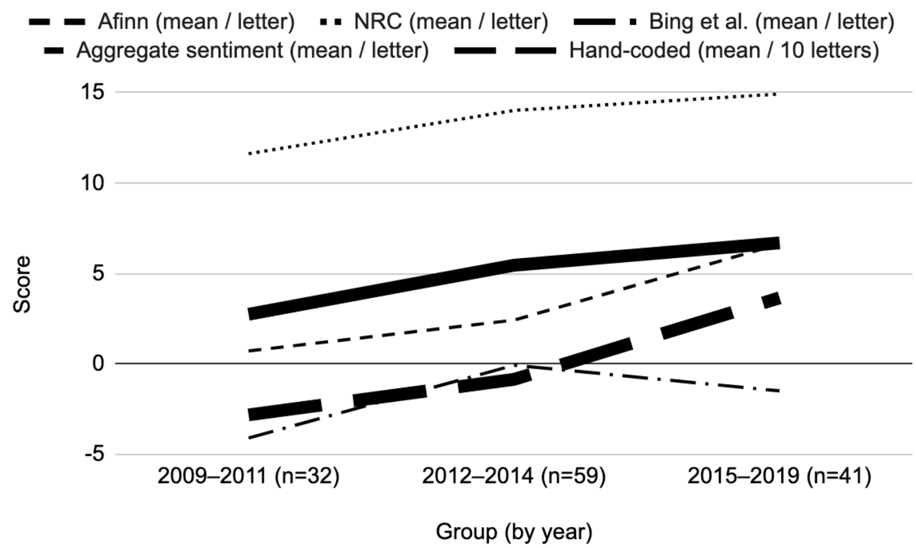

Figure 3.6. Sentiment/disposition analysis of letters to the editor (N=132) about the Bakken boom published in the *Williston Herald*, March 26, 2009–February 12, 2019

The lexicons used in this analysis each measure sentiment differently, assigning values to words either as positive, negative, or neutral, in the case of NRC (Mohammad and Turney 2013) and Bing et al. (Hu and Liu 2004), or on a scale from -5 to +5, in the case of Afinn (Nielsen 2011). I have also calculated the aggregate scores derived from my manually coded corpus, assigning unfavourably disposed letters a value of -1, neutral letters a value of 0, and favourably disposed letters a value of +1. The trends across measurements are clear: between 2009 and 2019, letter-writers expressed increasingly positive assessments of the boom (although in one case, namely Bing et al., sentiment peaked in 2012–14 but was still higher in 2015–19 than in 2009–11). The letters showed evidence of a trend observed in other booms: once people adjust to the new rhythm of life, and after the boom ends, they experience a recovery and an improved outlook on their material conditions in the near- to mid-future (Brown, Dorins, and Krannich 2005; Becker 2016). In short, they grow optimistic.

3.3.6. Roughness in the landscape's semiotic configuration: Underlying trends

How to explain this smoothing out in the corpus itself? On the one hand, letter-writers who appealed to affective values about the environment were unlikely to be swayed by those who appealed to functional values about jobs. On the other, those who wrote about the environment published fewer letters as the boom progressed, while letters about jobs continued.

The content of the letters and the events taking place in the Bakken suggest reasons for this trend. During the boom's early years, letter-writers were pessimistic because they were experiencing the shock of the boom. Aesthetic disruptions were everywhere – residents had to contend with drilling, traffic, and itinerant camps. One prominent camp was in the parking lot of the Walmart on the north side of Williston (Caraher 2016). Another was hosted by Concordia Lutheran Church, north of Williston's downtown (Conway forthcoming). But the Walmart camp was cleared by 2012, and the church's program to house homeless men ended in 2013.

In addition, the nature of the boom changed in 2014–15, as the price of oil dropped below US$85 a barrel, the point where new wells were profitable (Maugeri 2013, 14) (figure 3.7). Although the number of active wells continued to grow (as described in the introductory chapter, sec. 1.2), oil production itself dropped (figure 3.8). Both the price of oil and the number of barrels produced in North Dakota hit a relative low point in 2016 (Alberta 2021; North Dakota Department of Mineral Resources 2023).

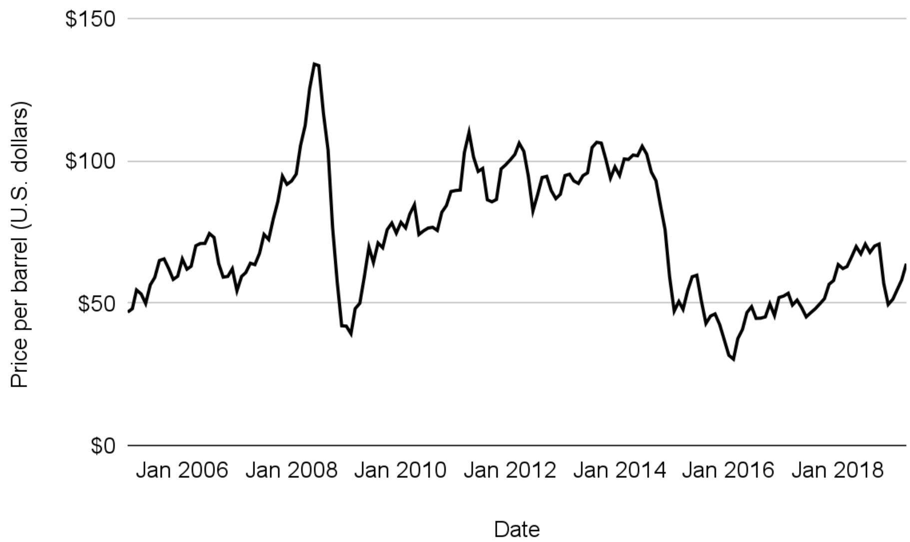

Figure 3.7. Monthly price for West Texas Intermediate crude oil, January 2005–April 2019. Data source: Alberta (2021)

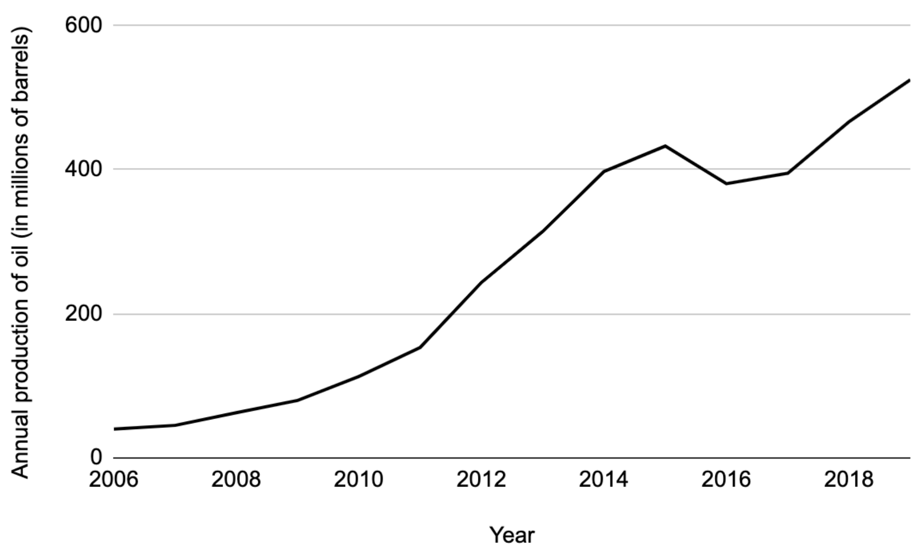

Figure 3.8. Annual oil production in North Dakota, 2005–2019. Data source: North Dakota Department of Mineral Resources (2023)

As the labour-intensive dimensions of drilling decreased, efforts to enforce regulations related to flaring increased, beginning in 2015 (Lade and Rudik 2020). At the same time, Williston's city government began work to enact a ban on temporary housing within city limits and the city's extraterritorial jurisdiction. The ban passed in 2016 (City of Williston 2016), although several large workforce housing companies fought it until 2018 (Melberg 2018).

All of these factors – the decreased aesthetic disruptions of temporary housing camps, the increased (if contested) attention to environmental concerns, the dropping rents due to smaller numbers of workers – contributed to a growing optimism observable in the letters to the editor published in the *Williston Herald*. Letters about the environment, both favourably and unfavourably disposed, ended in 2017. The last unfavourably disposed letter about housing was published in 2015, although favourably disposed letters continued through 2017. The last unfavourably disposed letter about jobs and economic development was published in 2015, although favourably disposed letters continued through 2019. Hence the smoothing out of the landscape's semiotic configuration: fewer negative letters and more positive letters suggested less disagreement among letter-writers. Similarly, the shift in emphasis to the value of jobs suggests that letter-writers achieved an increasingly wide agreement about the priority given to functional values.

3.4. Conclusion: The Bakken petroleumscape

Returning to the semiotic framework described in the introduction, this levelling-out represents a decomplexification of signs and their interpretants in so far as certain associations of central terms – especially contradictory associations evoked by terms related to jobs, the environment, and housing – were eclipsed.

The process by which this levelling out took place reveals important dimensions of the petroleumscape, which I described in chapter 1, quoting Carola Hein, as the "layered physical and social landscape that reinforces itself over time through human action and connects urban and rural spaces, culture and nature, materials and intangible practices" (2022, 3). As these letters show, residents acted in a dual capacity, first as consumers interacting with industry, second as citizens interacting with the government, not just with respect to oil extraction as such, but also in reaction to the needs oil extraction creates for infrastructure, housing, and the provision of resources such as water. Letter-writers mediated between these different entities, exerting influence and being influenced in return as they collectively negotiated the meanings attributed to (and evoked by) the words they used to describe their relationship to the Bakken landscape. When they expressed concern about the landscape's territorial configuration, they tended to do so in affective terms, writing about artifacts of industrialization and appealing, in many cases, to an idealized image of the region. Of course, as chapter 2 showed, reality was somewhat different: although well placement was increasingly dense, oil companies had been drilling wells for decades before the 2008 boom. Letter-writers' appeal to functional and cognitive values, in contrast, showed their collective awareness of the competing interests shaping the Bakken. In this respect, their perceptions of the physical environment were influenced by their relationship to the oil industry, as workers or observers or both. Residents agreed with the oil industry in some instances, for instance with respect to job-creation, and disagreed in others, for instance with respect to the physical environment.

In other words, as Lefebvre (1991) contends, the relationship was not one of opposition, for instance between industry and community interests, but one of shifting alliances when industry and citizen interests aligned, as this chapter and the last have shown. The Bakken landscape's territorial and semiotic configurations evolved together, in a relationship of mutual dependence, the overall nature of which I discuss in the next (and concluding) chapter.

4. Conclusion: Beyond a Settler Landscape

4.1. Introduction: The territorial and semiotic configurations of the Bakken landscape

The structure of the preceding two chapters, the first dealing with the territorial configuration of the Bakken landscape, the second with its semiotic configuration, might give the impression that these two categories are distinct, but that impression would be wrong. The distinction is useful analytically, but it obscures the ways that territory and meaning are intertwined. People read a space, so to speak, before building a structure or plowing a field or drilling a well. They ask where the ground is solid or nutrient-rich or likely to yield oil, interpreting its features as indices of latent qualities they wish to exploit. In some cases, their interpretations are more than utilitarian: different spaces evoke beauty and awe, or they evoke feelings of home and familiarity. Or, conversely, they evoke ugliness and disgust or feelings of alienation. And as spaces change, so do people's interpretations. What once made a person feel at home (say, a landscape perceived as pristine) can transform (the landscape is filled with oil wells) and make that same person feel out of place.

In chapter 1, I posed the question of agency, or people's ability to act in an oil boom that overwhelmed a region, imposing an industrial logic that many people found hard to resist. I cited Henri Lefebvre and Milton Santos, who provided conceptual tools to describe not just these forces, but the ways that people can act within and against the bounds they set. Lefebvre identified three dimensions of the production of space. The first was spatial practice, which "secretes [a] society's space" (1991, 38), configuring a landscape in a territorial sense while imbuing it with meaning. The results of spatial practice are observable in a landscape's roughness, or its accumulation of structures and alterations, but of course not only those structures, given the meaning that people attach to them (Santos 2021a, 2021b). In this respect, spatial practice operates in tension with two sets of interpretations, those produced by people who exercise official forms of power or occupy positions of authority (creating "representations of space," in Lefebvre's terms) and those ("representational spaces") produced by citizens or others outside official structures of power, who inhabit socially produced space and seek to "change and appropriate" it (Lefebvre 1991, 38–9). These two sets of interpretations also operate in tension also with each other, forming the triadic – rather than dyadic – relationship identified by Lefebvre.

What my analysis in the last two chapters has shown, however, is that in the case of the Bakken, the distinction between these two sets of interpretations is heuristic at best: people can occupy positions of power in some instances and act as a citizen in others. Consequently, each group's collective interpretations are not internally consistent. Letter-writers, for example, were divided about the boom's costs and benefits, even though most were writing in their capacity as citizens or residents rather than political or business leaders. In other cases there was agreement between certain residents and their leaders, especially with respect to the industry's benefits in the region. Indeed, a distinction that better reflects the Bakken was between those who were favourably disposed toward the boom, whatever their status or position of power, and those who were unfavourably disposed.

In this concluding chapter, I revisit these distinctions, first between a landscape's territorial and semiotic configuration, and second between discourses generated by people acting in different capacities. I do so from two perspectives, the settler perspective that my analysis described (and that shaped my analysis) in chapters 2 and 3 (sec. 4.2), and a non-settler perspective (sec. 4.3), the value of which, in the context of this thesis, is the way it demonstrates that the settler perspective is hegemonic but not inevitable and that residents of the Bakken had – and have – a wider range to manoeuvre than they might recognize.

4.2. The Bakken's settler landscape

One theme characterizing the analysis of the Bakken's territorial configuration in chapter 2 was its settler origins. Settler conceptions of time and space, I wrote, treat both categories as homogeneous, infinitely divisible into smaller units (kilometres and hectares, hours and minutes) which remain the same wherever they are observed. In other words, they presuppose a series of abstractions that, I also wrote, allow people to make predictions, in ways symptomatic of efforts within European modernity to rationalize the production and circulation of economic goods.

These abstractions were clear in the individual chapters, as I wrote in their respective conclusions, but also *between* the chapters, as I write here. Consider the different values that letter-writers associated with the Bakken landscape, from chapter 3. Each depends on an unspoken set of *a priori* assumptions about the nature of cause and effect, which allow people to make predictions about what might happen if certain actions are taken. I quoted one example of a statement emphasizing functional values (those that express the idea that changes will be useful or serve a purpose) that illustrates these assumptions well: "If oil exports are allowed," explained a letter from 2015, "then projects like the Dakota Access and Keystone XL pipelines will likely send North American oil to export terminals" (Wisness 2015, quoted in sec. 3.3.4). The author's wider argument related to agricultural interests in the state, and it took the form of a series of deductive syllogisms: if pipeline projects went forward, they would allow domestic oil companies to export oil, in spite of the industry's claims that it was contributing to American energy independence. Exporting oil would mean subjecting farmers to the whims of foreign producers, whose oil would have to be imported to meet farmers' needs. For that reason, he said, pipeline projects as they were being planned in 2015 were flawed.

Whether his argument was sound is not my interest here. Instead, it is the argument's structure, based on predictions arrived at through abstractions made possible by the flatness of time and space. The author of another letter I quoted (again in sec. 3.3.4) makes a similarly structured argument, albeit one that relies more on affective values (expressing an emotion or aesthetic judgment). Her letter, published in 2011, said, "If you are currently living in the country and enjoying the peace and quiet, and oil activity moves into your area, you will be living in a perpetual construction zone" (D. Ventsch 2011). In contrast to the first letter-writer, this one took a more inductive approach. She gathered a series of examples of negative impacts of oil, related to the uneven distribution of mineral rights and royalties, to challenges faced by local governments with respect to zoning, to increased housing costs, to traffic and safety, and finally to chemical and wastewater spills. She concluded that residents' "way of life will change dramatically" and that state legislators should "please slow down" (D. Ventsch 2011). As with the letter about pipelines, the unspoken warrant for her argument was the predictability of cause and effect across time and space.

The links between people speaking in official capacities and letter-writers were also clear with respect to the landscape's semiotic roughness, which is to say, those conceptual points that elicited disagreement and discussion over which speakers could not easily pass (see secs. 1.3.2–3). Something more surprising happened here, however. Over the course of the 2008 boom, the territorial configuration of the Bakken landscape grew rougher: new wells were spudded at a rate that increased until 2014 (and even then did not slow down as much as during earlier busts), while wastewater spills grew both in frequency and in size (sec. 2.4). But the frequency with which letter writers wrote about the environment *decreased* as the boom went on, while letter-writers' disposition toward the boom improved (secs. 3.3.5–6). The semiotic configuration smoothed out. These contradictory trends suggest that another factor was at play, one observed in other booms (e.g., Brown, Dorins, and Krannich 2005), namely the comfort of routine, which had an anaesthetizing effect.

An unavoidable problem here is that this analysis can capture the landscape's configurations at only one fleeting moment. The appearance of anything more than relative stability is an illusion. In Heraclitus's apt metaphor, related by Socrates in Plato's dialogue *Cratylus*, "you cannot step into the same river twice" (Plato, *Cratylus* 402a). As a river flows, it carves new channels and is thus no longer the same when a person takes their second step into it. Its roughness has changed, according to Jean Tricart (1960), from whom Santos adopted the term. Recognizing this flux, however, is key to seeing the range of options open to people acting within the Bakken landscape. If stability is only relative, then their choices are not dictated in advance. Although many residents of the Bakken felt as if the boom constricted their lives, in many ways it only obscured certain choices while making others more salient.

This idea is key, also, to seeing how the settler perspective, although dominant within the official State structures imposed on the region, is not inevitable. What would be another perspective? Better yet, for what perspectives is the settler view *other*?

4.3. An Indigenous Bakken landscape

In her book *A Billion Black Anthropocenes or None*, Kathryn Yusoff strips this question down to its simplest form, narrowing her focus to geology itself. She asks,

> [W]hat modes of *geological life* (material and psychic) are already imbricated in geologic practices, often in violent ways? Geology is a mode of accumulation, on one hand, and of dispossession, on the other, depending on which side of the geologic color line you end up on. (2018, 3)

It is a question whose implications I must heed. My analysis of oil extraction in North Dakota is itself extractive, as I dig through government or media websites for data that I refine into interpretable form (see appendices A1–A3). The history of settler scholars writing about Indigenous peoples has frequently followed a similar extractive pattern. As Shawn Wilson writes, “Studies done on Indigenous people and culture by ‘outsiders’ have been a thorn in the side of Indigenous people for generations” (2008, 130). Or, in Margaret Kovach’s words, “Knowledge generation ought not to be extractive but reciprocal to ensure an ecological and cosmological balance and maintain a process-orientated, animated culture” (2021, 72). As they both show, resource extraction and settler colonialism (and its attendant scholarship) are two expressions of the same impulse.

My question, then, leads me to a paradoxical place. Here I follow the lead of the authors of *Settling the Boom*, who write,

> We resolutely do not take it as our role, as white settlers, to represent Indigenous interests or subjects. […] Our goal is not to fracture settler frameworks and temporalities in order to elevate Native sites and subjects. We have not been invited to undertake these tasks. […] Our work [… is instead to] *unsettle* what settler colonial forces assume is resolved. (Thomas and Braun 2023, x–xi)

I am guided by Kovach’s questions for researchers writing about Indigenous people: “Has my research hindered or helped to engender a trusting relationship with the Indigenous peoples involved? Does the research assist the community? […] Can I, as a researcher, sleep at night?” (2021, 101) Or, more simply, “How might we be researchers capable of vulnerability – be as unsettled as we are unsettling for an Indigenous community?” (2021, 134) That is to say, how might I listen to Indigenous scholars in order to complicate not only the settler view I am describing, but my view as a settler myself?

Hence my paradoxical approach: I am writing as a means to listen better, following the precept that a “researcher must make sure that the three R’s, Respect, Reciprocity and Relationality, are guiding the research” (Cora Weber-Pillwax, quoted in Wilson 2008, 58). Listening, says Wilson, “requires suspension of judgement on your part. […] It is also necessary for you to internalize the information that is presented” (2008, 134). For that reason, in this concluding section, I turn to

Indigenous scholars writing about the Bakken boom, in particular its effect on the MHA (Mandan-Hidatsa-Arikara) Nation, centred on the Fort Berthold Reservation southeast of Williams County (figure 4.1).

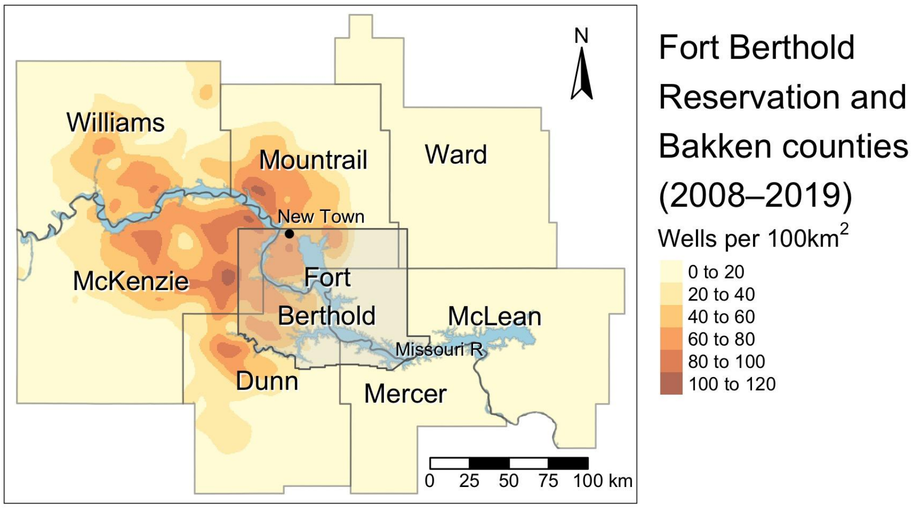

Figure 4.1. Map showing the density of wells spudded between 2008 and 2019 on the Fort Berthold (MHA Nation) Reservation, surrounded by Williams, Mountrail, Ward, McKenzie, Dunn, Mercer, and McLean Counties, North Dakota (kernel density estimation, σ = 5km). Data sources: NDIC Oil and Gas Division (2020, 2024), North Dakota GIS Hub (2002), U.S. Department of Justice (2022)

4.3.1. The MHA Nation

A concluding chapter is not the place to introduce new analysis, except to discuss the bearing it has on what precedes it. Such is my purpose here. Fort Berthold, underneath which lies an estimated 300 billion barrels of oil, has been the site of a large percentage of Bakken activity, as much as 25 percent by some estimates (Cross 2011, 538; Thomas and Braun 2023, x). Some of the Bakken's most intense drilling took place in the reservation's western half, as figure 4.1 shows. In that respect, the contrasting views of time and space shaping scholarship by Indigenous scholars describing the MHA Nation bring the produced nature of the settler Bakken landscape into sharp relief, showing the degree to which it is not, in fact, inevitable.

The Fort Berthold Reservation was initially formed in 1851 with the signing of the first Fort Laramie Treaty. Its boundaries were described as

> commencing at the mouth of Heart River: thence up the Missouri River to the mouth of the Yellowstone River; thence up the Yellowstone River to the mouth of Powder River in a southeasterly direction, to the head-waters of the Little Missouri River; thence along the Black Hills to the head of Heart River, and thence down Heart River to the place of beginning. (Treaty of Fort Laramie with Sioux, etc., at 594)

The Fort Laramie Treaty was meant to ensure settlers' safe passage toward the western frontier, in anticipation of policies (later realized as the Homestead Act, whose effects I describe in sec. 2.3.3) designed to encourage settlement by Europeans and Americans of European descent. But its precedents had been set three decades earlier by the U.S. Supreme Court under chief justice John Marshall. In 1823, the court established the "discovery doctrine," which assigned ownership of land to those who "discovered" it rather than those who occupied it, when it ruled that European countries (including Britain) had "the sole right of acquiring soil from the natives, and establishing settlements upon it" (Johnson v. McIntosh, at 573). In 1831 it ruled that Native tribes were "domestic dependent nations" whose "relations to the United States resemble that of a ward to his guardian" (Cherokee Nation v. Georgia, at 2). Thirty-five years after the 1851 Fort Laramie Treaty, the reservation was reduced dramatically in size when the "Mandan, Hidatsa and Sahnish [Arikara] signed away 1,600,000 acres of Fort Berthold land and the reservation was opened to white settlement" (MHA Nation 2018). This took place shortly before the passage in 1887 of the Act to Provide for the Allotment of Lands in Severalty to Indians on the Various Reservations, known (after its author) as the Dawes Act.

Contemporary scholars see "domestic dependent nation" as an ambivalent recognition, one with important implications for managing Fort Berthold's energy resources. On the one hand, it acknowledges the historical roots of Native sovereignty with respect to treaties that tribes had entered into with Great Britain, while on the other, it emphasizes the idea that Native tribes were *not* foreign nations “because they were within the territorial boundaries of the United States and because, through the treaties, they had placed themselves under the ‘sole protection’ of the United States” (Coffey and Tsosie 2001, 192). The implementation of this form of sovereignty during the Bakken boom was complicated by the newness of the technologies of extraction: “development brings with it novel regulatory challenges” unaccounted for in older policies, according to MHA Nation legal scholar Raymond Cross, and “the tribe will doubtless encounter substantial legal and political barriers if it seeks to regulate development within the reservation” (2011, 544–5). Specific challenges related to fracking and wastewater spills (Forbis and DeMasters 2016; Thompson 2016), tax policy and jurisdiction (Beacom 2015), and the prosecution of crime (Finn, Gajda, Perin, and Fredericks 2017).

4.3.2. Contours of an Indigenous landscape

The Supreme Court decisions, the 1851 Fort Laramie Treaty, and the Dawes Act in 1887 are of a conceptual piece with the Homestead Act, especially with respect to assumptions about the homogeneity of time and space. In fact, the Dawes Act broke reservation lands into allotments the same size as those distributed under the Homestead Act (160-acre quarter-sections). In this case, the U.S. government “gave” land to Native individuals, rather than to settlers, relying on a similar abstraction, where a person’s identity mattered less than the role they were to play. In fact, as the MHA Nation recounts,

> When people moved onto individual allotments, they were each given one of the following: a cook-stove, a yoke of work oxen, a breaking plow, a stirring plow, a cow, a wagon, an ax, a hoe, a spade, a hand rake, a scythe, and a pitch fork. They were expected to build a frame or log house on their allotment. (MHA Nation 2018)

The government’s goal was to transform Native peoples into citizens, as defined in U.S. law.

This conception of time and space contrasts dramatically with the one described by Indigenous scholars during the boom when they described people's relationship to the land on which Fort Berthold was located. They described, first of all, a deep connection to place. According to MHA creation stories,

> Lone Man and First Creator selected the Fort Berthold lands as the tribal people's permanent homelands. By the people's continuing re-enactment of their cultural and religious practices, they strive to renew their ties to these lands and to help secure the creator's continued blessing for their good uses of those lands. (Cross 2011, 545; see DeFlyer 1990 for a telling of this story)

In other words, the land is *not* equivalent to land elsewhere, despite the U.S. government's treatment of it as such. This point was made explicit during a Senate hearing in 1945, when Congress was preparing to construct the Garrison Dam on the Missouri River, an act that would displace 90 percent of Fort Berthold's residents. The chair of the hearing asked Martin Cross, chair of the tribal business council of what was then called the Three Affiliated Tribes, whether his people would be "willing to exchange that land for other land, if other land were available," to which Cross answered, "No, sir." When asked the monetary value of the land, Cross explained that he was "not permitted to tell that. [...] We are not here on the question of selling our land. We want to keep it." And finally, when asked, "How long have your ancestors been living there?" he answered, "From time immemorial we have been living there" (U.S. Senate 1945, 6–7).

Cross's answer is consistent with the ways that MHA scholars describe the tribe's sense of time: not as homogeneous or "flat," but deeply rooted in history and punctuated by violent acts of dispossession, not least of which was the construction of the Garrison Dam in 1946. The continued flooding in Fort Berthold is clear in figure 4.1, where the centre of the reservation is covered by the Missouri River. It is an event that residents call "the Taking" (Andrews 2018, 80). The MHA Nation lost 153,000 acres of bottomland, covered in rich topsoil, its members forced to relocate in 1951 to New Town, "about as far north as one can go and still be on the Reservation" (2018, 81).[1]

It is not without irony, then, that Fort Berthold sits on top of some of the richest portions of the Bakken oil formation. Indeed, some scholars note an ironic stance that some MHA Nation members take toward the settlement of North Dakota. Stephen Andrews, for instance, remarks upon a sign overlooking Lake Sakakawea, the name given to the lake in the centre of Fort Berthold that was created when the Missouri River was dammed. It purports to offer a description of the vista in front of the sign written by Meriwether Lewis, who with William Clark and the Corps of Discovery mapped the Missouri River from St. Louis to the Pacific Ocean between 1804 and 1806.[2] "This scenery, already rich, pleasing and beautiful," Lewis wrote, "was still further hightened [*sic*] by Immense herds of buffalo, deer and elk… which we saw in every direction feeding on the hills and plains" (quoted in Andrews 2018, 101). Now the sign, a paean for natural beauty and conservation, overlooks oil rigs. "If the sign proper underscores Native absence," Andrews observes,

> the rig and pumps that ostensibly "mar" the "beauty" of the landscape affirm Native presence as much as they underscore global capital. Where work is to be done on behalf of "environmental protectionism," that work will have to be undertaken and enforced by the very people who have for so long been its primary victims. (Andrews 2018, 103)

Andrews quotes residents who find poetic justice in the idea that "the bad land they'd been shunted off to [has turned] out to be the most valuable, at least in the short run," all while looking for ways to safeguard the tribe's newfound wealth into the future (2018, 98–9).

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[1] Members of the Standing Rock Sioux Reservation, to the south of Fort Berthold, describe their sense of place and history in similar ways. On this topic, Nick Estes' *Our History is the Future* (2019) is an excellent guide, while David Archambault's *New York Times* opinion piece, "Taking a Stand at Standing Rock" (2016), provides a succinct overview.

[2] In fact, the description more likely comes from the time that Lewis and Clark were passing through what is now Lyman County, South Dakota (Andrews 2018, 102).

4.4. Conclusion: Ironic reading and the potential for change

I want to close by considering the value of this ironic reading. In rhetorical theory, irony is a trope or figure of speech that consists in saying one thing but meaning its opposite. A necessary ingredient for irony is the ability to take a critical step back so that an observer can see the world in a different way. With respect to the boom and bust cycle of oil extraction in North Dakota, an ironic reading develops when we as observers step back and ask whether that cycle is in fact inevitable. So many messages, official and otherwise, work to convey this idea, but what if its opposite were true? What would the world look like then?

One of the biggest obstacles in arriving at an ironic reading is imagining the world other than it is. As I wrote above, the distinction between official and citizen discourses about the Bakken landscape – the ways people interpreted the changing configuration of the environment – is perhaps not as useful as the distinction between ideas expressed by people with favourable or unfavourable dispositions toward the boom. But even that distinction hides unspoken assumptions about time and space that structure the ways residents understand fundamental relationships between themselves and the landscape. The hegemonic settler discourse remains consistent because the differences in disposition or between official and citizen discourses draw our attention away from it.

Hence the value of an Indigenous perspective. To be clear, the sketch I provide above is incomplete. At best, it is merely a starting point, an invitation to settlers like me to listen to people who know the world in different ways. Listening in this respect requires humility, as does imagining experiences of time and space that are not flat, as we expect, but textured, variegated, and anchoring. This is a necessary (but not sufficient) step toward remediating the problems brought about by oil extraction, such as wastewater spills (and many others I have not mentioned). It is also a necessary (but not sufficient) step toward realizing something like the ideal evoked by the letter-writer I quoted in the opening paragraphs of this thesis. While the nostalgia that writer expressed might be for a landscape that never existed, it nonetheless suggests that the landscape of oil in western North Dakota could be other than it is, something worth working toward, if people decide that the landscape as they have come to know it could, in fact, be better.

Appendix 1. Distance from Well Sites to Roads (with Source Code)

A1.1. Introduction: Well sites and roads

The density map showing all wells spudded between 2008 and 2019 (figure 2.5 in chapter 2) is characterized by an interesting pattern: the well sites form neat, parallel lines that follow the roads at the borders of townships and land parcels dating back to the 1862 *Homestead Act* (figures 2.6 and 2.7). I suspect the reason is that oil companies choose well sites based on their accessibility by truck. In this appendix I test that hypothesis.

One challenge is that during the boom the state of North Dakota built a number of roads to accommodate increased levels of traffic, especially around Williston. The shapefile provided by the state includes all of these new roads. The biggest change came in 2015, when a bypass on Highway 85 opened to the northwest of Williston. To reflect this change, I split the wells into those spudded before and after Oct. 14, 2015, the day the bypass opened. The end date of my analysis, Dec. 31, 2019, is the same as the end date of my KDE analysis.

Data sources: Williams County roads: U.S. Census Bureau (2021); well sites: NDIC Oil and Gas Division (2024); Williams county outline: North Dakota GIS Hub (2002)

A1.2. Hypothesis and approach

My hypothesis is as follows:

- H_0: The average distance from wells spudded between 2008 and 2019 in Williams County to the road nearest to each can be produced using a CSR process.
- H_1: Wells are closer to roads than would be the case if their locations were generated by a CSR process.
- Criterion for the rejection of H_0: $\alpha = 0.05$
- Test: Using a Monte Carlo approach, I calculate the *p*-value based on 99 point patterns simulated within the Williams County polygon. Specifically, I calculate the mean distances from the simulated points to the road nearest to each, values that I compare to the observed mean distance. The test is one-sided, following H_1.

I test this hypothesis by creating a data set including wells spudded within the relevant dates (sec. A1.3). Then I create a function to measure the distance from a well site to the nearest road (sec. A1.4), before calculating the distance for each well in my data set (sec. A1.5). I then simulate 99 sets of wells (sec. A1.6), before finally calculating and interpreting the p-value (secs. A1.7–8) (R Core Team 2022; Baddeley and Turner 2005).

A1.3. Well sites

I begin by creating a function to delete duplicate points (shamelessly lifted from exercise 4 of GEG6103, University of Ottawa, Winter 2024). Then I create a set of wells within the relevant dates.

```
library(dplyr)
library(sf)
library(spatstat)

# delete duplicate point function

delete_duplicate_points <- function(point_set_sf){
  subunique <- st_equals(point_set_sf,
                         remove_self = TRUE,
```

```
                        retain_unique = TRUE)

  if (length(unlist(subunique) != 0)) {
    # unlist: flattens list by transforming it into vector containing
elements of list
    # if this vector contains any elements, then the if-statement is
triggered
    point_set_sf <- point_set_sf[-unlist(subunique),]
    # removes rows revealed by st_equals to have duplicate values
    }

return(point_set_sf)
}

wells <- st_read("/Users/kyle/bakken-shapefiles/OGD_Wells") %>%
  st_transform(crs = 3857) %>%
  delete_duplicate_points()

## Reading layer `OGD_Wells' from data source
##   `/Users/kyle/bakken-shapefiles/OGD_Wells' using driver `ESRI Shapefile'
## Simple feature collection with 41099 features and 22 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: -104.0468 ymin: 45.94582 xmax: -96.67712 ymax:
48.99866
## Geodetic CRS:  NAD83

# subset wells in Williams County

williams_cty_wells <- wells[(wells$County == "WILLIAMS"),]

# for legibility: create data frame with relevant data only

well_temp <- data.frame(spud_date = williams_cty_wells$spud_date,
                        latitude = williams_cty_wells$latitude,
                        longitude = williams_cty_wells$longitude,
                        status = williams_cty_wells$status,
                        geometry = williams_cty_wells$geometry)

# subset pre-2015 wells

wells_2008_2015 <- well_temp[well_temp$spud_date >= as.Date("2008-01-01") &
                             well_temp$spud_date <= as.Date("2015-10-13"),]
%>%
  na.omit() %>%
  st_as_sf()

# subset post-2015 wells
```

```
wells_2015_2019 <- well_temp[well_temp$spud_date >= as.Date("2015-10-14") &
                             well_temp$spud_date <= as.Date("2019-12-31"),]
%>%
  na.omit() %>%
  st_as_sf()
```

A1.4. Distance-to-road function

This function creates a vector of values measuring the distance from each well to the closest road.

```
distance_to_road <- function(wells,  # sf object of points representing wells
                             roads){ # sf object of linestrings representing
roads

  # create vector identifying the road nearest to each well

  index <- st_nearest_feature(wells, roads)

  # calculate distance from well to nearest road, assign to vector
`distances`

  distances <- c()

  number_iterations <- nrow(as.data.frame(wells))

  for(i in 1:number_iterations){
    distances[i] <- st_distance(wells[i,], roads[index[i],])[1,1]
  }                 # note 1: `st_distance` returns a
                    #   data frame where the value in row 1, column 1
                    #   is distance between objects
                    # note 2: `st_distance` also returns a measurement unit
(in this case, metres)

  # return vector of distances between wells and closest road

  return(distances)
}
```

A1.5. Calculate distances from wells to nearest roads

Here I import a shapefile of roads in Williams County. For the pre-2015 road configuration, I exclude the Highway 85 bypass, identified by the values in column LINEARID.

```
williams_cty_roads <- st_read("/Users/kyle/bakken-
shapefiles/tl_2021_38105_roads") %>%
  st_transform(crs = 3857)

## Reading layer `tl_2021_38105_roads' from data source
##   `/Users/kyle/bakken-shapefiles/tl_2021_38105_roads' using driver `ESRI
Shapefile'
## Simple feature collection with 8879 features and 4 fields
## Geometry type: LINESTRING
## Dimension:     XY
## Bounding box:  xmin: -104.048 ymin: 47.95769 xmax: -102.828 ymax: 48.63391
## Geodetic CRS:  NAD83

# pre-2015 highway configuration

williams_cty_roads_pre2015 <-
  williams_cty_roads[williams_cty_roads$LINEARID != 11010936341059 &
                     williams_cty_roads$LINEARID != 11010933636715,] #
remove Highway 85 bypass

# post-2015 highway configuration

williams_cty_roads_post2015 <- williams_cty_roads

# calculate distances of wells spudded between 2008 and 2015 to nearest roads

distances_2008_2015 <- distance_to_road(wells_2008_2015,
                                        williams_cty_roads_pre2015)

# calculate distances of wells spudded between 2015 and 2019 to nearest roads

distances_2015_2019 <- distance_to_road(wells_2015_2019,
                                        williams_cty_roads_post2015)
```

A1.6. Simulate 99 sets of wells and calculate distances

Here I simulate the point patterns to which I will compare values related to my observed point pattern. First, I simulate 99 sets of wells with the same number of elements as the number of pre-2015 wells. Then I calculate the distances from those simulated wells to the pre-2015 set of roads. Second, I simulate 99 sets of wells with the same number of elements as the post-2015 wells. Then, in the same way, I calculate the distances from those simulated wells to the post-2015 set of roads. To both the pre- and post-2015 sets I append my observed distances, calculated above.

```r
# load Williams County outline

nd_counties <- st_read("/Users/kyle/bakken-
shapefiles/NDGISHUB_County_Boundaries",
              "County_Boundaries") %>%
  st_transform(crs = 3857) # transform CRS to projected pseudo-Mercator

## Reading layer `County_Boundaries' from data source
##   `/Users/kyle/bakken-shapefiles/NDGISHUB_County_Boundaries'
##   using driver `ESRI Shapefile'
## Simple feature collection with 53 features and 19 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -104.0489 ymin: 45.93498 xmax: -96.55449 ymax:
49.00059
## Geodetic CRS:  WGS 84

williams_cty <- nd_counties[(nd_counties$NAME == "Williams"),]

# simulate wells to measure against pre-2015 road configuration

well_distances_pre2015 <- data.frame(matrix(ncol = nrow(wells_2008_2015),
                                            nrow = 100))

for(n in 1:99){
  simulated_points <- st_sample(williams_cty,
                                size = nrow(wells_2008_2015),
                                type = "random")

  well_distances_pre2015[n,] <- distance_to_road(st_as_sf(simulated_points),
                                                 williams_cty_roads_pre2015)
}

# append observed values as last row

well_distances_pre2015[100,] <- distances_2008_2015

# simulate wells to measure against post-2015 road configuration

well_distances_post2015 <- data.frame(matrix(ncol = nrow(wells_2015_2019),
                                             nrow = 100))

for(n in 1:99){
  simulated_points <- st_sample(williams_cty,
                                size = nrow(wells_2015_2019),
                                type = "random")

  well_distances_post2015[n,] <- distance_to_road(st_as_sf(simulated_points),
                                                  williams_cty_roads_post2015)
```

```
}

# append observed values as last row

well_distances_post2015[100,] <- distances_2015_2019
```

A1.7. Calculate *p*-value

Finally I test my hypothesis by normalizing my data sets to calculate the *p*-value.

```
# compile a vector of average distances

avg_distance <- c()

for (i in 1:100){
  avg_distance[i] <- (sum(well_distances_pre2015[i,]) +
                        sum(well_distances_post2015[i,])) /
                        (ncol(well_distances_pre2015) +
                           (ncol(well_distances_post2015)))
}

# calculate normalized average (simulated) distance

norm_distance <- (avg_distance - mean(avg_distance)) / sd(avg_distance)

# calculate normalized observed average distance

norm_observed <- (avg_distance[100] - mean(avg_distance)) / sd(avg_distance)

# calculate p-value: one-sided test (alternative: less-than)

p_val <- sum(norm_distance <= norm_observed) / length(avg_distance)

paste("p-value =", p_val)

## [1] "p-value = 0.01"
```

A1.8. Interpretation

Because $p < 0.05$, I reject H_0 in favour of H_1. This result is not surprising: it follows my reasoning from the introduction, providing further support of the idea that the location of roads influenced where wells were spudded.

Appendix 2. Cross-*K* Analysis of Well Sites and Brine Spills (with Source Code)

A2.1. Introduction and hypothesis

This script examines relationships of spatial dependence between well sites and brine/wastewater spill sites in Williams County, North Dakota. The dataset of spill sites includes events between Dec. 31, 2013 and July 23, 2019.

I am testing variations of the following hypothesis:

- H_0: The relationship between well sites and spill sites is one of spatial independence.
- H_1: The relationship between well sites and spill sites is one of attraction.
- Criterion of rejection for H_0: $\alpha = 0.05$.
- Test: Using a Monte Carlo technique, I simulate 199 point patterns of well and spill sites, which I use to calculate $\widehat{K}_{12}$ values (expressed as $\widehat{L}_{12}$). To test for significance, I use a one-tailed DCLF test, testing for attraction.

In the first case, I test all of the spill sites in relation to the wells spudded between 2008 and 2019 (using the same subset of wells I used for my KDE analysis of the 2008 boom). Then I look at individual years, from 2014 to 2018 (the years with the most complete spill data). I compare each year's spill sites to the sites of wells spudded in the previous *two* years (e.g., I compare 2014 spills to wells spudded in 2013 and 2014). My reasoning is that wastewater is produced during or immediately after fracking, and fracked wells have a half-life of about a year, making the two first years their most productive (Maugeri 2013).

I begin by loading the Williams County outline (sec. A2.2) and spell and well data (secs. A2.3–A2.3.2). Then I perform the K_{12} calculations (sec. A2.4), first for 2008–2019 (secs. A2.4.1–2), then by individual years (sec. A2.4.3). I conclude with a table summarizing the analyses (sec. A2.5) and an interpretation of the DCLF results (A2.6).

Data sources: Williams county outline: North Dakota GIS Hub (2002); Brine spills: North Dakota Brine Spills (2019); well sites: NDIC Oil and Gas Division (2024)

A2.2. Williams County outline

```
library(sf)
library(tmap)
library(dplyr)
library(spatstat)

nd_counties <- st_read("/Users/kyle/bakken-
shapefiles/NDGISHUB_County_Boundaries",
              "County_Boundaries") %>%
  st_transform(crs = 3857) # transform to pseudo-Mercator

## Reading layer `County_Boundaries' from data source
##   `/Users/kyle/bakken-shapefiles/NDGISHUB_County_Boundaries'
##   using driver `ESRI Shapefile'
## Simple feature collection with 53 features and 19 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: -104.0489 ymin: 45.93498 xmax: -96.55449 ymax:
49.00059
## Geodetic CRS:  WGS 84

williams_cty <- nd_counties[(nd_counties$NAME == "Williams"),]
```

A2.3. Spill and well data

Here I load the data describing spill and well locations.

A2.3.1. Spill data

```
# create function to remove duplicate points (source: GEG6103, uOttawa,
Winter 2024)
```

```
delete_duplicate_points <- function(point_set_sf){
  subunique <- st_equals(point_set_sf,
                         remove_self = TRUE,
                         retain_unique = TRUE)

  if (length(unlist(subunique) != 0)) {
    # unlist: flattens list by transforming it into vector containing
elements of list
    # if this vector contains any elements, then the if-statement is
triggered
    point_set_sf <- point_set_sf[-unlist(subunique), ]
    # removes rows revealed by st_equals to have duplicate values
    }

return(point_set_sf)
}

# load spill data

brine_spills <- st_read("/Users/kyle/bakken-
shapefiles/North_Dakota_Brine_Spills") %>%
  st_transform(crs = 3857) # transform to pseudo-Mercator

## Reading layer `North_Dakota_Brine_Spills' from data source
##   `/Users/kyle/bakken-shapefiles/North_Dakota_Brine_Spills' using driver
`ESRI Shapefile'
## Simple feature collection with 5367 features and 19 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: -104.0412 ymin: 45.94772 xmax: -100.5756 ymax:
48.99725
## Geodetic CRS:  WGS 84

# subset spills occurring in Williams County

williams_cty_spills <- st_intersection(williams_cty, brine_spills) %>%
  delete_duplicate_points()

## Warning: attribute variables are assumed to be spatially constant
throughout all
## geometries
```

A2.3.2. Well data

```
wells <- st_read("/Users/kyle/bakken-shapefiles/OGD_Wells") %>%
  st_transform(crs = 3857) # transform to pseudo-Mercator
```

```
## Reading layer `OGD_Wells' from data source
##   `/Users/kyle/bakken-shapefiles/OGD_Wells' using driver `ESRI Shapefile'
## Simple feature collection with 41099 features and 22 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: -104.0468 ymin: 45.94582 xmax: -96.67712 ymax:
48.99866
## Geodetic CRS:  NAD83
```

```
# subset wells in Williams County

williams_cty_wells <- wells[(wells$County == "WILLIAMS"),] %>%
  delete_duplicate_points()

# for legibility: create data frame with relevant data only

well_temp <- data.frame(spud_date = williams_cty_wells$spud_date,
                        latitude = williams_cty_wells$latitude,
                        longitude = williams_cty_wells$longitude,
                        status = williams_cty_wells$status,
                        geometry = williams_cty_wells$geometry)

# create wells_2008_2019 sf object for 2008 boom (following revised KDE
analysis)

wells_2008_2019 <- well_temp[well_temp$spud_date >= as.Date("2008-01-01") &
                          well_temp$spud_date <= as.Date("2019-12-31"),] %>%
  na.omit() %>%
  st_as_sf()
```

A2.4. K_{12} calculation

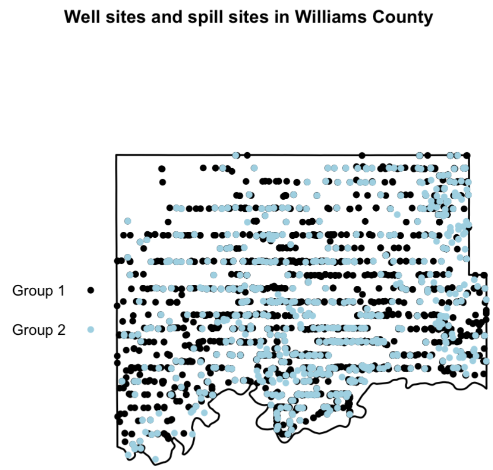
A2.4.1. All wells (2008 to 2019) and all brine spills

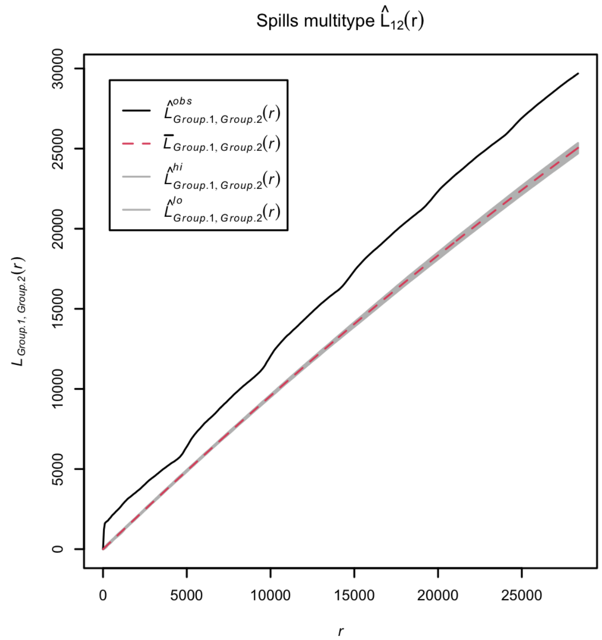
Here I compare all the brine spills in Williams County to all of the wells spudded between 2008 and 2019. This test will help me interpret the KDE analyses of both sets of events, which bear a striking visual resemblance (hence the H_1 testing for attraction).

The wells are group 1 and the spills group 2.

```
# set parameters for visual display

par(pty = "s",
    mfrow = c(1, 2),
    cex = .5)
```

```r
# create ppp of well locations spudded between 1980 and 2019 (following KDE
analysis)

wells_2008_2019_ppp <- as.ppp(st_coordinates(wells_2008_2019),
                         as.owin(williams_cty))

marks(wells_2008_2019_ppp) <- factor("Group 1")

# create ppp of all spill locations

spills_ppp <- as.ppp(st_coordinates(williams_cty_spills),
                     W = as.owin(williams_cty))

marks(spills_ppp) <- factor("Group 2")

spills_multi <- superimpose.ppp(wells_2008_2019_ppp, spills_ppp)

# create simulation envelope

spills_envelope <- envelope(
  spills_multi,
  Lcross,
  nrank = 1,
  nsim = 199,
  fix.n = TRUE,
  use.theory = FALSE,
  funargs = list(correction = "none"),
  savepatterns = TRUE,
  verbose = FALSE
)

# plot well / spill sites, observe L-cross simulation envelope

plot(spills_multi,
     pch = 16,
     cols = c("black", "lightblue"),
     main = "Well sites and spill sites in Williams County")

plot(spills_envelope,
     xlim = range(spills_envelope$r),
     main = expression(paste("Spills multitype ", hat("L")[12](r))))
```





A2.4.2. DCLF test: All wells (2008 to 2019) and all spills

To test whether the observed patterns are significantly similar or not, I use a DCLF test, using the $\hat{K}(r)$ / $\hat{L}(r)$ envelopes simulated above (Baddeley et al., 2014). I include the results in a data frame table at the end of the appendix.

```
spills_k12_dclf <- dclf.test(
  spills_envelope,
  Lcross,
  funargs = list(correction = "none"),
  use.theory = FALSE,
  alternative = "greater",
  verbose = FALSE
)

# the relevant results are included in row 6 of spills_summary below
```

A2.4.3. Analysis by year

Here I subset the well and spill data further. I compare each full year of spill data (2014 to 2018) to the data from the two preceding years of fracking activity (e.g., spill sites from 2014 and well sites from 2013–2014), for reasons outlined in sec. A2.1.

```
# for legibility: create data frame with relevant data only

spills_temp <- data.frame(well_name <- williams_cty_spills$Well_Name,
                          date = williams_cty_spills$Date_Incid,
                          latitude = williams_cty_spills$lat,
                          longitude = williams_cty_spills$lon,
                          geometry = williams_cty_spills$geometry)

# create vectors to use in for-loop below

years <- c("2014", "2015", "2016", "2017", "2018")

well_start_date <- c("2013-01-01", "2014-01-01", "2015-01-01", "2016-01-01",
"2017-01-01") %>% as.Date()

spill_start_date <- c("2014-01-01", "2015-01-01", "2016-01-01", "2017-01-01",
"2018-01-01") %>% as.Date()

end_date <- c("2014-12-31", "2015-12-31", "2016-12-31", "2017-12-31", "2018-
12-31") %>% as.Date()

# create lists to populate in for-loop below

wells <- list()                    # wells spudded in two years leading up to
end_date
wells_yearly_ppp <- list()         # ppp of wells spudded
spills <- list()                   # spills in year leading up to end_date
spills_yearly_ppp <- list()        # ppp of spills
spills_yearly_multi <- list()      # multi.ppp of wells (group 1) and spills
(group 2)
spills_yearly_envelope <- list() # Lcross envelope
spills_yearly_k12_dclf <- list() # DCLF results of Lcross envelope

spills_summary <- data.frame()   # data frame summarizing key calculations

for (n in 1:5){
  # subset well_temp by well_start_date and end_date

  wells[[n]] <- well_temp[(well_temp$spud_date >= well_start_date[n]
                       & well_temp$spud_date <= end_date[n]),] %>%
    na.omit() %>%  # remove NA values
    st_as_sf()

  # transform into ppp object

  wells_yearly_ppp[[n]] <- as.ppp(st_coordinates(wells[[n]]),
                                  as.owin(williams_cty))

  marks(wells_yearly_ppp[[n]]) <- factor("Group 1")
```

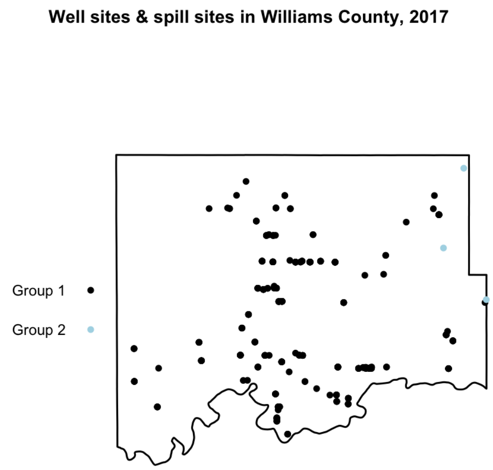
```r
# subset spills_temp by spill_start_date and end_date

spills[[n]] <- spills_temp[(spills_temp$date >= spill_start_date[n]
                        & spills_temp$date <= end_date[n]),] %>%
  st_as_sf() # transform back into sf object

# transform into ppp object

spills_yearly_ppp[[n]] <- as.ppp(st_coordinates(spills[[n]]),
                           as.owin(williams_cty))

marks(spills_yearly_ppp[[n]]) <- factor("Group 2")

# combine ppp objects into multi.ppp object

spills_yearly_multi[[n]] <- superimpose.ppp(wells_yearly_ppp[[n]],
                                            spills_yearly_ppp[[n]])

# create envelope

spills_yearly_envelope[[n]] <- envelope(
  spills_yearly_multi[[n]],
  Lcross,
  nrank = 1,
  nsim = 199,
  fix.n = TRUE,
  use.theory = FALSE,
  funargs = list(correction = "none"),
  savepatterns = TRUE,
  verbose = FALSE
  )

# calculate DCLF values

spills_yearly_k12_dclf[[n]] <- dclf.test(
  spills_yearly_envelope[[n]],
  Lcross,
  funargs = list(correction = "none"),
  use.theory = FALSE,
  alternative = "greater",
  verbose = FALSE
)

# place relevant data into spills_summary data frame

spills_summary[n,1] <- years[n]
spills_summary[n,2] <- spills_yearly_k12_dclf[[n]]$statistic$u
spills_summary[n,3] <- spills_yearly_k12_dclf[[n]]$statistic$rank
```

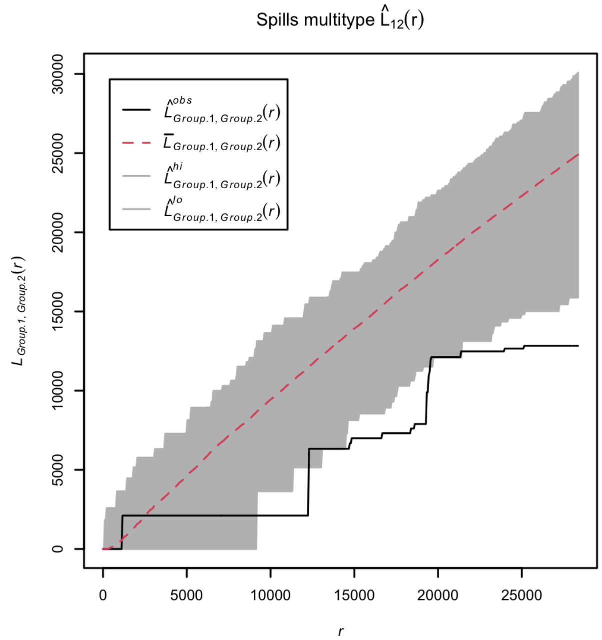
```
  spills_summary[n,4] <- spills_yearly_k12_dclf[[n]]$method[5]
  spills_summary[n,5] <- spills_yearly_k12_dclf[[n]]$method[6]
  spills_summary[n,6] <- spills_yearly_k12_dclf[[n]]$p.value
}
```

```
## Error in Kcross(X, i, j, ..., correction = correction) :
##   No points have mark j = Group 2
## [retrying]
## Error in Kcross(X, i, j, ..., correction = correction) :
##   No points have mark j = Group 2
## [retrying]
## Error in Kcross(X, i, j, ..., correction = correction) :
##   No points have mark j = Group 2
## [retrying]
## Error in Kcross(X, i, j, ..., correction = correction) :
##   No points have mark j = Group 2
## [retrying]
## Error in Kcross(X, i, j, ..., correction = correction) :
##   No points have mark j = Group 2
## [retrying]
```

The errors produced in the K_{12} calculation above occur in the process of creating a $\widehat{K}_{12}(r)$ simulation envelope for 2017. There are only three recorded spills (group 2) in Williams County in 2017, and the errors occur when the envelope function fails to generate any simulated spill sites, forcing it to retry. The resulting envelope suggests that the relationship between well and spill sites is not one of attraction:

```
# set parameters for visual display

par(pty = "s",
    mfrow = c(1, 2),
    cex = .5)

# plot data from 2017

plot(spills_yearly_multi[[4]],
     pch = 16,
     cols = c("black", "lightblue"),
     main = "Well sites & spill sites in Williams County, 2017")

plot(spills_yearly_envelope[[4]],
     xlim = range(spills_envelope$r),
     main = expression(paste("Spills multitype ", hat("L")[12](r))))
```





A2.5. Summary of spills data

Here I compile the results into the final data frame, which I display as a table below.

```
spills_summary[6,1] <- "2008-2019"
spills_summary[6,2] <- spills_k12_dclf$statistic$u
spills_summary[6,3] <- spills_k12_dclf$statistic$rank
spills_summary[6,4] <- spills_k12_dclf$method[5]
spills_summary[6,5] <- spills_k12_dclf$method[6]
spills_summary[6,6] <- spills_k12_dclf$p.value

names(spills_summary) <- c("year", "u", "rank", "alternative", "interval",
"p.value")

print(spills_summary)

##        year             u rank           alternative
## 1      2014  3.832761e+11    1 Alternative: greater
## 2      2015  6.854394e+11    1 Alternative: greater
## 3      2016  7.574942e+11    1 Alternative: greater
## 4      2017 -1.402901e+12  200 Alternative: greater
## 5      2018  5.387858e+11    1 Alternative: greater
## 6 2008-2019  3.018093e+11    1 Alternative: greater
##                                          interval p.value
## 1 Interval of distance values: [0, 28358.0286415678]    0.005
## 2 Interval of distance values: [0, 28358.0286415678]    0.005
## 3 Interval of distance values: [0, 28358.0286415678]    0.005
## 4 Interval of distance values: [0, 28358.0286415678]    1.000
```

```
## 5 Interval of distance values: [0, 28358.0286415678]    0.005
## 6 Interval of distance values: [0, 28358.0286415678]    0.005
```

A2.6. Interpretation

All of the tests (except that of 2017) produce *p*-values < 0.05 over the interval distance $0 \le r \le 28358.0286415678$. Hence the rejection of H_0 and acceptance of H_1. With respect to 2017, the analysis appears to indicate acceptance of H_0. However, only 3 of 699 recorded spills occurred in 2017 (about 0.5 percent of the overall total). The data are simply not very useful. The fact that there is a strong spatial attraction overall, and for all the other years, should not be surprising: the fracking process produces the brine wastewater that is spilled.

Appendix 3. Co-occurrence and Sentiment Analyses (with Source Code)

A3.1. Introduction: Premises and approach

I am working from the assumption that when people write letters to the editor, they want to persuade others to see the world as they do: letter-writing is a fundamentally rhetorical act. To that end, they make propositional claims (for instance, that *X is Y* or *A does B*), in the process drawing links between the ideas they perceive as important. Consequently, their letters are also interpretive, reflective of the way they make meaning of their environment.

One way to observe the links people make is, simply enough, by tallying which words appear together in individual letters and with what frequency, which is to say, by observing rates of co-occurrence. In the following analysis, I take a corpus of 132 letters to the editor published in the *Williston (ND) Herald* between 2009 and 2019 (scraped from the *Herald*'s website in 2019).

After importing the corpus in R (R Core Team 2022), in the form of a comma-separated value (.csv) spreadsheet, I transform the letters into a tibble (data frame) by tokenizing and lemmatizing their content (while removing stop words) (sec. A3.2). Then I create a figure describing the frequency with which hand-coded themes co-occur, to get an overview of the corpus (sec. A3.3). I also create a list of lemmas ranked by frequency over the entire corpus (sec. A3.3.1). For each of the three most common themes, namely *jobs*, *environment*, and *housing* (sec. A3.4), I identify the three most frequent relevant lemmas and create figures showing the most frequent co-occurrence pairs that include at least one of those lemmas (secs. A3.4.1–3).

For the sentiment analysis (sec. A3.5), I count the number of letters (sec. A3.5.1) and then calculate the mean sentiment per letter, drawing from three different lexicons: AFINN (Nielsen 2011), NRC (Mohammad and Turney 2013), and Bing et al. (Hu and Liu 2004) (secs. A3.5.2–4). I finish by adapting this code to calculate a similar measure, that of letter-writers' disposition toward the boom, based on manual coding of the corpus, performed with a research assistant in 2020 (sec. A3.5.5).

Note: The code I have used draws heavily on Julia Silge and David Robinson's *Text Mining with R: A Tidy Approach* (2017), especially chapter 8 for the co-occurrence maps and chapter 2 for the sentiment analysis.

A3.2. First things first: Libraries and initial tibble

Here I load the relevant libraries, import the corpus of letters, and transform it into a tibble of lemmatized tokens (Silge and Robinson 2016; Rinker 2018).

```
library(tidyverse)
library(tidytext)
library(textdata)
library(textstem)
library(widyr)
library(igraph)
library(ggraph)

herald_letters <- read.csv(file = "/Users/kyle/Desktop/herald-letters-
redux/herald-letters-r-analysis-round2/Letters-prepared-for-r-may2023-no-
possessive-nouns.csv",
                           header = TRUE,
                           sep = ",") # import .csv of letters

herald_letters_tibble <- tibble(herald_letters) # transform into tibble

custom_stop_words <- read.csv(file = "/Users/kyle/Desktop/herald-letters-
redux/herald-letters-r-analysis-round2/customized-stop-words-for-r.csv",
                              header = TRUE,
                              sep = ",") # import .csv of custom stop words

herald_stop_words <- tibble(custom_stop_words) # transform stop word list
into tibble

herald_letters_unnested <- herald_letters_tibble %>%
```

```
  unnest_tokens(word, LETTER_TEXT) %>%
  anti_join(herald_stop_words, by = "word") # unnest herald_letters_tibble,
filter out stop words from custom list

herald_letters_unnested_lemma <- herald_letters_unnested %>%
  add_column(lemma = lemmatize_words(herald_letters_unnested$word)) %>%
  select(-word) # add column with lemmas, delete word column
```

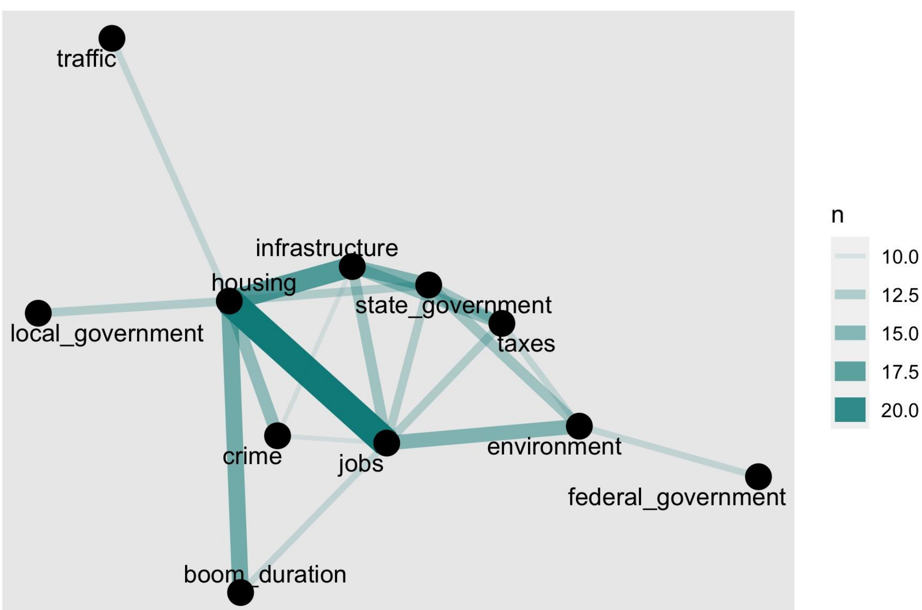
A3.3. Thematic analysis

When I compiled the corpus in 2019, I worked with a research assistant to hand code the letters, noting the themes addressed by each letter. Here I import a spreadsheet with each letter's thematic tags.

```
herald_themes <- read.csv(file = "/Users/kyle/Desktop/herald-letters-
redux/herald-letters-r-analysis-round1/Letters-to-Editor-tagged-for-
correlation-analysis-may2023.csv",
                           header = TRUE,
                           sep = ",") # import .csv

herald_themes_tibble <- tibble(herald_themes) # transform into tibble

hl_themes_unnested <- herald_themes_tibble %>%
  unnest_tokens(word, THEMATIC_TAGS) # unnest herald_themes_tibble

hl_theme_count <- hl_themes_unnested %>%
  count(word, sort = TRUE) # create tibble called hl_theme_count listing
lemmas from most to least frequent

hl_theme_count

## # A tibble: 24 × 2
##    word                   n
##    <chr>              <int>
##  1 jobs                  46
##  2 environment           44
##  3 housing               43
##  4 infrastructure        39
##  5 taxes                 37
##  6 state_government      36
##  7 boom_duration         29
##  8 local_government      25
##  9 crime                 23
## 10 federal_government    18
## # … with 14 more rows
```

The following chunk creates a figure showing the network of co-occurring thematic tags that appear at least 10 times.

```
hl_tag_pairs <- hl_themes_unnested %>%
  pairwise_count(word, TITLE, sort = TRUE, upper = FALSE)

set.seed(6)

hl_tag_pairs %>%
  filter(n >= 10) %>%
  graph_from_data_frame() %>%
  ggraph(layout = "fr") +
  geom_edge_link(aes(edge_alpha = n, edge_width = n), edge_colour = "cyan4")
+
  geom_node_point(size = 5) +
  geom_node_text(aes(label = name), repel = TRUE, point.padding = unit(0.2,
"lines"))
```



A3.3.1. Lemma frequency list

The following chunk displays a table listing the forty most frequent lemmas from the entire corpus.

```
hl_lemma_count <- herald_letters_unnested_lemma %>% count(lemma, sort = TRUE)
# create tibble called hl_lemma_count listing lemmas from most to least
frequent
```

```
hl_lemma_count %>% print(n = 50)
```

```
## # A tibble: 4,190 × 2
##    lemma              n
##    <chr>          <int>
##  1 williston        241
##  2 people           196
##  3 water            153
##  4 city             139
##  5 time             128
##  6 community        127
##  7 industry         127
##  8 tax              124
##  9 house            109
## 10 area              95
## 11 gas               93
## 12 rule              92
## 13 boom              90
## 14 pay               85
## 15 job               78
## 16 live              78
## 17 bakken            77
## 18 bill              74
## 19 build             73
## 20 company           73
## 21 support           72
## 22 western           68
## 23 local             67
## 24 vote              67
## 25 public            66
## 26 town              66
## 27 family            65
## 28 land              65
## 29 million           65
## 30 money             65
## 31 county            62
## 32 project           62
## 33 property          60
## 34 fund              59
## 35 business          58
## 36 energy            58
## 37 infrastructure    57
## 38 issue             57
## 39 life              57
## 40 percent           56
## 41 place             56
## 42 school            54
## 43 day               53
## 44 owner             53
```

```
## 45 home              51
## 46 increase          50
## 47 lot               50
## 48 concern           49
## 49 plan              49
## 50 move              48
## # … with 4,140 more rows
```

A3.4. Semantic analyses

Letter-writers' interaction with meaning has both a received and an active dimension. In the first instance, speakers in general, and letter-writers in particular, must use the tools they have at hand – words in a language that they share with others. In the second, they actively use those tools to specific ends of their own defining. The following analysis proceeds from this observation, in particular the idea that the patterns characterizing which words appear together in different contexts reflect, first, the associations that different words evoke for letter-writers, and second, letter-writers' efforts to evoke specific associations for their (imagined) readers.

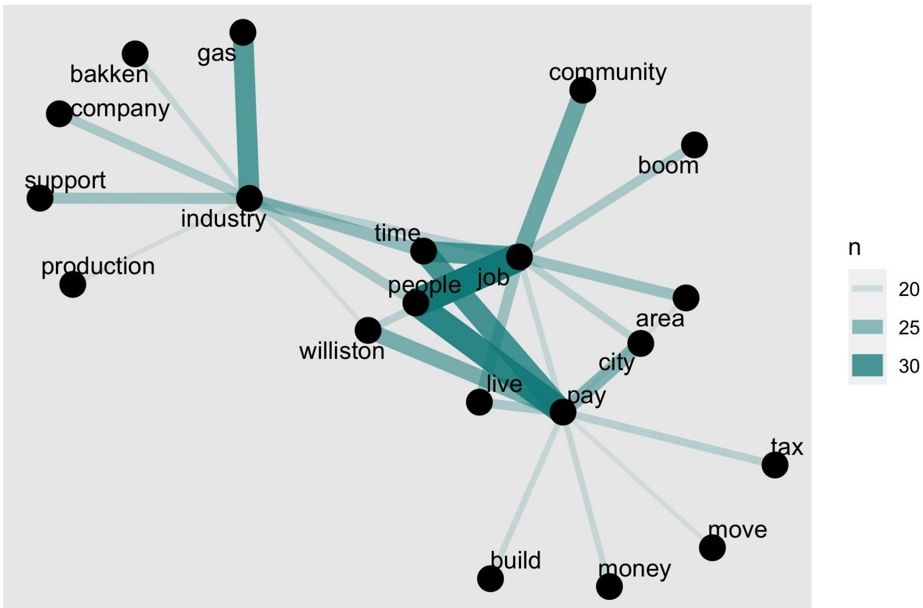
A3.4.1. Semantic map: Theme of jobs

In the list generated in A3.3, three most frequent lemmas related to *jobs* are *industry*, *pay*, and *job*. The following chunk creates a figure that shows the most frequent co-occurrence pairs that include at least one of those lemmas.

Here (as in steps A3.4.2 and A3.4.3) I set a threshold for the minimum number of pairs to be displayed: the lower the minimum, the greater the number of pairs. I determined the threshold by finding the point where the resulting figure was as rich as possible (i.e., it showed as many links as possible) but still remained legible.

In this instance, the threshold is 19. When I set it at 18, the figure was too dense too read; when I set it at 20, certain links disappeared. I determined the thresholds for the other figures in the same way.

```
hl_lemma_pairs <- herald_letters_unnested_lemma %>%
  pairwise_count(lemma, TITLE, sort = TRUE, upper = FALSE) # create pairwise
count of Herald Letters lemmas

# The following function creates semantic maps. Its arguments include:
# full_lemma_list: the pairwise count of lemmas from the Herald corpus
(tibble)
# lemma_subset: the specific lemmas around which to build clusters (vector of
characters)
# min_pairs: the minimum number of pairs to display (integer)
# semence: the seed for the random number generator (integer)

semantic_map <- function(full_lemma_list,lemma_subset,min_pairs,semence){

set.seed(semence)

full_lemma_list %>%
  filter(n >= min_pairs & (item1 %in% lemma_subset | item2 %in%
lemma_subset)) %>%
  graph_from_data_frame() %>%
  ggraph(layout = "fr") +
  geom_edge_link(aes(edge_alpha = n, edge_width = n), edge_colour = "cyan4")
+
  geom_node_point(size = 5) +
  geom_node_text(aes(label = name), repel = TRUE, point.padding = unit(0.2,
"lines"))
}

hl_lemma_pairs %>% semantic_map(c("industry","pay","job"),19,44) # display a
semantic map of "industry," "pay," and "job" with a minimum of 19 pairs (and
a random seed of 44)
```

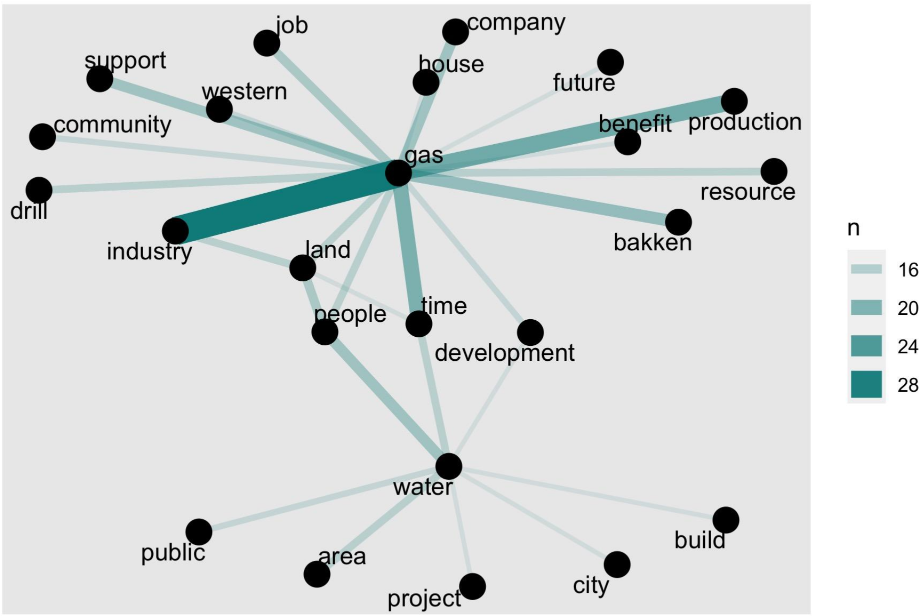


A3.4.2. Semantic map: Theme of environment

Most of the passages my research assistant and I coded as making reference to the environment mentioned local and national parks, bodies of water, or local flora and fauna. The number of lemmas repeated across letters was therefore relatively small. The three most frequent (namely water, land, and gas) thus appear further down the list in sec. A3.3 than those related to the themes of jobs or housing.

As above, the following chunk creates a figure that shows the most frequent co-occurrence pairs that include at least one of those lemmas.

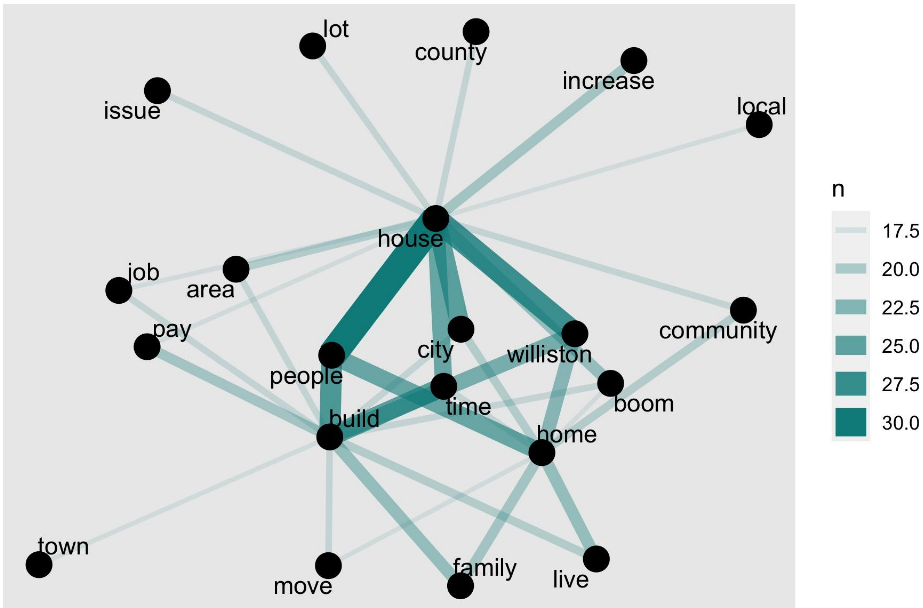
```
hl_lemma_pairs %>% semantic_map(c("water", "land", "gas"),13,4) # display a semantic map of "water," "land," and "gas" with a minimum of 13 pairs
```



A3.4.3. Semantic map: Theme of housing

Three most frequent lemmas from the list in A3.3 related to housing are house, build, and home. As above, the following chunk creates a figure that shows the most frequent co-occurrence pairs that include at least one of those lemmas.

```
hl_lemma_pairs %>% semantic_map(c("house", "build", "home"),17,9) # display a semantic map of "house," "build," and "home" with a minimum of 17 pairs
```



A3.5. Sentiment analysis

In this section I use the "Bag of Words" method for quantifying (in an approximate way) the negative or positive sentiments expressed in each letter (see Wankhade, Rao, and Kulkarni 2022). I use three lexicons: AFINN (sec. A3.5.2), NRC (sec. A3.5.3), and Bing et al. (sec. A3.5.4).

A3.5.1. Compute letter_count

In a later step I will compute the mean sentiment value for each letter. To do that, I will need to know how many are in each group. (The groups are the same as those I use in the correspondence analysis calculated with KH Coder.)

```
letter_count <- c(count(distinct(filter(herald_letters_unnested, GROUP == 1)[4])),
                  count(distinct(filter(herald_letters_unnested, GROUP == 2)[4])),
                  count(distinct(filter(herald_letters_unnested, GROUP == 3)[4])))

letter_count_tibble <- tibble(GROUP = 1:3, COUNT = as.integer(letter_count))
```

A3.5.2. Sentiment analysis: AFINN lexicon

The AFINN lexicon attributes values between -5 and 5 to indicate both valence (negative or positive) and the strength of the sentiment (absolute value from 0 to 5).

```
library("textdata") # necessary to load sentiment lexicons

# Create a tibble by merging herald_letters_unnested_lemma and the tibble
generated by get_sentiments("afinn") wherever a word in
get_sentiments("afinn") matches a lemma in herald_letters_unnested_lemma:

hl_afinn_lemma <- herald_letters_unnested_lemma %>%
  inner_join(get_sentiments("afinn"), by = (join_by(lemma == word)))

hl_afinn_sentiment_lemma <- hl_afinn_lemma %>%
  group_by(group = GROUP) %>% # group letters by GROUP column
  summarise(sentiment = sum(value)) %>% # calculate sum of values in
sentiment column
  mutate(method = "AFINN") # add column to identify which lexicon I have used

hl_afinn_sentiment_lemma <- hl_afinn_sentiment_lemma %>%
  add_column(nbr = letter_count_tibble$COUNT) %>% # add column indicating
number of letters per group
  add_column(avg_sentiment_afinn_lemma = hl_afinn_sentiment_lemma$sentiment /
letter_count_tibble$COUNT) # add column calculating sentiment averaged over
individual letters

show(hl_afinn_sentiment_lemma)
## # A tibble: 3 × 5
##   group sentiment method   nbr avg_sentiment_afinn_lemma
##   <int>     <dbl> <chr>  <int>                     <dbl>
## 1     1        23 AFINN     32                     0.719
## 2     2       143 AFINN     59                     2.42
## 3     3       272 AFINN     41                     6.63
```

A3.5.3. Sentiment analysis: NRC

The NRC lexicon attributes a negative or positive valence to each word. The technique below calculates a letter's sentiment by subtracting the number of negative words from the number of positive words.

```
# Create a tibble including all (but only) the lemmas in nrc coded as
positive or negative:

hl_nrc_lemma <- herald_letters_unnested_lemma %>%
  inner_join(get_sentiments("nrc"), by = (join_by(lemma == word))) %>%
  filter(sentiment %in% c("positive","negative"))

# Calculate sentiment for each group by calculating difference between number
of words coded as positive and number of words coded as negative by first
grouping letters together by the value indicated in column GROUP

hl_nrc_sentiment_lemma <- hl_nrc_lemma %>%
  group_by(index = GROUP) %>%
  count(sentiment) %>%
  pivot_wider(names_from = sentiment,
              values_from = n,
              values_fill = 0) %>%
  mutate(sentiment = positive - negative)

# Then calculate sentiment as an average per letter:

avg_sentiment_nrc_lemma <- hl_nrc_sentiment_lemma$sentiment /
letter_count_tibble$COUNT

# Add columns indicating number of letters and average sentiment:

hl_nrc_sentiment_lemma <- hl_nrc_sentiment_lemma %>%
  add_column(nbr = letter_count_tibble$COUNT) %>%
  add_column(avg_sentiment_nrc_lemma)

show(hl_nrc_sentiment_lemma)

## # A tibble: 3 × 6
## # Groups:   index [3]
##   index negative positive sentiment   nbr avg_sentiment_nrc_lemma
##   <int>    <int>    <int>     <int> <int>                   <dbl>
## 1     1      459      831       372    32                    11.6
## 2     2      792     1619       827    59                    14.0
## 3     3      558     1170       612    41                    14.9
```

A3.5.4. Sentiment analysis: Bing et al.

The Bing et al. lexicon, like the NRC lexicon, attributes a negative or positive valence to each word. The technique below calculates a letter's sentiment by subtracting the number of negative words from the number of positive words.

```
# Create a tibble including all (but only) the lemmas in Bing et al. coded as
positive or negative:

hl_bing_lemma <- herald_letters_unnested_lemma %>%
  inner_join(get_sentiments("bing"), by = (join_by(lemma == word))) %>%
  filter(sentiment %in% c("positive","negative"))

# Calculate the sentiment by grouping by letters together by the value
indicated in column GROUP and calculating difference between number of words
coded as positive and number of words coded as negative:

hl_bing_sentiment_lemma <- hl_bing_lemma %>%
  group_by(index = GROUP) %>%
  count(sentiment) %>%
  pivot_wider(names_from = sentiment,
              values_from = n,
              values_fill = 0) %>%
  mutate(sentiment = positive - negative)

# Calculate sentiment as an average per letter:

avg_sentiment_bing_lemma <- hl_bing_sentiment_lemma$sentiment /
letter_count_tibble$COUNT

# Add columns indicating number of letters and average sentiment:

hl_bing_sentiment_lemma <- hl_bing_sentiment_lemma %>%
  add_column(nbr = letter_count_tibble$COUNT) %>%
  add_column(avg_sentiment_bing_lemma)

show(hl_bing_sentiment_lemma)
```

```
## # A tibble: 3 × 6
## # Groups:   index [3]
##   index negative positive sentiment   nbr avg_sentiment_bing_lemma
##   <int>    <int>    <int>     <int> <int>                    <dbl>
## 1     1      373      242      -131    32                  -4.09
## 2     2      631      627        -4    59                  -0.0678
## 3     3      434      373       -61    41                  -1.49
```

A3.5.5. Hand-coded sentiment analysis

Here I load Letters-to-Editor-tagged-for-correlation-analysis-may2023.csv, to which I've added a column grouping the letters as above. This approach follows the same logic as that of sections A3.5.3-4, but rather than count words that are positive or negative, I am counting letters. (I worked with a research assistant to assign the positive and negative values manually.) Because the value range for each letter is effectively -1 to 1, the resulting values are much smaller. I am therefore expressing the values as a mean per 10 letters. The absolute values are not what interest me. Instead, I want to observe the relative values across the three groups, something that becomes clearer for the hand-coded values when expressed as a mean per 10 letters.

```
hl_tags <- read.csv(file = "/Users/kyle/Desktop/herald-letters-redux/herald-
letters-r-analysis-round1/Letters-to-Editor-tagged-for-correlation-analysis-
may2023.csv",
                           header = TRUE,
                           sep = ",") # import .csv

hl_tag_disposition <- hl_tags %>% # group the letters together by the value
indicated in column GROUP
  group_by(index = GROUP) %>%
  count(DISPOSITION) %>%
  pivot_wider(names_from = DISPOSITION,
              values_from = n,
              values_fill = 0) %>%
  mutate(DISPOSITION = favorable - unfavorable) # calculate sentiment for
each group by calculating difference between number of words coded as
favorable and number of words coded as unfavorable

avg_sentiment_tags <- (10 * hl_tag_disposition$DISPOSITION) /
letter_count_tibble$COUNT # calculate disposition as a mean per 10 letters
```

```
hl_tag_disposition <- hl_tag_disposition %>% # add columns indicated number of letters and average sentiment
  add_column(nbr = letter_count_tibble$COUNT) %>%
  add_column(avg_sentiment_tags)

show(hl_tag_disposition)
## # A tibble: 3 × 7
## # Groups:   index [3]
##   index favorable neutral unfavorable DISPOSITION   nbr avg_sentiment_tags
##   <int>     <int>   <int>       <int>       <int> <int>              <dbl>
## 1     1         9       5          18          -9    32             -2.81
## 2     2        20      14          25          -5    59             -0.847
## 3     3        27       2          12          15    41              3.66
```

Finally, I create a tibble containing the average sentiment values calculated above. I will export this tibble as a .csv, which I will import into Google Sheets, whose graphing functions I prefer.

```
combined_sentiment <- tibble(GROUP = letter_count_tibble$GROUP,
                  COUNT = letter_count_tibble$COUNT,
                  AFINN = hl_afinn_sentiment_lemma$avg_sentiment_afinn_lemma,
                  NRC = hl_nrc_sentiment_lemma$avg_sentiment_nrc_lemma,
                  BING = hl_bing_sentiment_lemma$avg_sentiment_bing_lemma,
                  Hand_coded = hl_tag_disposition$avg_sentiment_tags)

show(combined_sentiment)
## # A tibble: 3 × 6
##   GROUP COUNT AFINN   NRC    BING Hand_coded
##   <int> <int> <dbl> <dbl>   <dbl>      <dbl>
## 1     1    32 0.719  11.6 -4.09      -0.281
## 2     2    59 2.42   14.0 -0.0678    -0.0847
## 3     3    41 6.63   14.9 -1.49       0.366
```

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