From black to green to gold

alternative land use strategies for abandoned and decommissioned oil well sites in southeast Saskatchewan

by: Kyla Tulloch

A practicum submitted to the
Faculty of Graduate Studies of
The University of Manitoba

in partial fulfillment of the requirements of the degree of
Master of Landscape Architecture

Department of Landscape Architecture
Faculty of Architecture
University of Manitoba
Winnipeg, MB, Canada

July 19, 2017

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To make a prairie it takes a clover and one bee,

One clover, and a bee.

And revery.

The revery alone will do,

If bees are few.

Emily Dickinson, n.d.., cited in Ashok, 2013

Figure 1.1.01: remnants of oil well sites in southeast Saskatchewan

abstract

Through the historic and current study of southeast Saskatchewan, this practicum reveals the present day conditions of the exploited and extended rural landscape. The pothole prairie landscape has been structured and altered beyond recognition from agricultural land use and oil extraction, affecting flora and fauna and ecosystem services. This practicum strives to reconsider how we use the land and advocates for large-scale change through small-scale interventions. Abandoned and decommissioned oil well sites are repurposed through the alteration of government regulations, the combination of conservation initiatives, the recognition of private land ownership limitations, and the proposal of a new land use management system. This creates a shift from the oil well sites as barren bits of gravel amidst the monoculture matrix to thriving sites of forage and nesting for native bee species.

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acknowledgments

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To Robyn, for always listening and asking, no matter the amount of repetition.

To Adam, for helping me to laugh off a frump.

To Nathan, for always being a shoulder, usually two.

GOALS AND OBJECTIVES

goals

To explore a land use strategy that repurposes abandoned oil well sites in southeast Saskatchewan. This will be done through a focused application on a section of land that will create and promote the alternative land use strategy on the landscape. This application will acknowledge the agriculture and resource extraction that dominates the landscape, but will be designed according to the lens of post-industrialism.

This practicum will explore what exists and what could exist. It will question how we can reconsider post-industrial sites to become a new industrialism, whether it is for people or not for people. It will question the possibility of repurposing oil well sites from black, to green, to gold.

objectives

1 To reflect the history of the oil well sites post-decommissioning

This practicum takes place in the future when oil well sites are no longer productive, but abandoned and decommissioned. The oil infrastructure will be treated to reflect the history of the previous oil well sites and their impact on the landscape. The proposed strategy will visually commemorate the removed infrastructure, reminding the viewer that, although we can hide the impact of human-based land use, it is not truly erased from the landscape itself. This will reduce the impression that we can use land and heal it to its previous state, instead acknowledging that human use of land has long-lasting impact.

2 To create a visual, defining feature on the landscape that redefines 'productivity' and allows others to reinterpret the productivity of the landscape through visual elements

As an alternative land use strategy is the goal of this practicum, it is beneficial to promote the understanding of what this strategy means. Although the landscape of southeast Saskatchewan appears productive with seemingly endless open space and fields of food-producing crops, it is productive only with the diligence of land users, particularly farmers. The design will not only aspire to create a new perception of sustainable productivity, but to allow others to access the elements of this through a semiotic interpretation of visual aides.

3 To repurpose abandoned and decommissioned oil well sites

Although human occupation and understanding are all a part anthropogenically modified and inhabited landscapes, people do not always need to be a hands-on, interactive element of a designed landscape. Instead, the strategy will respect the limitations of private land ownership and use rampant on the landscape.

4 To implement the necessities for native bee populations to survive

The alternative land use strategy will focus on an often overlooked but inherently necessary aspect of a rural, agricultural landscape: what is missing, what is there, and what can be added to encourage appropriate ecological requirements for native bee populations. The proposed strategy will focus on the requirements for bees to survive in the agricultural landscape and provide valuable ecosystem services.

1 FROM BLACK ...

mind the gap

1.1 THE REGION

more than plain

Figure 1.1.02: monoculture field of durum in southeast Saskatchewan

SOUTHEAST SASKATCHEWAN

musings on a misunderstood prairie plain

“There’s nothing to see.”

A commonly verbalized and impatiently ruminated phrase by both those who are familiar and unfamiliar with the prairies of southeast Saskatchewan. There’s nothing spectacular in sight: no mountains, no cliffs, no rolling hills framed by impenetrable walls of conifers and shadows and wildlife-pioneered trails begging to be explored. There are no secrets, no hidden caches to stumble upon, no unexplored heights or depths that only the toughest and trained can traverse. Everything is bared free to the wind, the sky, the horizon. The lack of visible mystery on Saskatchewan’s prairie landscape suggests that a two-dimensional perspective is enough to know the landscape, to comprehend the complexities with a glance. Because there’s nothing to see.

First impressions yield a vast space, a mosaic plain ambling between the deceivingly productive colour blocks of crops roughly fringed with weed-infested ditches and punctuated by cattail-smothered sloughs, all bordered by rutted grid roads intersecting broken asphalt highways and gray-topped railroad tracks. These are framed in the atmospheric blue wall of sky, sliced clean at the horizon line, a cut visible through the ever-conversed weather. Repeating patterns of gold, green, grey, blue. It is an industrial landscape disguised as fruitful, productive, layers of high-yield crops growing food that maintains Saskatchewan’s status as the Breadbasket of Canada. Farmyards dot the countryside, havens of trees and humanity amongst the strictly structured quarter sections, swathed into bands of yellows, blues, greens, and golds. Here and there a hawk glides along the currents, silent and steady, often betrayed only as his shadow drops to the ground and unwillingly reveals his position in the sky. Unbeknown to the traveler, a fox slinks through the ditches, searching, hunting, evading your presence with a wary ease. Carefully nestled in the fields, pronghorn antelope keep watch, feigning unconcern but ready to bolt at a moment, bounding through and over crops and graveled rocks. For them, there’s always something to watch, to see.

The landscape is not unfriendly. There are no visual barriers restricting exploration and the waving heads of durum and canola greet the viewer with gentle movement, almost beckoning if the prairie winds aren't hastening that day. But to be on the landscape is to know that limitless views still limits moves. To immerse one's self in the monochromatic yellow of a blooming canola field is romantic, unique, beautiful, trespassing. But there's a lure to inhabit a field of flowers, a bright yellow against a stormy sky, a palette of navy and sunshine, a reversal of land and air that inspires passersby to stop and stare. To ignore the rules, to forego ownership laws in the face of beauty and spectacle. A field of durum, of wheat, of barley, of gold can strike metaphorical musings into the mind. The golden crops, uninterrupted in their weed-free splendour, represents a landscape controlled. A landscape that produces only what is necessary, wasteless in its function. A landscape, when harvested, that transforms from plants to profit. But, still, there's nothing to see.

There's nothing to see when a viewer perceives Saskatchewan from a highway, moving through the gap, a Place to a Place, with Saskatchewan in the middle, blurring the details of individual plants, of camouflaged wildlife, of backroads and highways that lead to small towns and forgotten farmsteads. There's nothing to see when you aren't immersed in the willpower and war on weeds that farmers face, creating admirable rows of solid gold, yellow, and green. There's nothing to see when a two-dimensional perspective inhibits the senses, valuing sight over all the others: texture and sound, the taste of fresh air tinged with harvest dust underlaid with the acrid burnings of flax that inflame the city-folk's ire. There's nothing to see when you crave easily appreciated spectacle, inured majesty by the power of nature, wilderness, extreme environments.

I was born on the prairies and grew up thinking there's nothing to see. I grew up going out to the farm, a little Scottish settlement by the name of Dummer, and wishing the longest, most boring hour-long ride would be over. Because I did not recognize the farm I love(d) as a component of the prairie-drive I found so uninteresting. I did not recognize that the caragana shrubs alongside the green house with the red roof was part of the boring prairies. That the hours spent exploring the farmyard we'd already explored a hundred times or more was still exciting, something new to see every time. No, Dummer was (is?) my favourite place in the world. Forts in the bushes inhabited as much by us as by spiders, lumps of coal in the postcard-worthy dilapidated buildings, Dad chasing an escaped kite while Mom made hamburger-corn-macaroni stuff, our farm/house cat Spocker chasing after mice and scarring us animal-loving kids by only eating the heads, Adam picking up a discarded shoelace only to discover a garter snake in place, Robyn and I trying to get the telescope in the closet to work but always avoiding the haunted house with the two windows in the field over. These boring prairies host memories that will, with luck, last a lifetime. That shaped summers full of memories, of the outdoors, of time spent with family, of the freedom that always accompanied busy times on the farm. There was, and is, always something to see.

Figure 1.1.03: a typical southeast Saskatchewan scene

THE REGION OF STUDY

location provocation

My day begins leaving home in Regina, Saskatchewan, and traveling southeast along Highway 33. The sky is the soft gradient blue for the visible 180 degrees, sprinkled with the odd puffy cloud, hardly slowing the Vitamin D infecting its wards. But, in true Saskatchewan fashion, the threat of a thunderstorm lurks for late afternoon. This is not obvious to the casual observer but, a farming family, we were raised to analyze the weather we depend on. A quick turn can put a halt to the day or the growing season: hail has been known to reduce the upright ranks of stalks standing row on row to a beaten and broken insurance claim. Remnant of my childhood, the horror movie Twister always features prominently in my weather musings. The puffy clouds that I once saw shapes in now warn of isolated thunderstorms that are a breath away from becoming a rogue tornado. Thanks to my dad, my sister, and my never-resolved fear of tornadoes, I can read the weather, discerning the formation and types of clouds and the threat they may or may not pose. Cumulus, stratus, nimbus, cumulonimbus the most frightening of all. For now, though, my fears abate as the sun shines down on my left arm, the heat a welcome addition to the air-conditioned interior of my little car.

The black-topped highway features all the bumps and potholes characteristic of Saskatchewan's roads, a persistent remnant of winter's wrath when winter is long past. I've traveled this highway many times before but each year the hazards change as construction crews work all summer long to fix what will start all over next spring. I race through small towns that abut the highway: Lajord, Sedley, Francis, Fillmore, until I take a right at Stoughton to head south on Highway 47. So far the scenery has been stereotypical Saskatchewan prairie landscape: power poles separating highway from railroad, trains with hundreds of cars exploiting their single-lane benefit as they whistle at intersections without slowing, a hawk floating effortlessly far above the fields hunting prey I'll never see. A quick left takes me to Lampman, a small town that angles itself to the railroad, a common layout to rural centers. The gas station is easily found, on the corner of what appears to be the two main roads in town. A chocolate bar, a quick gas fill-up, and I'm ready to continue, anxious to be out of the car after two hours to breathe in the dust-laden summer air.

Heading south on Highway 605, the prairies look like the postcard plains of Saskatchewan: a staccato patchwork of crops and grid roads and dust kicked up from combines as far as the eye can see. Within minutes, however, a new shape looms on the horizon. And then again. And then again, appearing around the edges of semi-drowned bosques and tree-lined farmyards, a stark mechanical shape against the softly gradient sky. Although I do not pretend that I perceive the landscape to be organic, with its sharp lines, monochromatic fields, and divisive roads, the rigid pump jacks still appear harsh and rugged compared to the blurring of each field's individual horizon softened by the feathered edges of crops in bloom. The pump jacks, repeating shape on shape from all views, punctuate the fields with their weed-green edges on their personal gravel roads, their height, their grating sound a low grinding and thrum an octave higher than the wind caught in the power lines, a sound so low I perceive it as a vibration first and a sound second. As I adjust to these stark intrusions, a combine crosses my field of vision. First, relief: a shape, a sound, a familiar piece of equipment. Second, a surprising revelation. Are there are not complementary shapes amongst the pump jacks and combines? Are there not coordinating rhythmic movements that, at different speeds, are still reminiscent of the other? A big rig barrels by, half a section away, a non-static element of the pump jack's presence that removes me from my revery.

As I stand by my dusty car, almost camouflaged against the gravel roads, unsure where to start, I begin taking photographs, documenting the landscape, the vegetation, the farmers progress, and, most of all, the pump jacks. It's like I can't look away, can't not include them in my documentation, despite my aversion to their clunky frames disrupting the horizon. I find them intrusive, unnatural, uncanny. And yet I find the unnaturally yellow canola fields familiar, the necessarily weed-free durum crop next to it a piece of home. But they are no more natural than the pump jacks. I can't look around them, I can't ask them to move, I can't take a distance-based photograph without catching one, maybe two, in the lens. I drive, aimlessly touring the area, turning back when the pump jacks appear to end, reorienting myself according to the range road grid. I begin to adjust to the pump jacks. I use them to frame photographs, as blurred heavy backgrounds against the lightness of weeds and crops, as focal points miles away. I document their sneakiness, as they hide behind the water-logged trees, sometimes two or three seemingly nestled amongst the trees as if they don't wish to despoil the landscape. I try to capture their rhythm and repetition, one reflecting another, rows of pump jacks that don't align to the long-developed gravel roads, rows that force farmers to swath curvilinear patterns around them. I think of my dad, as he seeds and swaths around power poles, giving the guy lines extending outwards a safe berth. I asked him, once, if he was bothered by the power poles. He said no. He said he works around them like anything else. It seems the farmers here do the same. I question what I interpret as industrial. Do I consider agriculture as less industrial because the process involves planting? Because the process of seeding and harvesting is so familiar to me, passed down from Stone Age pioneers to my generation?

This is the region I choose to study. The region that makes me confront my own values, my own interpretations, and, most of all, my own double standards. I resent oil while living off the materials it provides. I worry for the future of the environment while driving my car for 7 hours that day alone to document and study said environment. I question the necessity of industrial landscapes while admiring my father for building and maintaining one. I question how I can be so supportive of agriculture as an industrial landscape when I know the pesticides and herbicides that make crops grow, the exchange of fertile soil for high-yield crops. And I wonder what will happen to this landscape when the oil is gone. What can these sites be? What can they DO?

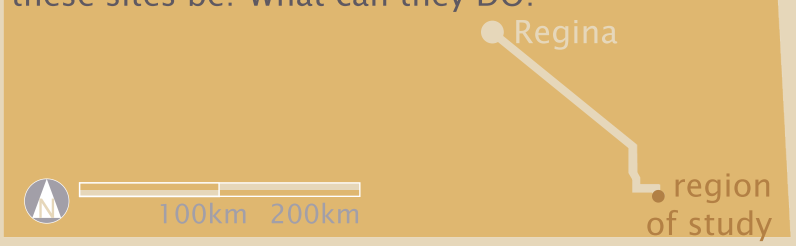


Figure 1.1.04: traveling to the region of study viewed via satellite

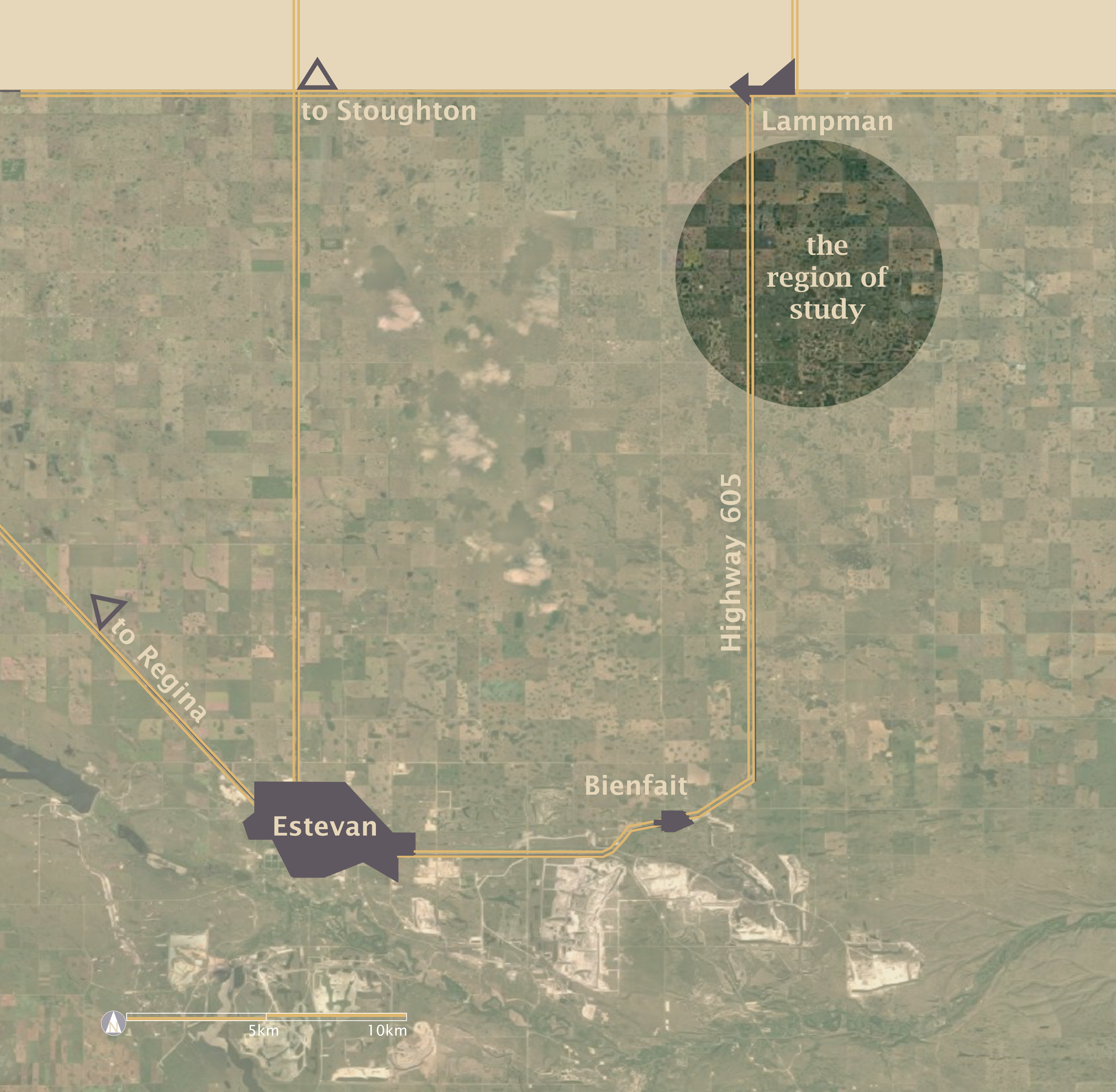


Figure 1.1.05: locating the region of study (Tulloch, K., 2017)

The Rural Municipality (R.M.) of Browning No. 34 hosts the region of study in this practicum. “Browning is primarily an agriculture based municipality, with an extensive commercial assessment due to the oilfield and oil related businesses” (R.M of Browning, n.d). The municipality “is 18 miles by 18 miles and consists of nine townships: 4-4, 4-5, 4-6, 5-4, 5-5, 5-6, 6-4, 6-5, 6-6, all west of the second meridian” and hosts the Town of Lampman and the hamlets of Willmar and Steelman (R.M of Browning, n.d).

“Prior to European settlement, indigenous people occupied the land area now known as Saskatchewan. They were primarily hunters and gatherers; their numbers relative to the food resources from bison, other animals and birds, native fruit and plants did not warrant an extensive agriculture production system to provide food” (Storey, 2006). However, from the 1890s to present day, European settlers would dominate this area and transform the prairie from a grassland oasis of biodiversity to a wheat-saturated exportation district (Storey, 2006). Settlers began occupying Saskatchewan with the development of the railway: “The Canadian Pacific Railway [CPR] crossed Saskatchewan in 1884 and was completed in 1885. It was now possible to bring in settlers and move out the agricultural commodities they would produce. The CPR and the federal government provided an image of the west as a ‘promised land,’ a garden of abundance where all material wants would be satisfied” (Storey 2006). It did not take long for what is now the southeast corner of Saskatchewan to receive pioneer settlers. “By the turn of the 20th Century … the west was settled and the native prairie was converted to cropland within a period of thirty years. Wheat was the staple crop on which the prairie economy was built, although other crops such as oats, barley, and flax were produced” (Storey, 2006).

As towns became settled from agricultural expansion, populations fluctuated parallel to resource discovery and extraction. As mining practices and oil drilling matured, the populations doubled in the surrounding towns: Lampman, Bienfait, and Estevan. Bienfait was one of the first towns to be affected by resource extraction: “the first viable coal mine was established a few kilometres south of the Bienfait town site at Roche Percée in 1891” (McLennon, 2008 cited in Bienfait, n.d.). As the government strategy encouraged more immigration to the west, the Bienfait region quickly expanded. “In the early 1900s, the CPR started Bienfait Mines Ltd. and soon more mines were opened in the area. Many local farmers used coal mining income to help them establish their farms” (McLennon, 2008 cited in Bienfait, n.d.). Lampman, north of Bienfait, saw settlers arrive at the same time as Bienfait. “In 1913, Lampman became the junction of two rail lines as the track linking Regina to the Port of Northgate on the Canada-US border was completed. The community grew slowly but steadily (except for a slight downturn during the 1930s) until the 1950s, when development of the area’s oil industry began” (McLennan, 2006b). Estevan’s population has, from the time of settlement, fluctuated with resources more than the other locales. “Growth was accelerated by the centralization of electrical power production and the development of coal and oil resources in the area: Estevan Generating Station was constructed in 1930, Boundary Dam Generating Station between 1957 and 1970, and Shand Generating Station in 1992. The population doubled to 8,500 within two years of the intense development of the local oil fields in 1955” (Salmers, 2006) .

The timeline on the next page lays out the historical relation between the town’s development and population fluctuations in the region.

timeline: immigration and industrialization

pre-contact

First Nations peoples were known to travel this area prior to European contact. Roche Percée, a town located south of Estevan and named for the unique hollowed sandstone rock, was long established as a camping point for First Nations and Metis peoples (Salmers, 2006).

1890

Primarily of European descent, the first settlers arrive in the area from other parts of Canada and the United States (Bienfait, n.d.).

1891

Coal is discovered in the Bienfait area. "Although the Palliser Expedition noted coal along the Souris River in 1857, quantities had been thought too insubstantial to warrant development. It was decades before the extent of the coal beds was realized, and the first lignite mined in the area was by individual entrepreneurs and small-time operators" (McLennan, 2006a).

1892

CPR completes a rail line from Brandon, MB, through Bienfait and Estevan (Bienfait, n.d.).

1893

Soo Line is extended through Bienfait and Estevan. This link supported "easy access to the area for many settlers coming from the United States, who were substantially of European origins" (Bienfait, n.d.).

1899

Estevan attains village status (Salmers, 2006).

1900

CPR establishes Bienfait Mines Ltd., prompting the opening of other, locally run mines in the area. Many farmers used coal mining to support the establishment of their farms (McLennan, 2006a).

1906

Estevan attains town status. The population grew from 141 in 1901 to 877 this year, largely due to coal mining in and around Bienfait (McLennan, 2008, p.120).

1909

Canadian National Railway (CNR) builds a line from Carlyle to Bienfait, creating a second line in the community. Lampman, along this line, is settled (Discover Estevan, n.d.).

1910

Lampman develops with the CNR line and attains village status that same year (McLennan, 2006b).

1911

Bienfait receives a second rail line from the CNR Carlyle extension (Bienfait, n.d.).

1912

Bienfait attains village status as coal mining continues to grow. This same year the Rural Municipality of Browning No. 34 is established (Bienfait, n.d.).

1913

Lampman becomes the junction of two rail lines: Regina to Port of Northgate (Canada – U.S. border) is built, intersecting with the Carlyle to Estevan line (McLennan, 2006b).

To understand the development of the surrounding populated areas of the site of study, the timeline indicates the major shifts in population growth and economic development. As page 9 discusses, the evolution of land use practice drove the populated areas expansion, indicating a direct correlation between land development and habitation on the new prairies.

1930

Estevan Generating System is built, increasing employability in the region and supplementing the agricultural and coal mining employment and ensuring steady population growth (Salmers, 2006).

1950s

Notably, the oil industry begins in the region. “The development of the oil industry in the 1950s, however, is what transformed the community. From a population of 3,935 in 1951, Estevan grew to number 7,728 a decade later” (McLennan, 2008, p.120). Meanwhile, Lampman’s population grows with the addition of Steelman Gas Processing Plant southeast of town, creating jobs in a nearby community; at the end of WWII, Lampman’s population was approximately 250, but “a frenzy of activity followed the drilling of the first successful wells in the district” (McLennan, 2008, p.120).

1957

Beinfait attains town status with a population of approximately 800 (Bienfait, n.d.), while Estevan expands to attain city status (McLennan, 2008, p.120).

1963

Lampman attains town status with a population around 650 (SunCountry Health Region, n.d.).

present day

The region continues to advance economically in much the same manner it has since settlement: agriculture, oil, and coal mining continue to employ many residents in the region. “Today, there are several thousand oil and gas wells in the area. Agriculture, too, is important to the economy: red spring wheat and durum are the predominant cereal crops grown in the region, and canola, mustard, flax, pea and lentil acreages have been increasing in recent years” (McLennan, 2008, p.120). The urban centers host a whole variety of services that allow residents to comfortably occupy the region: “Lampman has a full range of businesses and services, many of which cater to the oilfield and agricultural industries which form the basis of the regional economy” (McLennan, 2006b).

Figure 1.1.06: fields of the oil fields in the region of study

SASKATCHEWAN'S GRID

superimposed surveys, squares, and sections

The Information Services Corporation (ISC) (n.d.a) states: "From an aerial view, the surveyed portion of Saskatchewan looks like a grid. This grid illustrates how the province has been divided into smaller portions over the years to lay the groundwork for land ownership and development. The grid is the result of Saskatchewan's Land Survey System, which is the basis for describing land to the current day." Experientially, the landscape reveals a quilted mosaic of colour blocks, straight lines intersecting other straight lines, divisive regardless of landscape, terrain, habitat. There's a beauty in the organization, clarity on a featureless plain, a sense of structure that provides the occupant with direction when little else will visually suffice.

"Land Surveys began in Saskatchewan with the Dominion Land Survey System, which started in 1871. This survey system was based on the method used by the United States to allocate lands in the western part of the country after the American Revolution. The system divided land into townships that were six square miles each in terms of surface area. All land was surveyed - not just agricultural land" (ISC, n.d.b) This superimposed grid creates the aerially-visible mosaic. Each component of land is treated individually by farmers and the treatment visibly manifests as individual patterns, textures, and colours.

Although the subdivisions begin at the provincial scale down to the quarter legal section, I hear farmers generally speak in only a couple terms: quarter sections, half sections, and sections. Quarter sections generally refer to fields of singular crops and are not always farmed adjacent to each other; oftentimes land ownership requires farmers to farm quarter section by quarter section, obtaining and renting land as it is available.

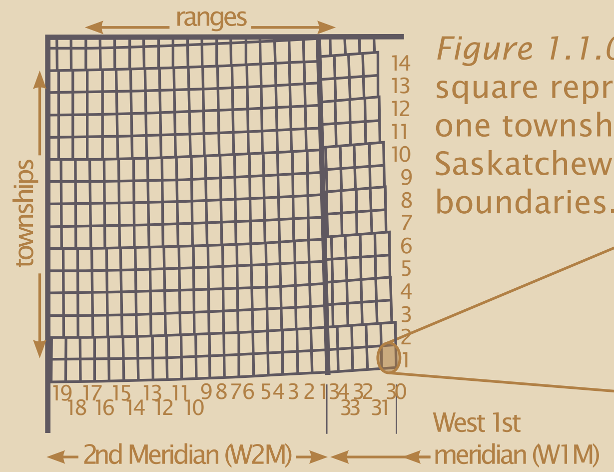


Figure 1.1.07: Each square represents one township in Saskatchewan's boundaries.

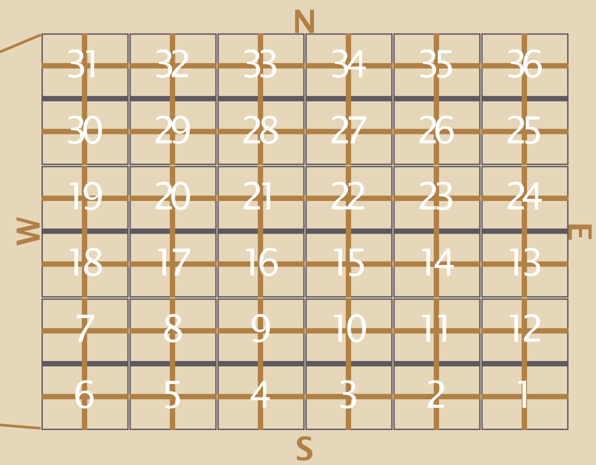


Figure 1.1.08: A township consists of 640 acres and contains 36 **sections**.

 Figures 1.1.07, 1.1.08, 1.1.09, 1.1.10, 1.1.11: diagrams of Saskatchewan's grid adapted from ISC's *The township system* (ISC, n.d.)

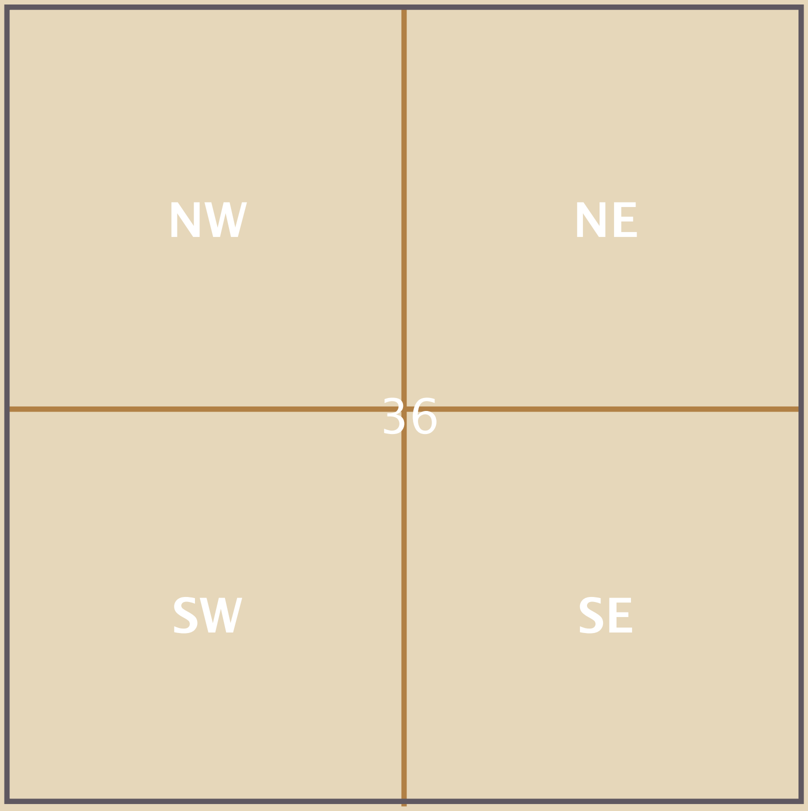


Figure 1.1.09: Each **section contains four quarters**, each quarter approximately 160 acres and denoted by its directional placement. For example, NW is referred to as the northwest quarter.

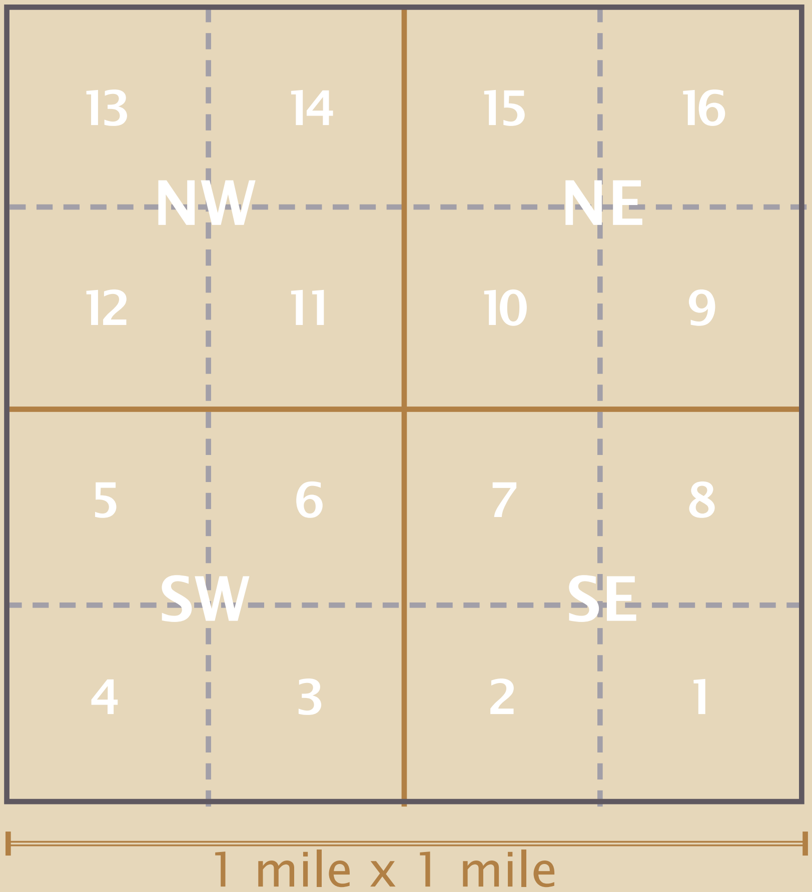
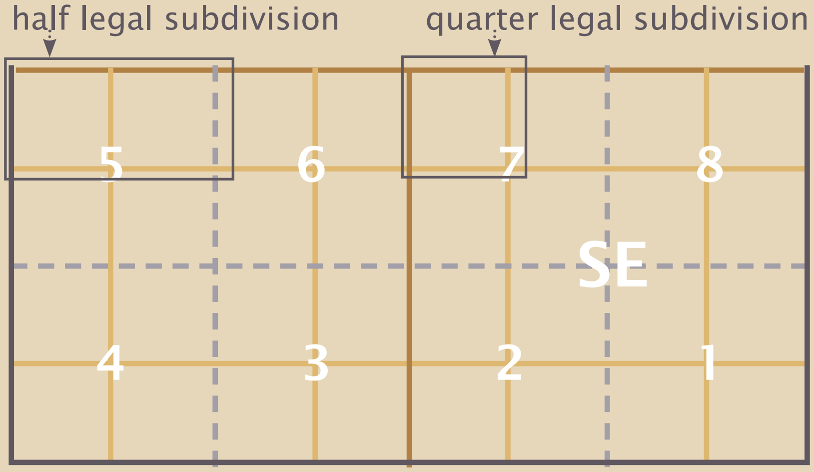


Figure 1.1.10: Each quarter is further subdivided into sixteen legal subdivisions at 40 acres in size.

Figure 1.1.11: Legal subdivisions can be further broken down into half and quarter legal subdivisions. Quarter legal subdivisions are approximately 10 acres in area.



Although the fields have titles such as "South East Quarter of Section 2, Township 38, Range 18, West of the Third Meridian" (ISC, n.d.a) they may be identified by features within or around the field. For example, my family has the "field with the five bins" and "Gerald's yard." The field with the five bins only has four bins, and Gerald's field is not Gerald's field, Gerald's yard is a legal quarter subdivision of the field my dad rents from Gerald. Those that inhabit the prairie seem to have an innate sense of direction and distance on the grid roads. My dad will often say things like "It's the second turn, four miles past G---" or "It's the third field, if you drive longer than ten minutes you've gone too far." Once one understands the structure and colloquialisms, however, it is comprehensible.

grid roads and structural loads

The gridded range and township roads of the Saskatchewan prairies are the points of access into a vast rural landscape. The roads, established as part of the Dominion Land Survey but only truly developed in 50 years, primarily run north-south and east-west (Stewart, 2006). These create a form of structure on a structure-less landscape: with a horizon all around, there are few vertical landmarks to locate one's self, but the surveyed grid provides that otherwise absent directionality.

Although the gridded structure is primarily uniform, the road usage restrictions are not. Not all municipal roads can support all frequencies of vehicular occupation; certain roads are structured to host more traffic and heavier vehicles, while some roads have weight restrictions and limited access. "However, railway branch-line abandonment, grain terminal consolidation, and rural depopulation are changing traffic patterns in rural Saskatchewan" and altering road maintenance and usage (Stewart, 2006).

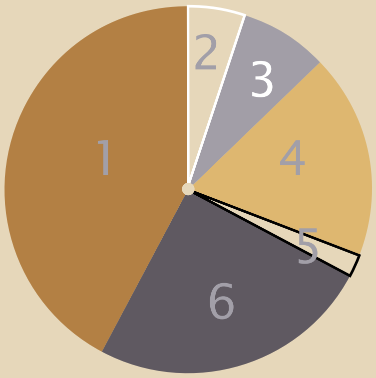
The municipal grid continues to connect inhabitants over the widespread area, but connections are getting longer: "farmers are hauling agricultural commodities over longer distances by truck" (Stewart, 2006).

1 "Land access roads give access to land only."
2 "Primary municipal roads link municipalities, highways and other primary municipal roads, and carry a minimum of 100 vehicles per day."
3 "Municipal roads provide major routes through municipalities and carry more than 60 vehicles per day."
4 "Main farm access roads carry a minimum of 30 vehicles per day, and access at least one permanent farm resident for every 1.6 km of road."
5 "Special roads lead directly into regional parks, resorts, industries, oil fields, and [First Nation's] reserves."
6 "Local roads provide access to more than just land, but do not meet the standards of a higher classification." (Stewart, 2006).

facts

"Saskatchewan has the largest municipal (grid) road network in Canada, totaling 165,000 km. In combination with the province's highway network, the province boasts over 190,000 km of rural roads—the most roads per capita of any jurisdiction in the world." "Only 1,500km (less than 1%) of municipal roads are paved" (Stewart, 2006).

road classes



land access
primary municipal
municipal
main farm access
special
local access

Figure 1.1.12: Saskatchewan road class percentages adapted from Stewart, 2006

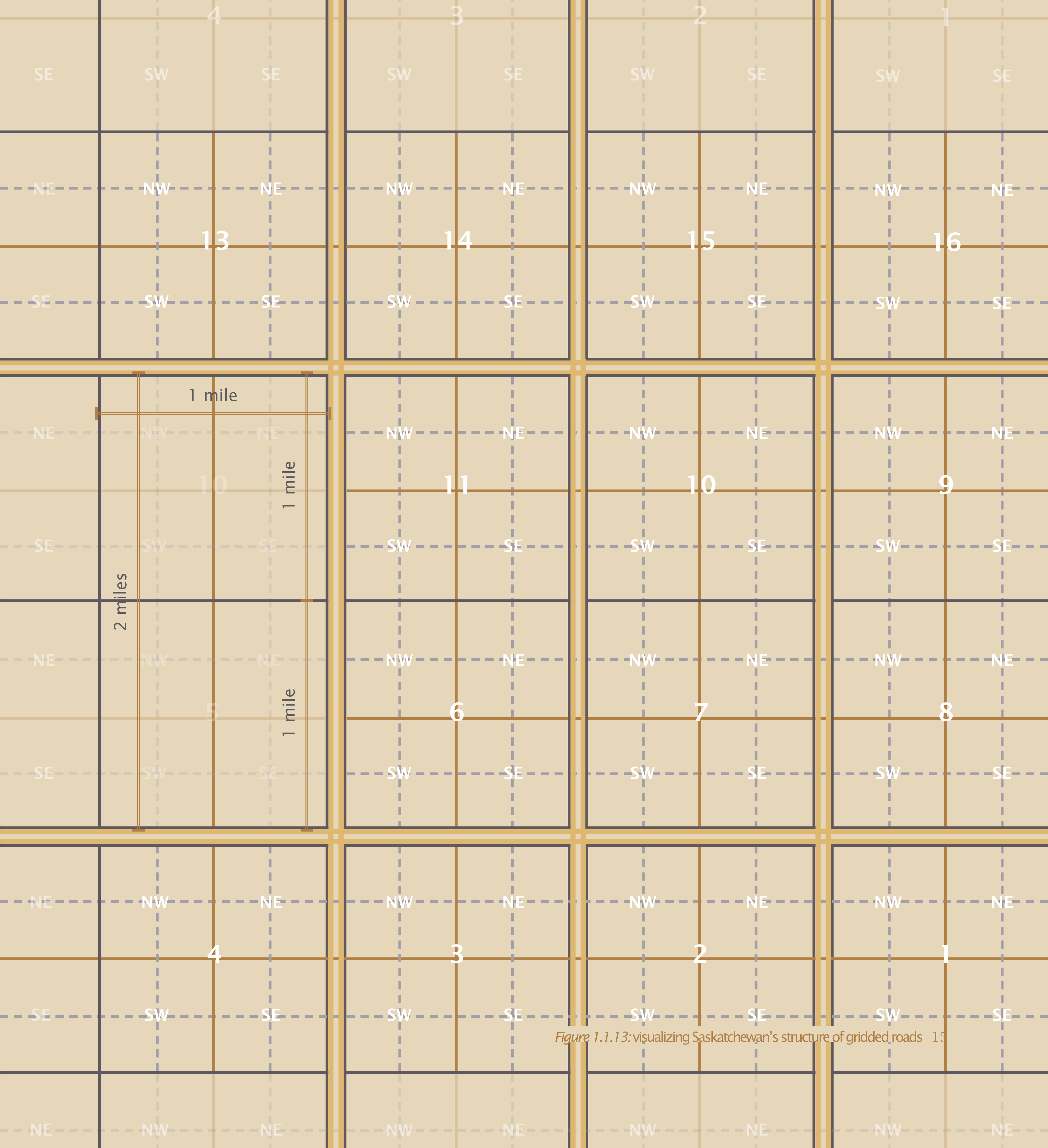


Figure 1.1.13: visualizing Saskatchewan's structure of gridded roads

SASKATCHEWAN'S AGRICULTURE

timeline: Marquis wheat, Depression heat, and high-yield seed

1750
The first wheat crop of Saskatchewan was, possibly, planted in the Carrot River Valley. However, agriculture would not expand for another 150 years.

1872
The Dominion Lands Act is initiated. The survey system, as seen in the previous page, is adopted and executed. The homestead system ensured conditional settlers that they could purchase a quarter section for ten dollars. To break the land was then a tough job: oxen and/or horses pulling a single-furrow plow were a common method, while wealthier farmers might use a steam/gas engine and gang plow.

1900s
Sir John A. Macdonald's National Policy required settlement in the West. To accomplish this, the transcontinental railway was built to bring settlers and supplies out west and then transport the resulting agricultural produce back east. Although settlement was slow to begin, the 1890s to WWI experienced a high influx of pioneers.

1909
Marquis wheat is developed at the Dominion Experimental Farm in Indian Head and released to farmers this year. The earlier-ripening quality of the wheat was crucial to farming success on the short growing season of the prairies. 2 years later, a farmer brings Saskatchewan to the forefront of agriculture with first prize at the New York Land Show for his Marquis wheat.

1920s
Agriculture is well established and many farmers are now able to afford mechanical equipment, including gasoline or kerosene powered tractors, binders, and threshing machines. A traveling threshing crew of 20 men or more move from farm to farm.

1924
Saskatchewan Wheat Pool is formed. This is a farmer-owned marketing cooperative that built and bought elevators all over the province to solve pricing and marketing issues.

mid-1920s
The first combine arrives. Horses are still necessary for farm work, but livestock herds are changing. There is pressure to emphasize purebred animals including horses, hogs, sheep, and poultry. Agricultural fairs grow across the prairies, showcasing prize animals.

When traveling through southeast Saskatchewan, it is apparent at a glance that agriculture dominates the landscape. Based on my description on pages 6 and 7 and viewed in the images throughout this document, oil and agriculture create an interweaving grid of perceived productivity. To understand how this came about, then, the history must be revealed. This timeline presents a basic overview of agricultural development as summarized from Bitner's (2010) *A brief history of agriculture in Saskatchewan*.

1930s

The Great Depression decimates Saskatchewan's growing lifestyle. The 1920s farming practices loosened soil that couldn't withstand the hot dry winds of a decade-long drought, causing viable top soil to blow away. Crops, gardens, and feed withered, insects plagued, and the horse population is devastated by a disease. The University of Saskatchewan and experimental farms begin experimenting with farm practices and machines to minimize soil degradation, including planting shelterbelts, strip farming, and seeding specific wheat varieties to hold the soil in place.

1936

Individual farms in Saskatchewan are approximately 142,000.

1940s

The rains return and the war effort assists in economic recovery. Although farm mechanization increases, it is hindered by the manufacturing sector's focus on war production.

1950s

New machinery begins to replace horses. "Rubber-tired tractors, cultivators, discers, swathers, self-propelled combines and trucks" make it possible for farms to expand per individual farmer. Disease and pest control chemicals evolve and fertilizers improve, hosting higher yield crops but at significant expense. The University of Saskatchewan continues to research new crop varieties more suited to withstanding Saskatchewan's weather. The reliance on eastern manufactured equipment reduces as a western industry develops.

1970s

Canola is developed from rapeseed by the Universities of Saskatchewan and Manitoba. This crop, plus lentils, field peas, and chickpeas, are a welcome addition to the previously exlusive wheat crops.

21st Century

Livestock sees a shift to new breeds of cattle, bison, elk, and llamas, while hog production increases. Farm practices shift: instead of summerfallow, fields now see direct seeding and minimum/zero tillage. Saskatchewan develops and perfects air seeding systems, used in harmony with other innovations such as GPS to guide planting and harvest. Organic crops are on the rise for the health-conscious consumer. The country elevator has all but disappeared as farmers haul their harvest to inland terminals. Farms have increased in size due to the automated machinery.

2006

There are just over 44,000 individual farms in Saskatchewan.

today

Saskatchewan farmers are some of the most productive worldwide. The equipment is bigger and more expensive, much the way farming practices evolved, but even with technological innovation they must still rely on weather, world markets, agricultural subsidies, and transportation systems to make a profit. This is more and more difficult despite the increased demand of food.

Figure 1.1.14: a swather situated against oil well infrastructure in the region of study

serial cereals, oilseeds in oil fields, plus planted pulses

pulse crops

According to Vandenberg (2006), beginning in the 1960s as a diversified source of farming income, pulse crops grew in popularity in Saskatchewan: “Common bean, field pea, chickpea, lentil, and faba bean” can all be harvested in Saskatchewan’s tough climate and short growing season. An annual legume, these crops are invaluable as a rotational crop: they fix nitrogen in the soil -- reducing the amount of necessary fertilizers -- and provide a gap in disease cycles that affect oilseed and cereal crops (Vandenberg, 2006). Today, Saskatchewan thrives from the international market for pulse crops and research and development groups continue to produce better crops for higher yields (Vandenberg, 2006).

cereal crops

Dyck (2006) states that, as a member of the grass family, Canada’s cereal crops are grown for their edible, starchy seeds for use in bread flour (wheat) and cake flour (winter wheat) production, pasta (durum), malting/brewing (barley), and livestock feed (all of them, to some degree). “The important cereal crops produced in Canada are wheat, barley, oats, rye and corn; small hectarages of triticale and grain millets are grown” (Dyck, 2006). Canada’s cereal crops vary in planting season: some crops are cool season (wheat, oats, barley, rye and triticale) that grow between 80 and 100 days – perfect for Saskatchewan’s climate – and warm season crops that cannot be grown in Saskatchewan in notable quantities (corn, grain millets) (Dyck, 2006).

oilseed crops

Saskatchewan’s oilseed crops began with rapeseed, flax, and, later, the evolution to canola (Klinck, 2007). The first oilseed processing plant opened in 1945 in Moose Jaw, slowing to a stop as World War II erupted, and closing post-WWII; however, another plant opened in 1946 and barely survived until 1963 when the oil uses moved from industrial to food-based value (Klinck, 2007). 1974 – 1978 saw the creation of the more nutritious canola from rapeseed, securing Saskatchewan’s role in the growth and use of canola. Today, millions of acres in Saskatchewan are dedicated to canola and flax, supplemented with multiple industrial plants to extract, process, and package oils for direct food consumption (Klinck, 2007).

 Figure 1.1.15: dividing lines of abutting crops in the region of study

The gridded landscape laid out by the Land Survey System in 1871 establishes the uniform layout of fields still used today (see *Figure 1.1.13*). Based on my observations and experience, smaller farm operations often plant fields by quarter sections and, on occasion, half sections. There may be similar crops grown side by side but, depending on the diligence and investment by the farmer, the fields will be distinguishable at the surveyed line. The distinguishing characteristics will result from weed percentage, density of the crop, colour, height, and texture. Other times, however, similar crops planted side by side appear to blend in to one another. More often, the crops grown side by side differ entirely, creating the familiar mosaic.

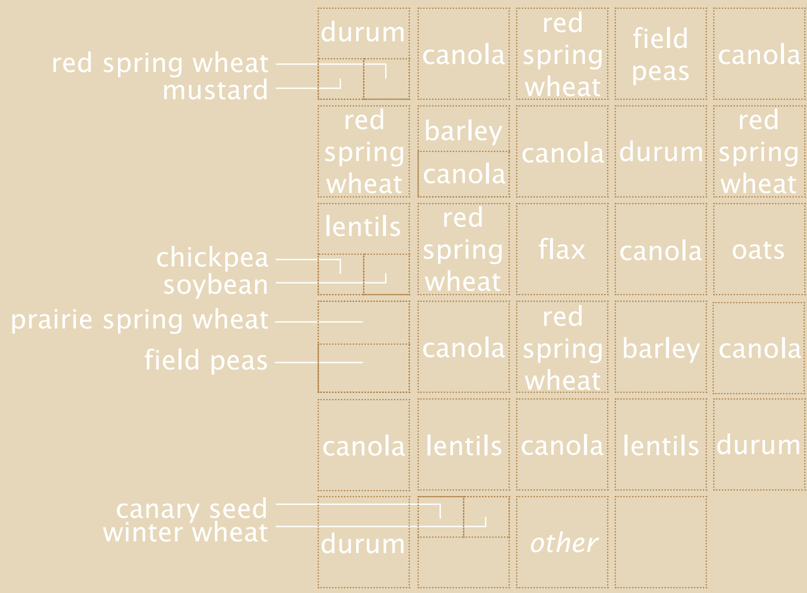


Figure 1.1.16: The evolution of colours in a season's Saskatchewan's crops.
Each square equals approximately 1 million acres of land planted with crops in Saskatchewan.

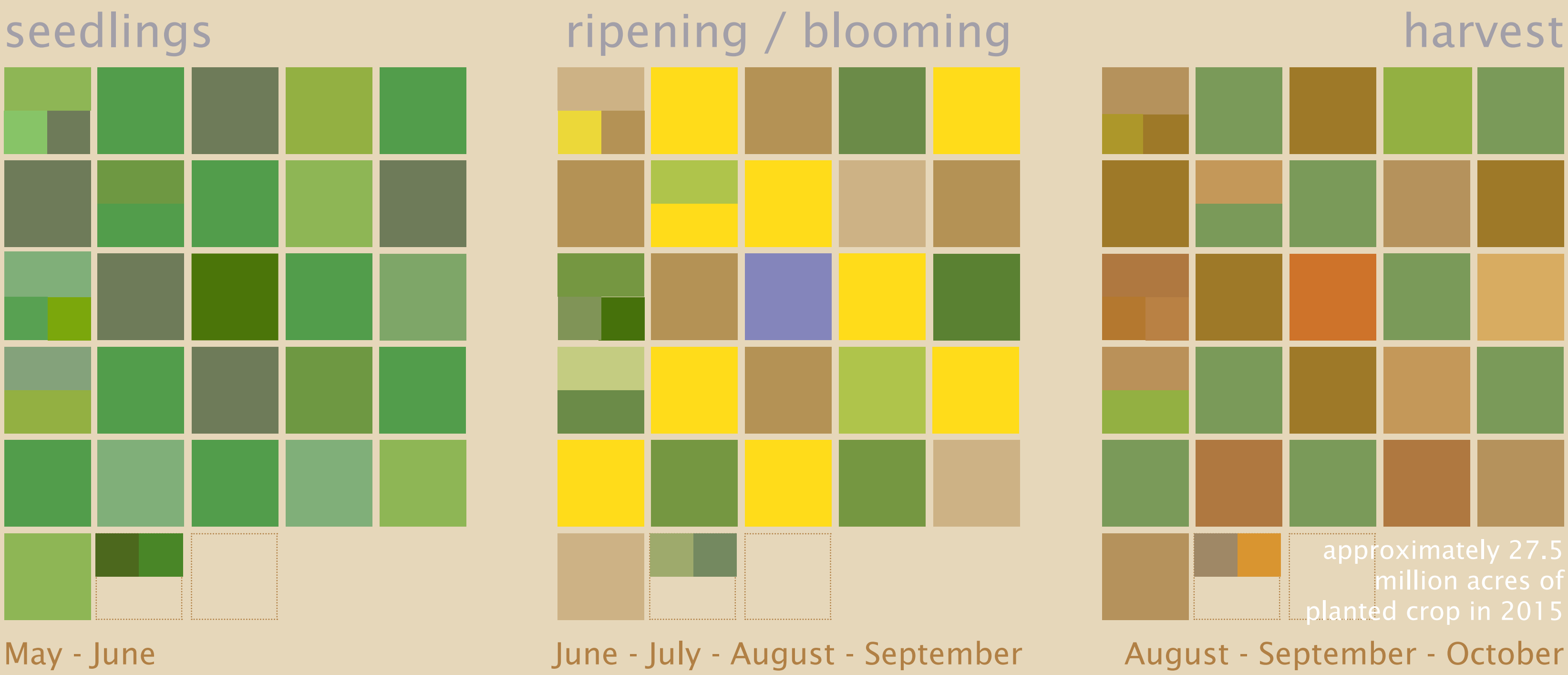


Figure 1.1.16: evolution of colours in a season's crops, adapted from information provided by Saskatchewan Crop Insurance Corporation, 2015.

 Figure 1.2.01: an isolated pump jack in the region of study

12 OIL OIL TOIL AND RUBBLE

pump jacks pump and big rigs rumble

OIL ON THE LANDSCAPE

black in the Bakken: formation, location, extrication

The juxtaposition of oil and agriculture becomes clear moving through the region. Agriculture, the dominant surface use, creates a flat line of crops, an intersection of sky and ground, a transecting line. The pump jacks and storage tanks punctuate this faux horizon, standing boldly in the fields, often out of reach as private roads cross private lands to create inaccessible points of extraction, visually available but physically out of reach.

The oil infrastructure is a visual indication of the underground resources available for extraction. To access underground oil, the surface is disrupted. Even without formal research, I know certain shapes by sight: the pump jacks, storage tanks, access roads, all of these become a part of the surface disruption that my travels have made me familiar with. This southeast corner of Saskatchewan -- already industrialized through agriculture -- gains more industrialization, reducing the existence of the already unrecognizable historic landscape to even less. But the oil infrastructure is not, likely, located at random.

The Bakken shale oil play, part of the Williston Basin, is the reason for oil infrastructure on and in the landscape of southeast Saskatchewan. *Figure 1.2.03* demarcates the range of underground oil.

In a document commissioned by the Saskatchewan Research Council, Luo and Li (2015, p.iii) state: "In Canada, the Bakken play covers 62,000 square kilometers (24,800 square miles) of southern Saskatchewan and smaller areas of southwest Manitoba and southeast Alberta. About 1.4 billion barrels of high-quality light oil and 2.9 trillion cubic feet of natural gas are considered economically recoverable from the Canadian Bakken, according to a recent joint assessment by the Saskatchewan Ministry of Economy and Canada's National Energy Board." Although Canada's Bakken resources were discovered in the 1950s, only since 2004 have they been experiencing a boom, primarily because of the combination of horizontal well drilling and multistage hydraulic fracturing technologies." I understand that fracking has not, however, become a large-scale practice in the region (yet).

 Figure 1.2.02: pump jacks within the region of study in southeast Saskatchewan

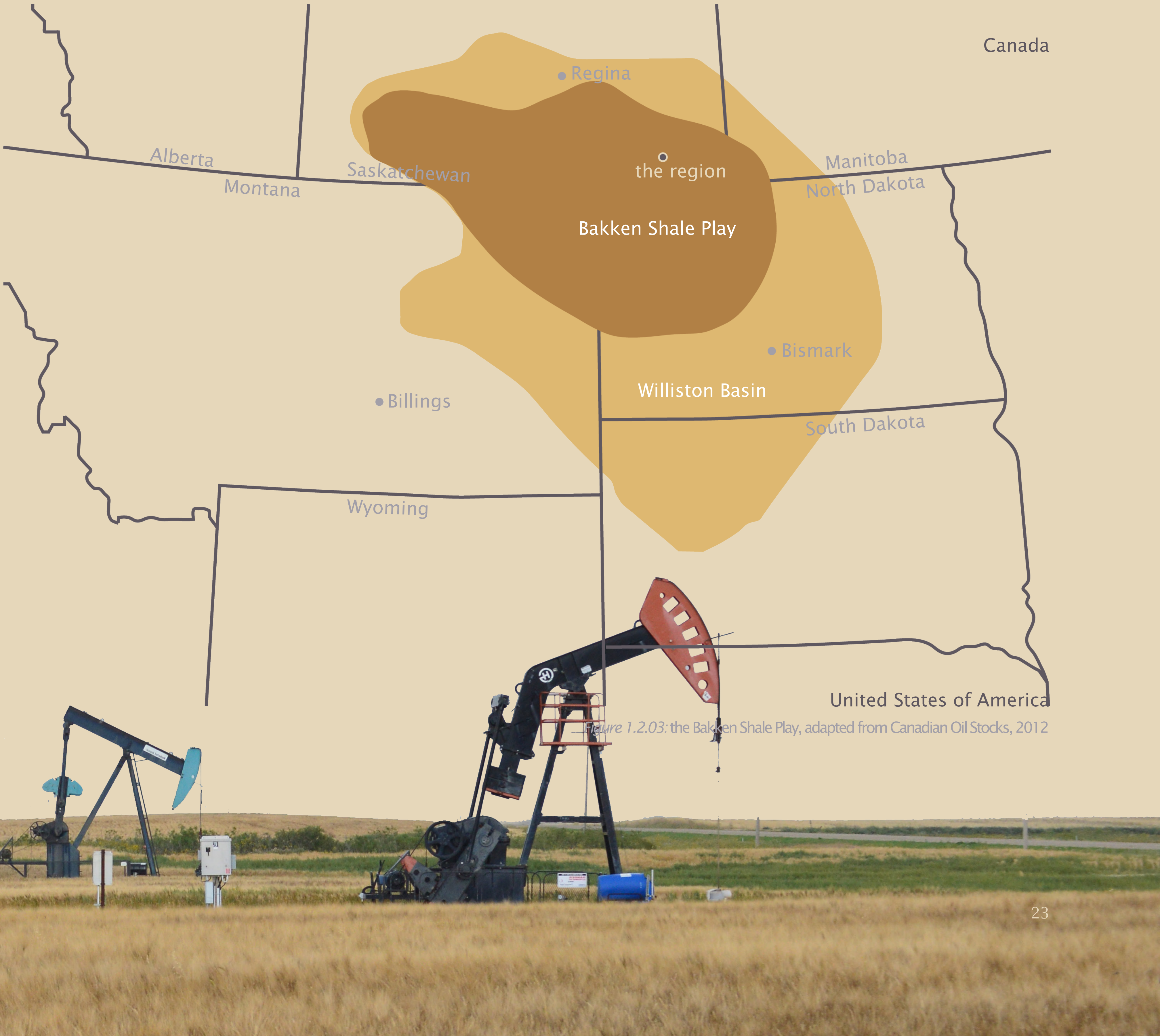


Figure 1.2.03: the Bakken Shale Play, adapted from Canadian Oil Stocks, 2012

The Saskatchewan Environmental Society commissioned a document, *When the Oilpatch Comes to Your Saskatchewan Backyard: A Citizen's Guide to Protecting Your Rights* (Fortugno, 2004), that references what the oil company and surface right owner's responsibilities entail. The guidelines referenced throughout the document summarize provincial legislation and, subsequently, represent reasonable expectations of what each party can expect. The myriad of laws and Act and resources can be daunting for surface rights owners to understand their rights when the below ground mineral rights are a separate ownership entity. The laws have been structured to provide equality for both parties, allowing mineral rights owners to access the below-ground resources while compensating for the above ground interruptions and damages.

78% of mineral rights are owned by the Government of Saskatchewan -- dating back to initial land grants of the first settlers -- and, when an oil company expresses interest, they first identify mineral rights from the provincial Land Titles system; assuming there are no heritage, Treaty land, or overriding environmental issues, the company may then lease those rights to access oil and gas (Fortugno, 2004, pp.3-4). The surface landowner or lessee cannot refuse entry or access to the mineral right owner to recover mineral materials but, to appease landowners, there are extensive compensatory regulations; "a surface owner is entitled to compensation for land value, loss of use, severance and adverse effects, nuisance and general disturbance, damages and other factors" (Fortugno, 2004, pp.5-7).

The well sites and access roads on pasteurized and/or cultivated land presents certain environmental considerations, such as "the transport of noxious weeds; air pollution caused by flaring; water pollution; waste management; loss or disturbance of topsoil; soil compaction from equipment; flooding due to drainage disturbance; loss of shelterbelt; and the use of chemicals on lease lands impacting on neighbouring organic crops" (Fortugno, 2004, p.8) could produce unwarranted and highly damaging effects. Farmer's ought to be aware of their cultivation methods in relation to oil well site installation: soil classification, crop rotation, actual yields from the previous three to five years, the field size and cultivation patterns, the equipment size and habitual use, and any other special conditions may affect further compensatory actions (Fortugno, 2004, p.12). Fortugno (2004, p.9) also believes it is a useful exercise to review the proposed placement of the well and access roads; although there are required offsets for the placement of the individual wells, the surface owner may have recommendations to lessen the impediments of installation.

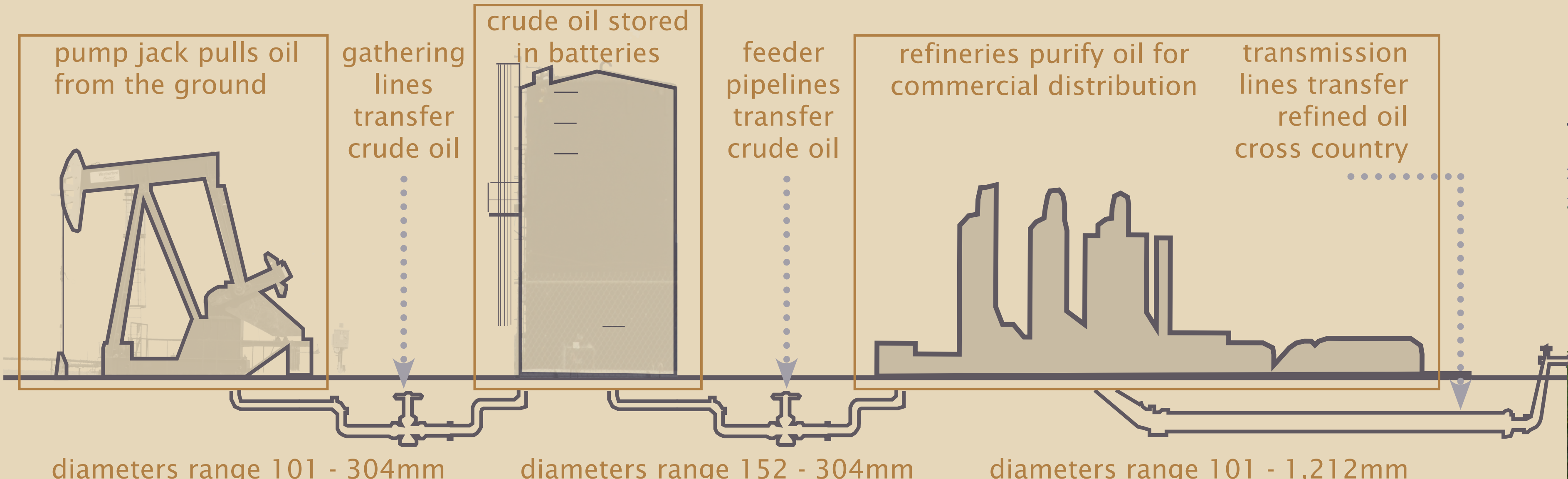


 Figure 1.2.04: the process of oil from pump jack to people's use, information and imagery adapted from Canadian Energy Pipeline Association, 2015

The components of an oil and/or gas project may impact surface landowners. These elements are added at the various phases: exploration, development, production, and decommissioning (Fortugno, 2004, p.15). There are three key infrastructural elements that will impact farmer's cultivated land most: drilling rigs, batteries, and pipelines (Fortugno, 2004). *Figure 1.2.05* portrays this infrastructure in its most simplified form as seen above-ground; pipelines are limited to signage, batteries are upright black storage structures, while pump jacks often stand as singular structures, but as one of many.

pipelines

A proposed pipeline route must be surveyed prior to construction and, alternative to pump jack installation where an agreement must be formed with the surface rights owners, can be done without consent to access. The right-of-way of a pipeline is almost always fifteen to thirty metres wide and must follow environmental restrictions, address landowner concerns, and fulfill remediation requirements post-installation (Fortugno, 2004, pp.32-40).

drilling rigs

Drilling rigs are simple: the bigger the rig, the deeper the drilling. Most rigs are cantilevered or jack-knife masts, (Fortugno, 2004, p.24) and I refer to them as the colloquial 'pump jacks' throughout this document. Based on my travels, each drilling rig is located on a gravel well pad and accompanied by an access road.

batteries

Batteries are immediate storage and separation facilities that are connected to (via pipeline[s]; see *Figure 1.2.04*) a well or multiple wells. They may consist of multiple tanks, separators, and dykes to prevent runoff. They must follow a setback of 75m from all anthropogenic structures (roads, buildings, etc.) (Fortugno, 2004, pp.41-42).

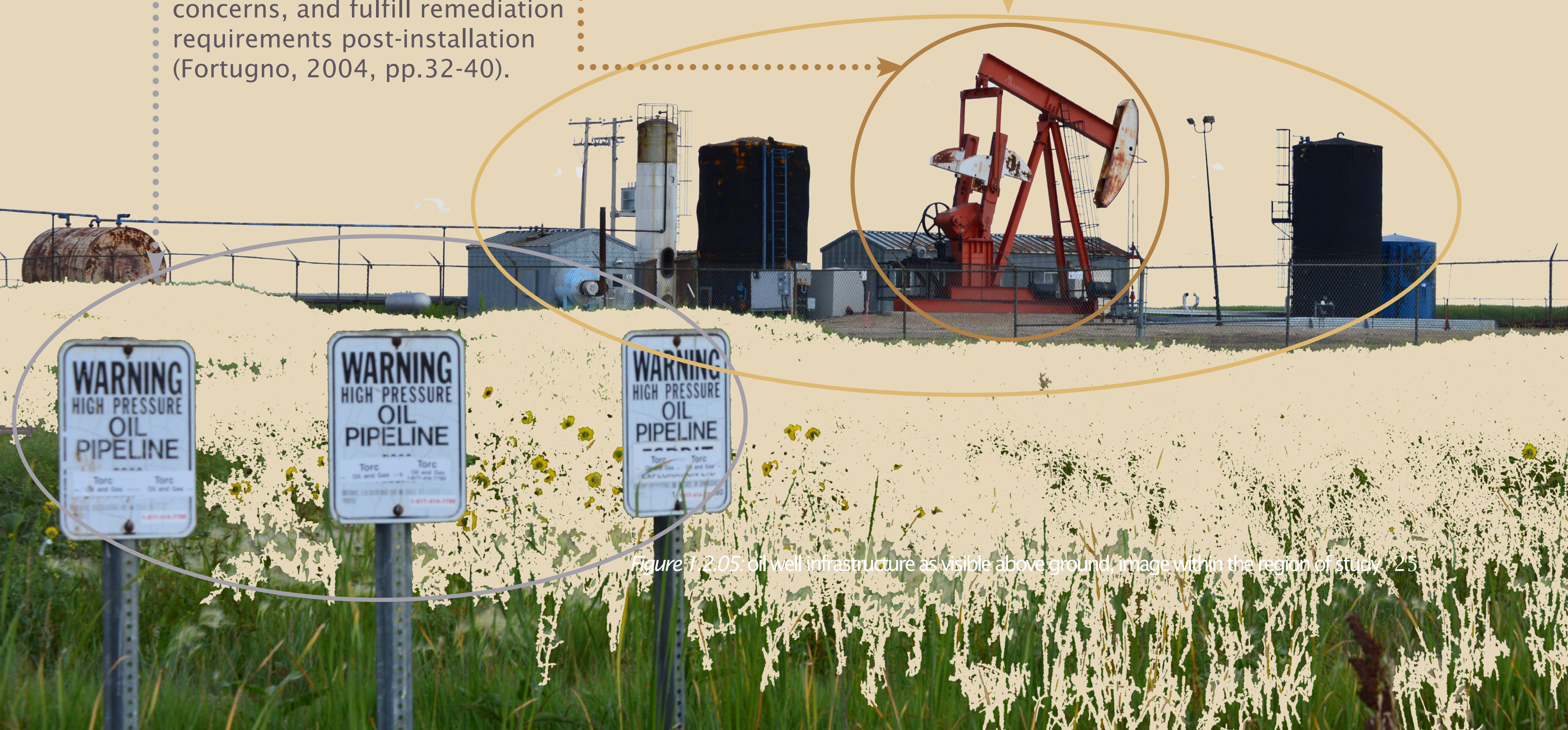
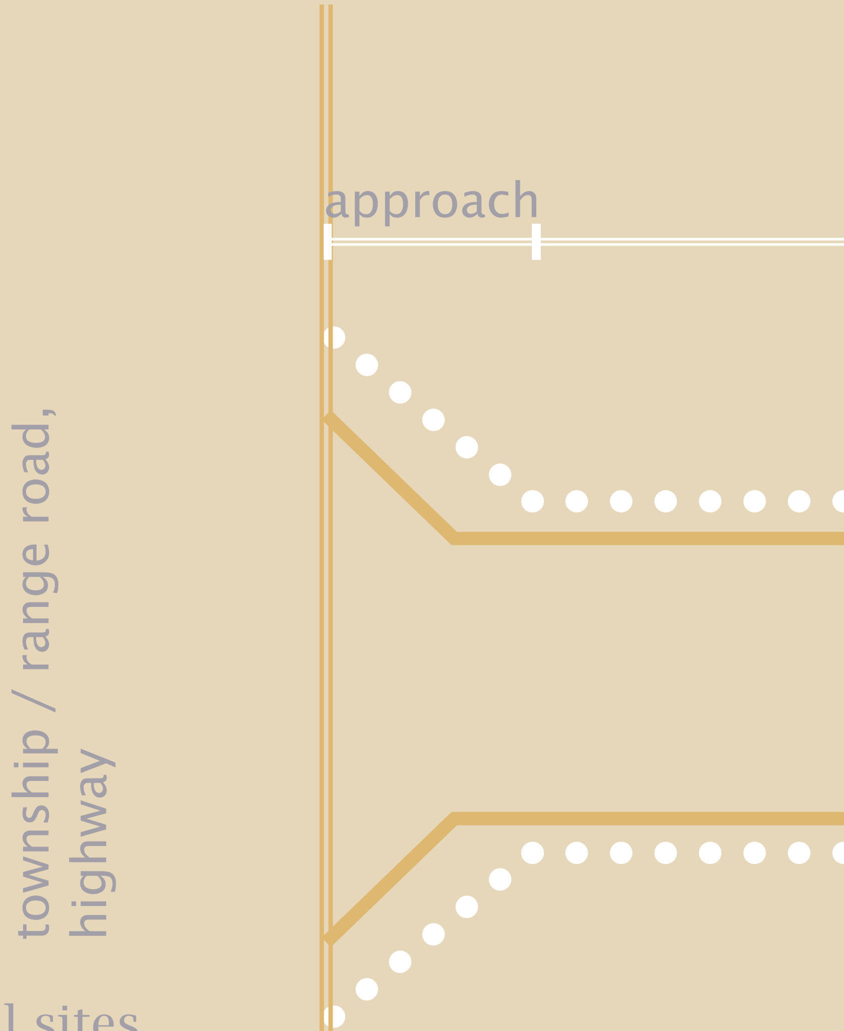


Figure 1.2.05: oil well infrastructure as visible above ground; image within the region of study

extended extractions: a typical site

Although a pump jack is small compared to the extent of the rural landscape, the disruption on individual fields is not limited to the ellipsis of the well site, but extended outward to one of the surveyed grid roads through the access gravel roads. Based on my travels through the region, the diagram -- *Figure 1.2.07* -- schematically explains my interpretations of the typical components of a pump jack and its infrastructure, from well pad to access road.



required signage

The Government of Saskatchewan The Oil and Gas Conservation Regulations, 2012 (2015c, p.17) ascribes: "Every licensee of a cased well and every operator of a constructed facility shall identify the well or facility with a conspicuous sign erected at the primary entrance to the well or facility that indicates:

(a) the name and telephone number of the licensee or operator ...; and

(b) the legal description of the surface location of the well or facility."

oil well sites

The Government of Saskatchewan (2015c, p.8) defines the well as: "'oil well' means any well capable of producing oil other than a gas well." In terms of the oil well site on which the well is drilled, it is defined as "'site' means, when used in relation to a well, structure test hole, oil shale core hole or facility, the site of the well, and the area immediately adjacent to that site" (Government of Saskatchewan, 2015c, p.9) For pump jacks, this is, therefore, the pump jack and the graveled oil well pad on which it resides.

 Figure 1.2.06: isolated imagery of found signs in southeast Saskatchewan

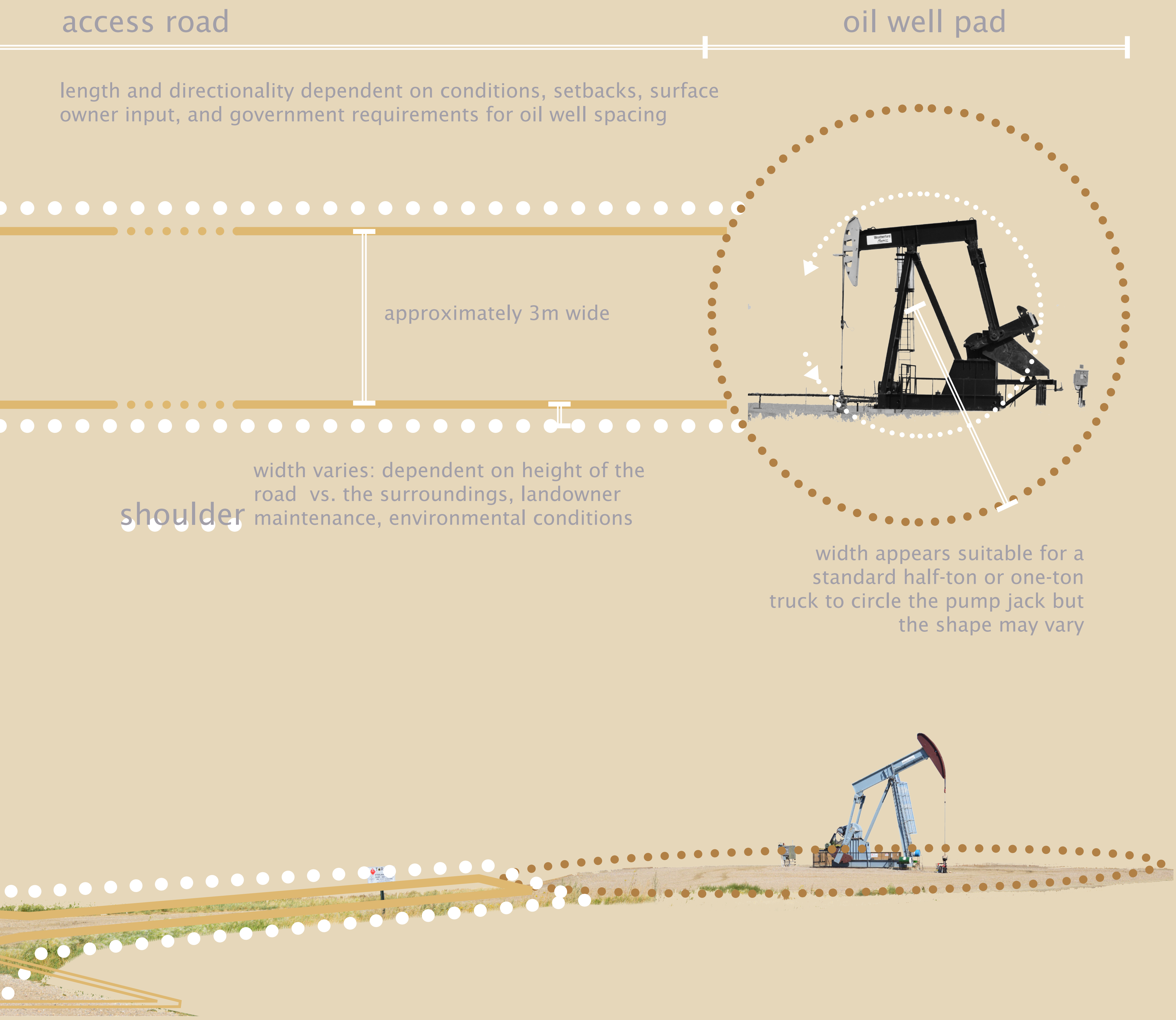


Figure 1.2.07: my interpretations of the typical components of a pump jack and its accompanying infrastructure

acc-section: the structure of access roads

Based on my travels in the region, each of the access roads are surrounded by different microhabitats. Some areas feature the monoculturistic crops, heavily sprayed and maintained by farmers. Other times, the individual tree copses and water bodies that punctuate the landscape become the borders for the access roads beyond the road shoulders that vary in width (as seen *Figure 1.2.07*).

The roads are edged by a shoulder and ditch on one or both sides. Often, they are breeding grounds for plants species that thrive in disturbed areas.

The gravelled access roads are approximately 3m wide. The roads have a centered crown to stay passable, but visible tire tracks are common.

Figure 1.2.08: schematic interpretation of the typical elements of access roads near the site of study

Figure 1.2.09: access road alongside a slough

Figure 1.2.10: access road amidst a wetland

Figure 1.2.11: access road raised in a field

If the road and field are of similar heights, farmers can seed crops to the edge, out-competing weeds and/or spraying them to elimination.

From ground level, the access roads often appear to bull through the landscape with little regard for the features around them. As *Figures 1.2.09* to *1.2.14* show, the roads cut through sloughs, fields, and tree copses with apparent minimal regard; with many access roads conspicuously located along and within wetlands and uncultivated areas. However, I refer back to Fortugno's document (2004, p.12): for the land owner, she instructs: "Review the location of the proposed well and access roads. Are they located to minimize inconvenience to you or your neighbours and also to permit the company to protect the environment?"

images of access roads in the region

Figures 1.2.09, 1.2.10, 1.2.11, 1.2.12, 1.2.13, 1.2.14: imagery of access roads in the region of study in southeast Saskatchewan

Figure 1.2.12: access road splitting a water body

Figure 1.2.13: access road edging a water body

Figure 1.2.14: access road overtaken by weeds

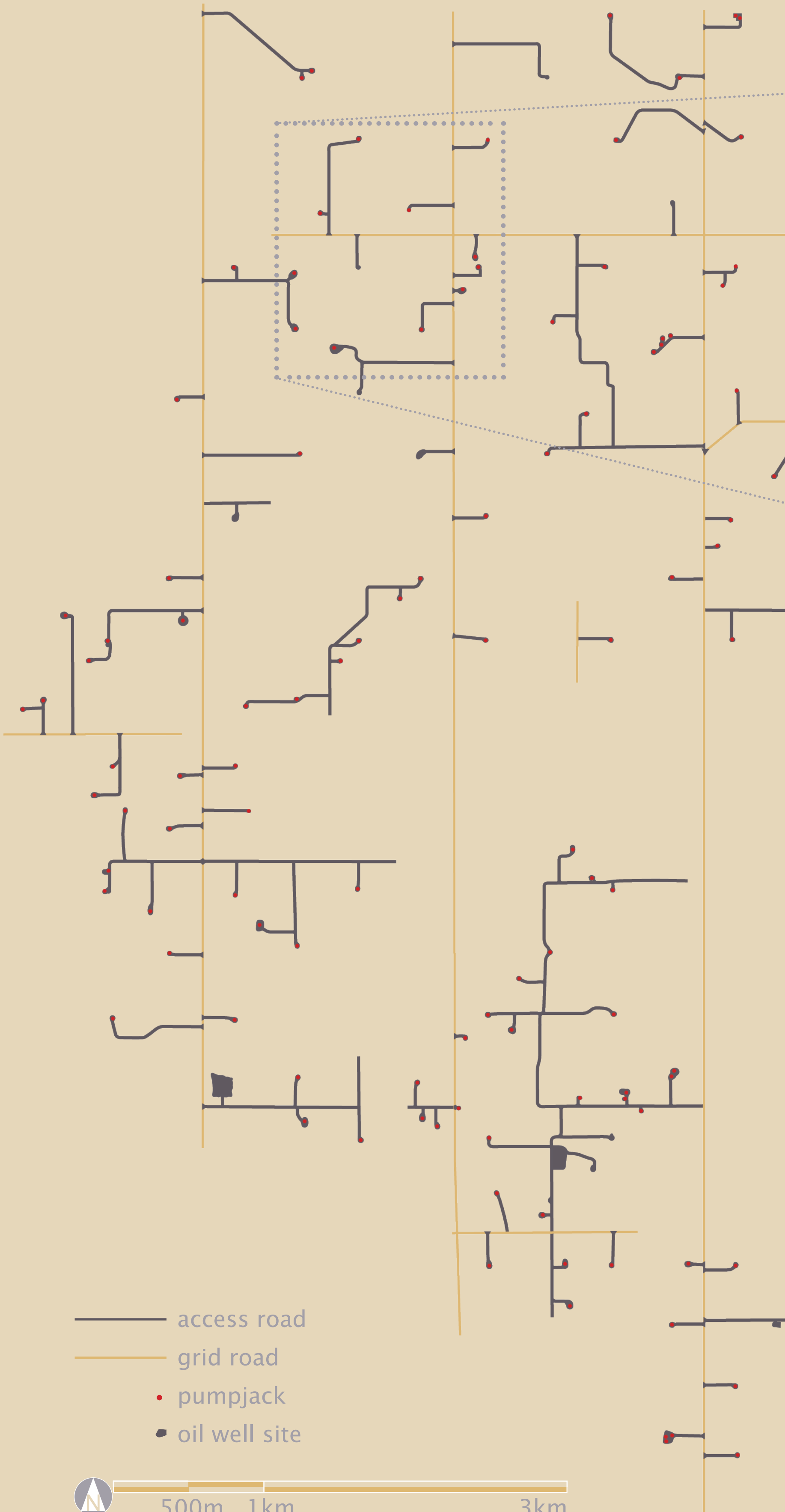


figure-ground of oil figures found

Figure 1.2.15 displays a figure-ground of a portion of the region, highlighting the amount of surface land devoted to the infrastructure of oil wells. Access roads, well pads, and pump jacks are easily observed from an aerial perspective (*Figure 1.2.16*) and this diagram is diluted to the infrastructural components.

Although the oil well sites and their accompanying access roads may be narrow (*Figure 1.2.07*), their impact on land use patterns can be viewed in *Figure 1.2.16* and *Figure 1.2.17*, displaying how deceivingly disruptive narrow corridors can impact the structure of a field.

Fortugno (2004, p.7) acknowledges this disruption as a key element for land users to evaluate as part of their surface rights compensation: “payment or allowance for severance (that is, severing or separating part of your land from the rest by the placement of access roads or well sites on your property)” and “the adverse effect of the right of entry on the remaining land caused by the severance (for example, placing of a well site and access road within cultivated land can severely impede a farming operation and increase the costs of farming the remaining land)” are payable compensation factors.

 Figure 1.2.15: diluted aerial perspective of pump jacks, well pads, and access roads in the region of study, adapted from Google Earth, 2017

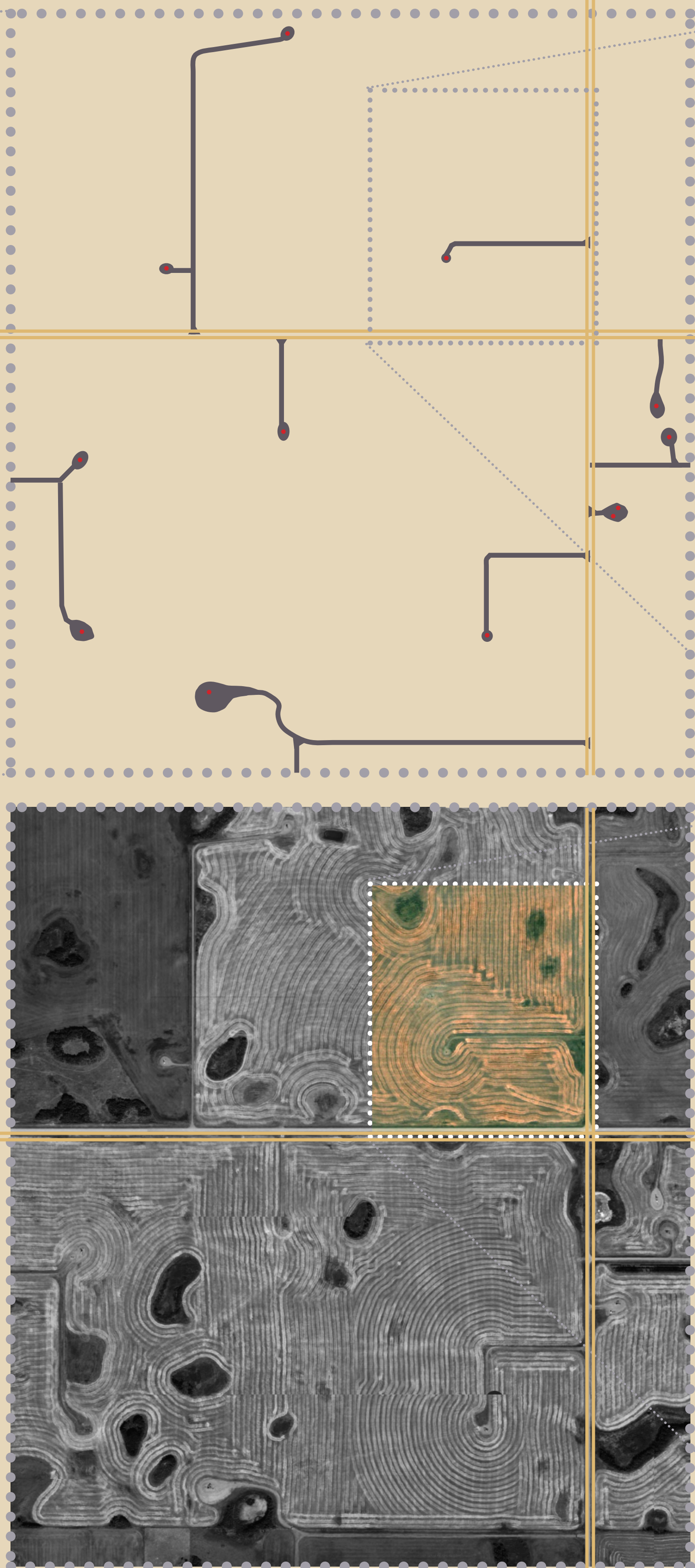


Figure 1.2.16: the effects of access roads on farming patterns, Google Earth, 2017

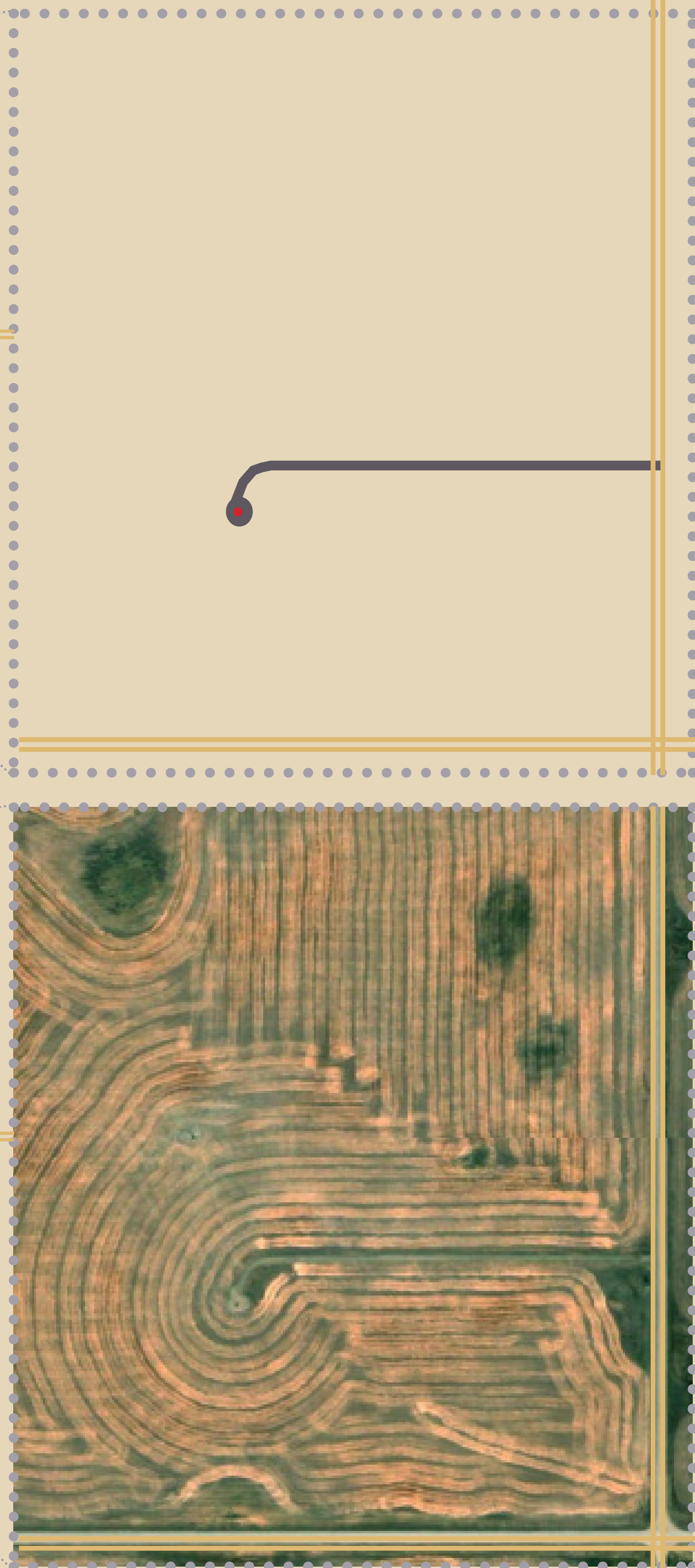


Figure 1.2.17: the effects of access roads on farming patterns, Google Earth, 2017

curving and compensating crop patterns

Figure 1.2.22 showcases the ground-level view of the aerial perspective of *Figure 1.2.18*. Both images were taken at harvest, showcasing the swathing of crops and the resulting farming pattern on the fields. These images showcase the farmer's diligence to create evenly spaced gaps between swaths, the practice as efficient as possible with the oil infrastructure impacting what may have been straight lines. However, the aerial perspective also showcases the farming patterns; concentric circles within the farm patterning is not uncommon in the fields of southeast Saskatchewan. Waterbodies, tree copses, even power poles cause outwards whorls of seeding in the fields in a similar manner to that of the oil sites: the farmer must adjust for ecological patterning in much the same way as he or she does for anthropogenic disturbances.

The farmers must adjust his seeding and swathing patterns for the inverted underground, exchanging GPS-straight lines for curves and concentric circles rippling outwards from oil pulled upwards to the surface. As I traveled the region, I witnessed farmer's working around the oil well sites during harvest, the swaths indicative of the impact of oil.

aerial view

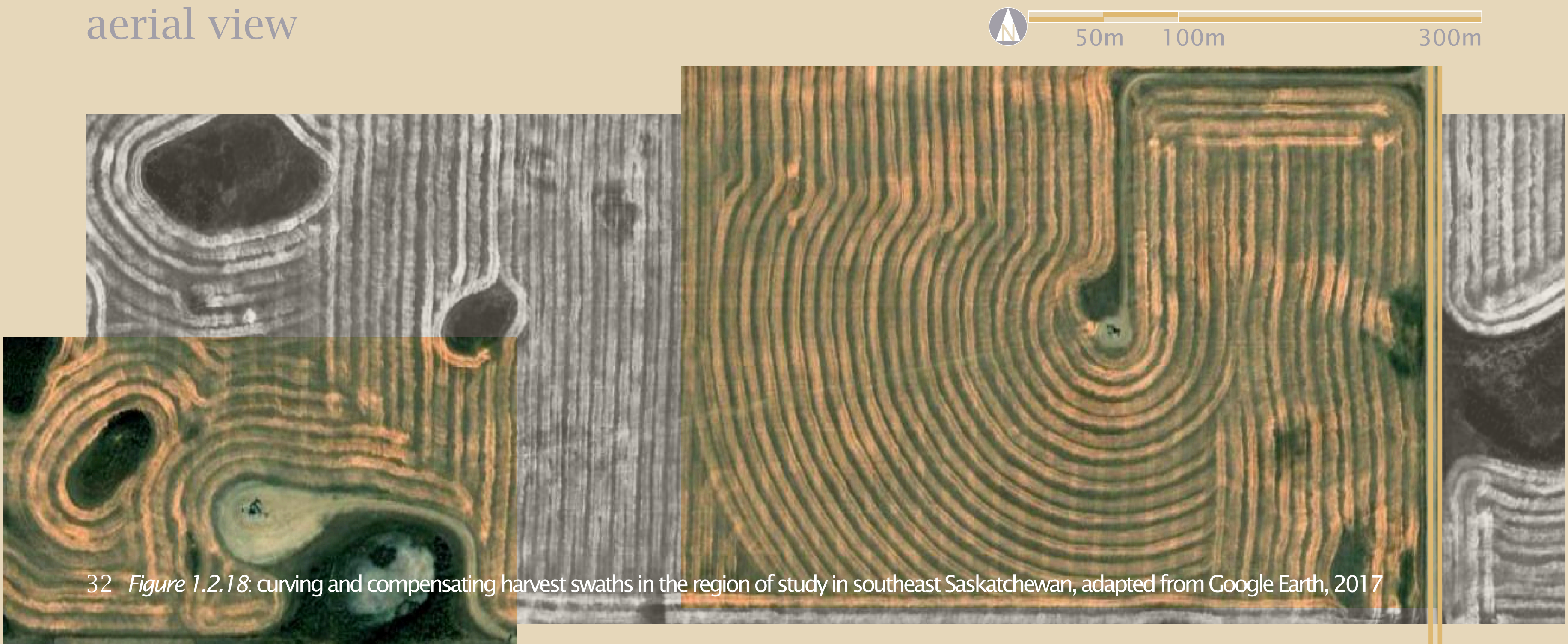


 Figure 1.2.18: curving and compensating harvest swaths in the region of study in southeast Saskatchewan, adapted from Google Earth, 2017

examples

Figures 1.2.19, 1.2.20, and 1.2.21 relays on-the-ground examples of how the farmers in the region work around the oil well sites, visible by the swaths and remnant seeding lines.

Figure 1.2.19: swaths of canola curve around a pump jack within a field

Figure 1.2.20: freshly harvested seeding lines indicated the pattern taken by the farmer around a pump jack

Figure 1.2.21 swaths of canola surround a pump jack

Figure 1.2.22 is a prime example of farmers working around both oil well sites and uncultivated areas. As witnessed by the swathing of canola, the farmer uses the pieces of land between uncultivated areas, curving around the sites despite the (probable) inconvenience.

Figure 1.2.22: curving and compensating harvest swaths in the region of study in southeast Saskatchewan, on-the-ground

STRUCTURE OF OIL ON THE LANDSCAPE

sections and spacing and oil well sites placement

The Government of Saskatchewan regulates all oil well spacing in the province through a series of steps. According to the document Determining Drainage Units and Target Areas 1 (Government of Saskatchewan, 2017a), there are three steps to take when proposing an oil well:

1) Determine if the proposed well is within a defined pool.

This can be found on available maps from Saskatchewan Economy (2017; see *Figure 1.2.25*) -- the Saskatchewan Oil and Gas Information infomap. This interactive map is available to identify spacing down to the legal subdivision (LSD); by clicking on the box where the oil well is proposed, one is able to determine what Oil Pool the well would access. Each Oil Pool has unique spacing and location requirements that must be followed and it is a legal responsibility for the proposing oil company to identify the correct location. In the case of the proposed region for this practicum, the oil wells are all a part of the Steelman Midale Beds Pool / Steelman Frobisher Beds Pool.

"Defined pool: The Saskatchewan Ministry of the Economy has set up areas of 'defined pools' within the province, based on well production and reservoir analysis. Defined pools have defined land boundaries and will often have an associated Pool Order that outlines the drainage unit size, and target area for the well completion."

2) Determine what legislation will define the drainage unit and target area.

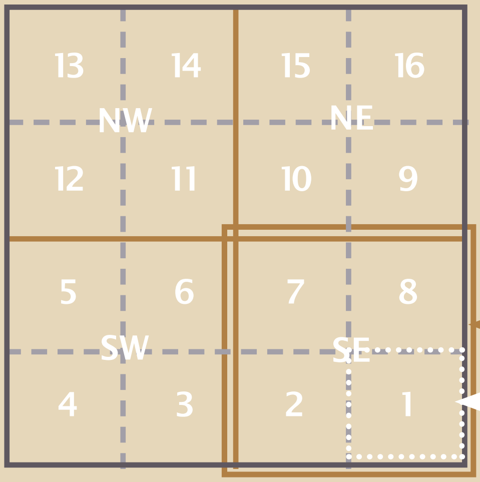
Review the Pool Orders, the Spacing Area Orders, and the Oil and Gas Conservation Regulations, 2012 (in that order).
Using an example of the Pool Order text, the spacing requirements are defined neatly in a single document, "Minister's Order Under the Oil and Gas Conservation Regulation Act, 2012: Steelman Midale Beds Pool / Steelman Frobisher Beds Pool" (Government of Saskatchewan, 2016). The diagram on page 35 lays out the required spacing. This organization scheme was updated July 2016 and all future wells must follow these requirements.

3) If the proposed well is within a Pool Order, follow the guidelines listed in the regulatory documents.

Unless there are necessary exemptions, *Figures 1.2.23* and *1.2.24* are all the information this practicum requires.

definitions

Drainage unit (DU): means the area allocated to one or more wells for the purpose of drilling for and producing oil or gas.
Target area (TA): means the specified area within a drainage unit allocated to one well completion for the purpose of producing oil or gas."
(Government of Saskatchewan, 2017a, p.3).

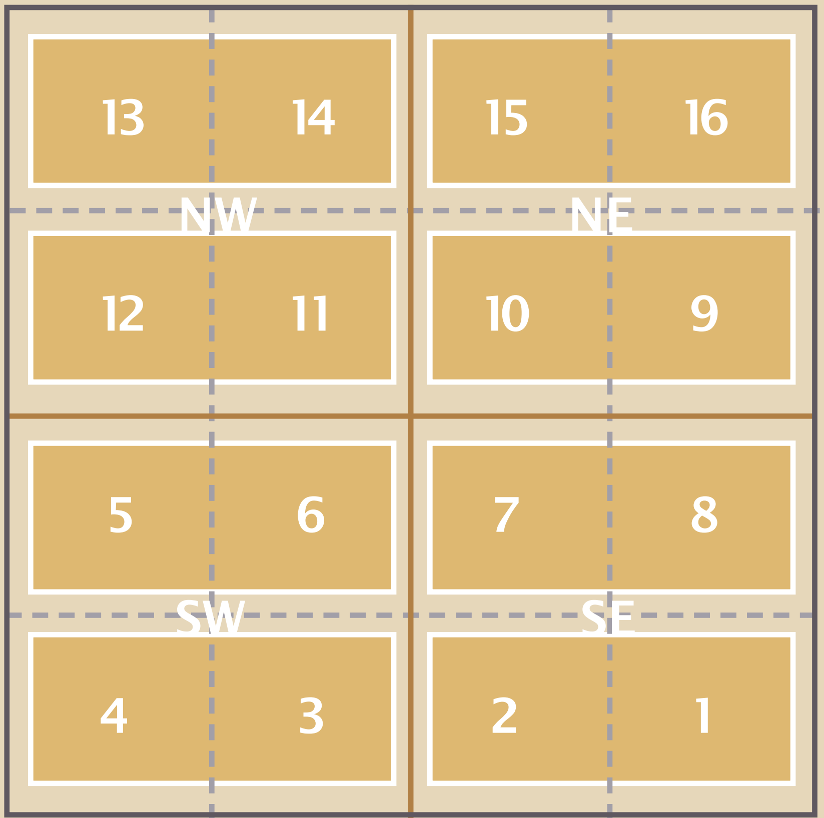


The standard surveyed section provides the base for the new overlaid grid of oil well sites.
Here, a section is broken into quarter sections and legal subdivisions (LSD).

The requirements for the Steelman Midale Beds Pool / Steelman Frobisher Beds Pool (Government of Saskatchewan, 2016) as of 23 July 2016 are

"1. The drainage unit shall be comprised of two legal subdivisions in a Section grouped as follows: Legal subdivisions 1 and 2; 3 and 4; 5 and 6; 7 and 8; 9 and 10; 11 and 12; 13 and 14; and 15 and 16.

2. Within a drainage unit, the sides of the target area shall be located 100m from and parallel to the corresponding sides of the odd numbered legal subdivision."



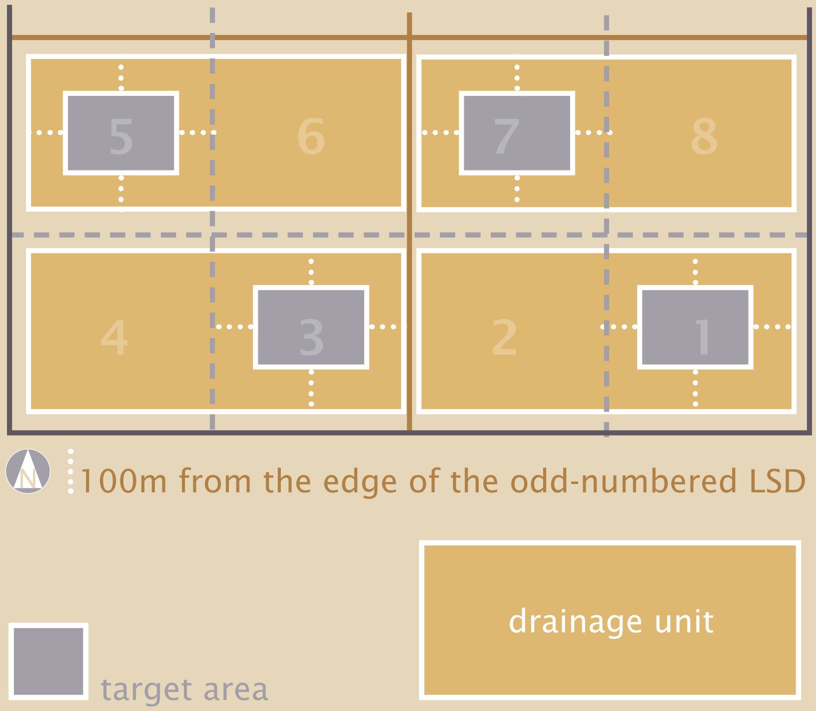


Figure 1.2.23 diagram of oil well spacing requirements, information adapted from guidelines set forth by Government of Saskatchewan, 2016

Figure 1.2.24: Oil and Gas Conservation Regulations, 2012 requirements (Government of Saskatchewan, 2015c)

"Surface Improvement: a railway; an above-ground pipeline; a canal; an above-ground power, telephone or other utility line; a road allowance; a surveyed roadway; an aircraft runway or taxiway" (Government of Saskatchewan, 2015c, pp.9-10).

Figure 1.2.24: diagram of oil well spacing, information adapted from guidelines set forth by Government of Saskatchewan, 2015c

oil oil everywhere and not a drop untouched

At ground level, I find the placement of the pump jacks often appear organic, pump jacks appearing around landscape features such as hills and shelterbelts. These locations hint at lines I cannot perceive, rows of pump jacks gap-toothed with missing pump jacks, becoming a visual haphazard placement despite a possible gridded organization.

Figure 1.2.25 confirms my suspicions. Although the pump jacks appear haphazard when moving through southeast Saskatchewan, the plan perspective provided by Saskatchewan Economy (2017) locates pump jacks, seemingly evenly spaced and aligned on a grid. This grid is notably structured, reflective of the structural grid of Saskatchewan (see *Figure 1.1.13*) but with a new purpose: oil extraction. This structure is, therefore, also reminiscent of the surveyed grid being applied on the landscape regardless of existing landscape features, an overlay of multiple grids on, what was, a grid-free landscape.

"As of July 31, 2012, Saskatchewan had 87,000 oil and gas wells and 5,300 facilities. Of the 87,000 wells, 58,000 were active wells (i.e., producing oil and gas), 24,000 were non-producing and the remaining 5,000 wells were abandoned (i.e., wells permanently sealed up) but the sites have not yet been reclaimed. Of the 24,000 non-producing wells, 9,700 are wells that have been inactive for five or more years" (Provincial Auditor Saskatchewan, 2012, p.239).

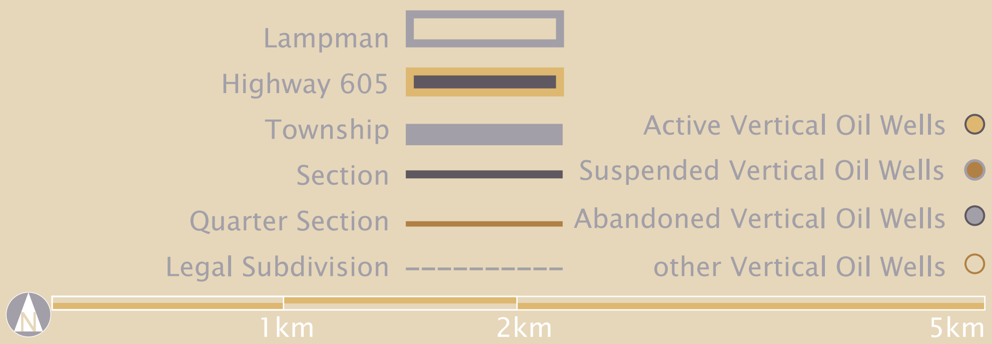
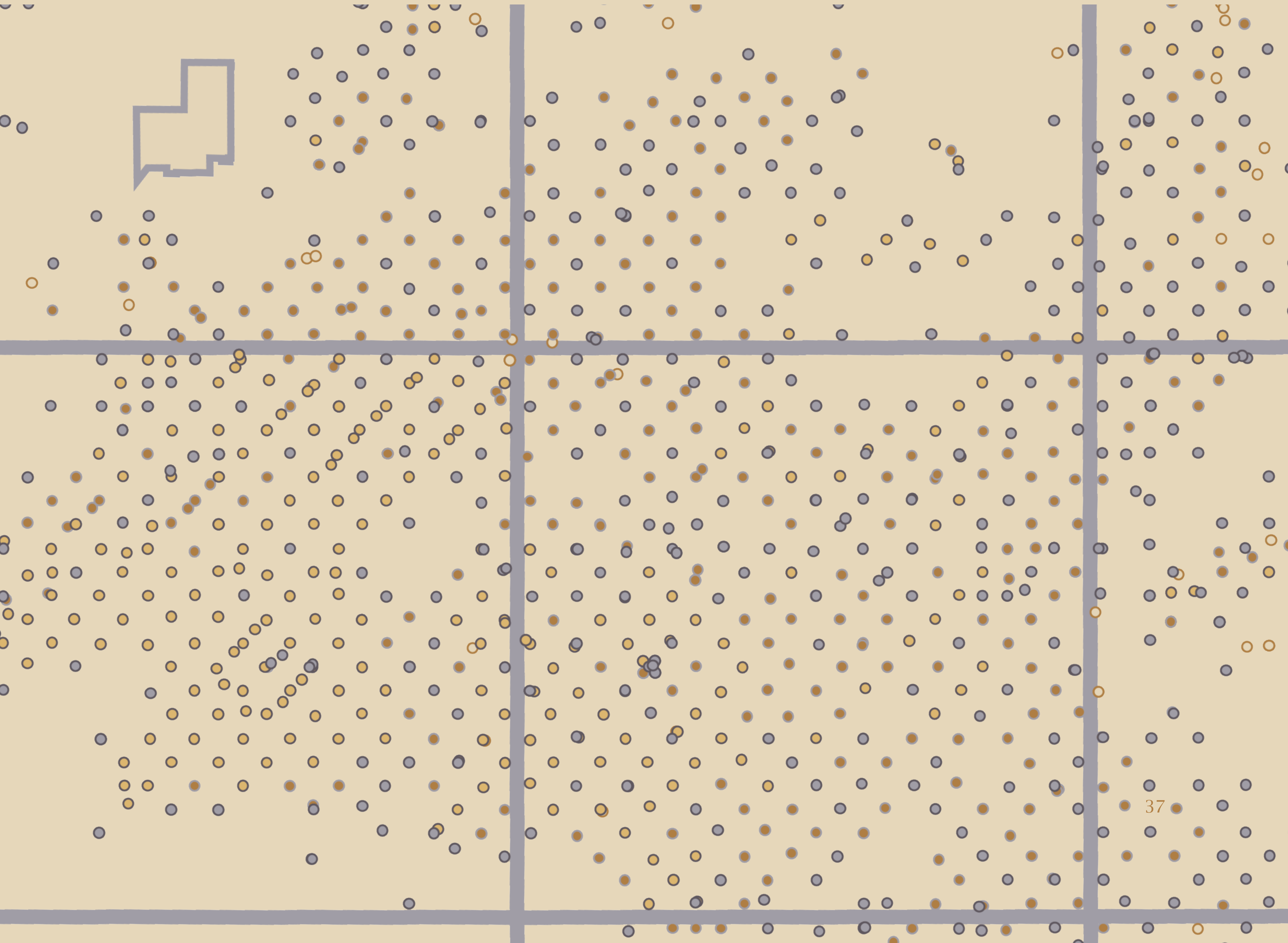


Figure 1.2.25: oil well sites, adapted from Saskatchewan Economy, 2017



active oil wells

After reading various government publications, it appears active oil well sites can be brand new wells, re-established suspended wells (see page 40), and re-opened abandoned wells (see page 42). To establish an active oil well, the interested company must first apply for a license, following the process laid out by the Government of Saskatchewan (Government of Saskatchewan, 2017b):
1) Obtain appropriate subsurface mineral rights.
2) Obtain surface lease and surface access from the surface owner of the chosen site.
3) Obtain a Heritage Resource Review through the Government of Saskatchewan's Ministry of Parks, Culture and Sport (Heritage Branch).
4) Submit a $10,000 non-refundable Orphan Fund fee if the licensee has not previously held a well/facility license pursuant to The Oil and Gas Conservation Regulations, 2012 in the province of Saskatchewan.
Assuming the license is verified, the speculative oil company must then work with the surface landowners. According to Fortugno (2004, p.5), "because a mineral owner has the legal right to develop and extract the minerals (oil and gas), a farmer, rancher or other landowner cannot refuse surface access to the oil and gas" but it is in the interest of both parties to establish goodwill relations. The oil/gas company is also expected to address any concerns by the surface rights owner: "address changes in the oil field installation practice (if applicable) since drilled or last reviewed; provide a comprehensive description of oil field equipment on site and any changes in activity; and, provide future plans for the site" (Fortugno, 2004, p.12).

According to *Figure 1.2.26*, there are currently active wells in the region of study, all of which will, one day, be abandoned or decommissioned sites requiring remediation. Although the points per well are not to scale on this map, they represent ample land dedicated to oil wells and their infrastructure (access roads and well pads) as visualized in *Figures 1.2.15 - 1.2.17*.

definitions

Active wells: "producing oil and gas" (Provincial Auditor Saskatchewan, 2012, p.242).
Mineral: "any non-viable [non-living] substance formed by the processes of nature, irrespective of chemical or physical state and both before and after extraction, but does not include any surface or ground water, agricultural soil or sand or gravel" (Fortugno, 2004, p.3).

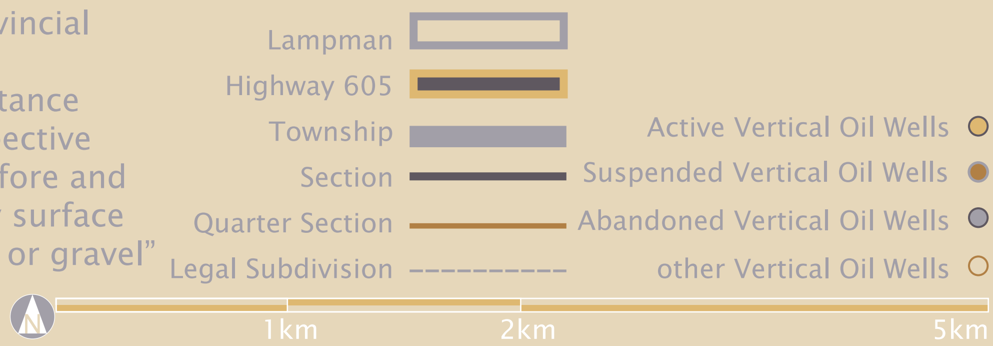
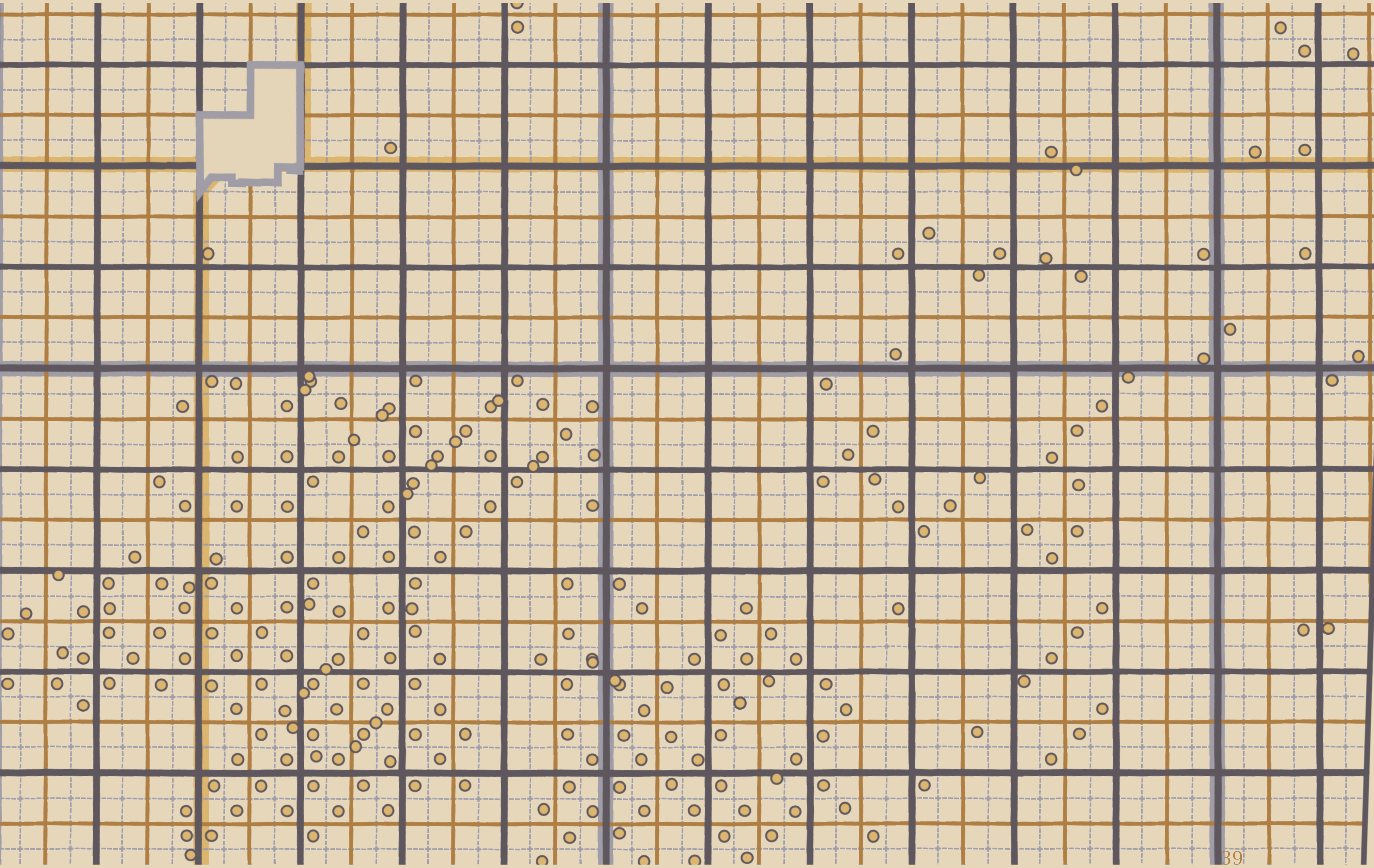


Figure 1.2.26: active oil well sites, adapted from Saskatchewan Economy, 2017



suspended oil wells

Suspended oil wells are wells that have been temporarily plugged and, therefore, inoperable (Provincial Auditor Saskatchewan, 2012, p.242). According to the Oil and Gas Conservation Regulations, 2012, (Government of Saskatchewan, 2015c, p.55) wells may be suspended “if, in the opinion of the minister, it is necessary to do so for the purpose of preventing a well, facility, structure test hole, oil shale core hole or flowline from contaminating an oil-bearing, gas-bearing, oil-and-gas bearing, fresh-water-bearing or other mineral-bearing formation” while other reasons may include availability of the workforce, infrastructural needs, or financial flow.

These wells are not yet ready for abandonment, despite their suspended state. The licensees are still accountable for remediation and clean-up, but they may also re-open these wells. This means that the infrastructure may be left in place, including the oil well site, pump jack(s), and connecting pipelines. Until proper abandonment, the licensee is not required to return the site to its original condition (remediate) beyond necessary environmental protection (Provincial Auditor Saskatchewan, 2012).

Figure 1.2.27 indicates the amount of wells currently suspended in the region. Compared to the previous page of active wells, we can see that the suspended wells are similar in number, particularly in the northern portion of the diagram. On average, these wells are spaced at one, possibly two wells per legal subdivision. Almost without exception, they follow the guidelines listed for the Steelman Midale Pool Beds / Steelman Frobisher Pool Beds (see *Figure 1.2.23* for more).

The in-limbo state of these oil wells are difficult to work with. They cannot yet be altered; they must maintain the status quo until they are either reactivated or decommissioned entirely. They will, one day, be abandoned when the oil is no longer needed to be extracted.

definitions

Inactive wells: “wells and facilities that have not reported any production, injection, or disposal activities for a period of 12 consecutive months or longer” (Provincial Auditor Saskatchewan, 2012, p.242).
Well suspension: “temporarily plugging inactive wells to prevent leakage”
(Provincial Auditor Saskatchewan, 2012, p.242).

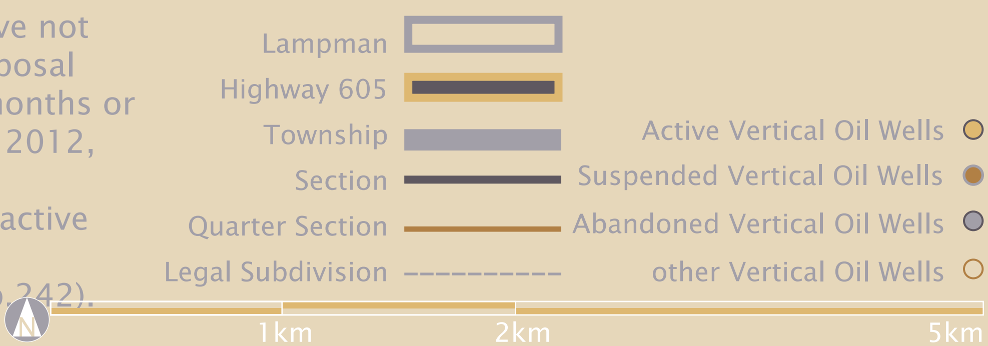
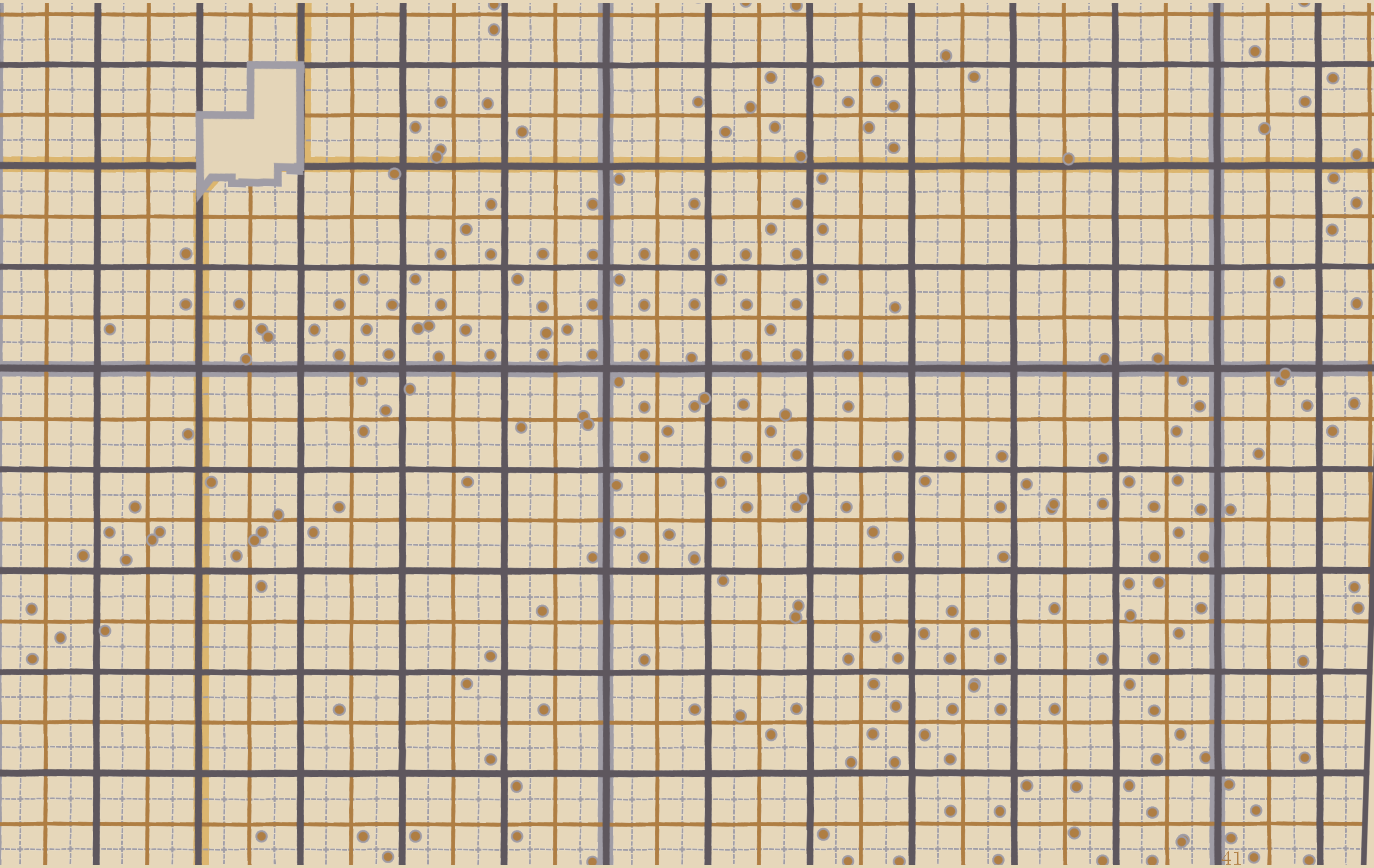


Figure 1.2.27: suspended oil well sites, adapted from Saskatchewan Economy, 2017



abandoned oil wells

Contrary to the suspension process, the capping/ plugging in an abandonment case is permanent: "Abandonment is part of the well decommissioning / dismantling process, and involves the capping or plugging of a well." (Fortugno, 2004, p.48).

The Government of Saskatchewan (2015b) created the Well Abandonment Requirements document to outline the necessary steps to abandon a well, to be used in conjunction with the requirements laid out in the Oil and Gas Conservation Regulations, 2012 (Government of Saskatchewan, 2015c). It begins by stating: "Saskatchewan oil and gas regulations stipulate that no well can remain unplugged or uncased after it is no longer used for the purpose for which it was drilled or converted" (Government of Saskatchewan, 2015b, p.4). The remainder of the document outlines the administrative components of well abandonment, relying on the technical specifications laid out in the Oil and Gas Conservation Regulations, 2012, to infill the technical and procedural gaps.

To begin abandonment: "A company must submit an application and a plan of abandonment to the Ministry for any well that they will no longer be using" (Government of Saskatchewan, 2015b, p.4). This step, although summarized in a few words, includes a complex procedure: "A detailed step-by-step procedure of the proposed abandonment including the isolation procedure that will be used, the testing requirements, and a detailed wellbore history" and "A schematic drawing of the components–both surface and subsurface–of a well, the depth at which the components are located, and how the components relate to the principal dimensions of the well" (Government of Saskatchewan, 2015b, p.6) may be required.

The abandonment process states: "All wells must have production casing landed and be cemented full length from surface to total depth" (Government of Saskatchewan, 2015b, p.4). This process, therefore, guarantees safety from environmental contamination in the long-term.

definitions

"Cut and cap: refers to the cutting and removal of surface and production casing stubs one metre (1 m) below ground level, and the capping of a well by approved means"
(Government of Saskatchewan, 2015b, p.4)

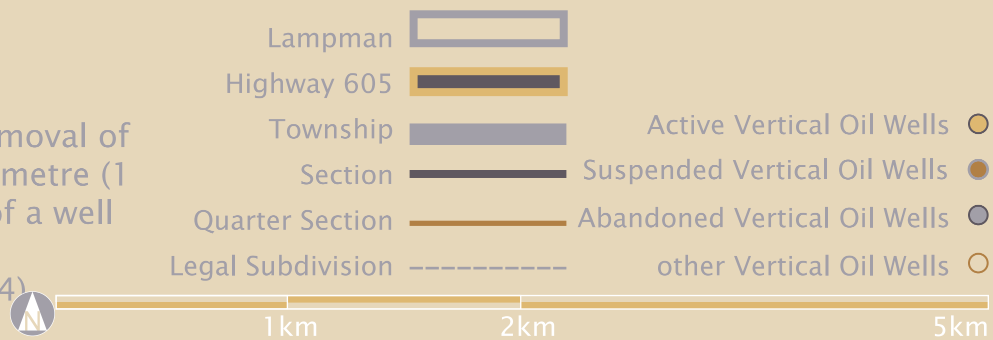


Figure 1.2.28: abandoned oil well sites, adapted from Saskatchewan Economy, 2017

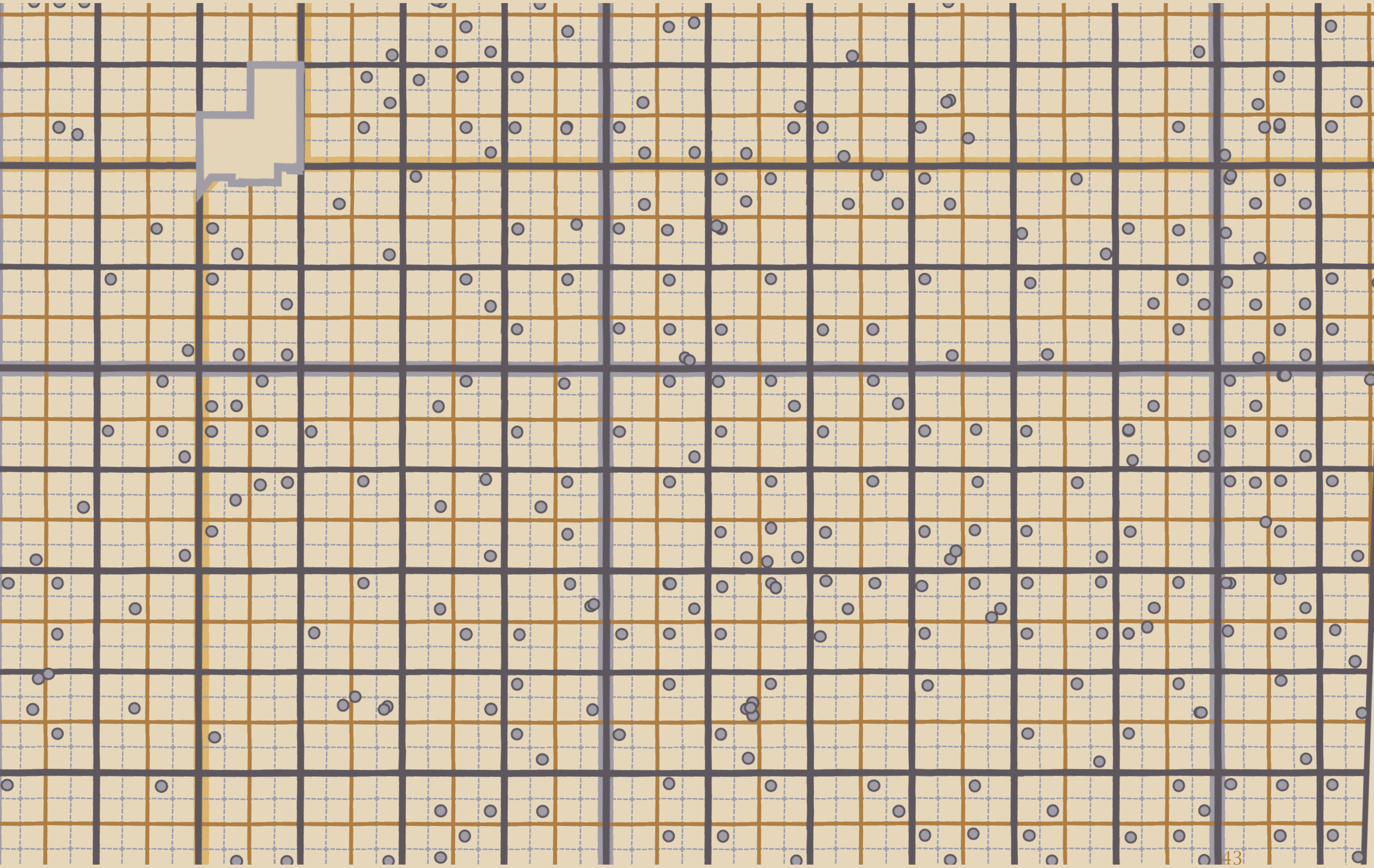


Figure 1.3.01: an uncultivated area in the region of study in southeast Saskatchewan

1.3 ECOREGION INVESTIGATION

characteristics and components

ECOREGION: MOIST MIXED GRASSLAND

common characteristics and components

According to the Saskatchewan Conservation Data Center (SCDC) (2014), the region of study is located in the prairie ecozone, specifically, the moist mixed grassland ecoregion. The landscape typically contains sloughs that are surrounded by small aspen groves, providing valuable habitat for a variety of species including waterfowl (SCDC, 2014). In the industrialized landscape, the sloughs are surrounded by agricultural crops, primarily cereal crops but with a growing presence of oilseeds and pulse crops while native patches of grassland are "confined largely to non-arable pasture lands, where speargrasses and wheatgrasses, along with deciduous shrubs such as snowberry, rose, chokecherry, and wolf willow are among the more common species" (SCDC, 2014). This open grassland landscape hosts a multitude of wildlife species, the most common being white-tailed deer, mule deer, coyotes, jack rabbits, red fox, the western meadowlark, piping plover, and sharp-tailed grouse (SCDC, 2014).

Figures 1.3.03, 1.3.04, 1.3.05, 1.3.06, 1.3.07, 1.3.08: some of the common flora and fauna of the moist mixed grassland ecosystem

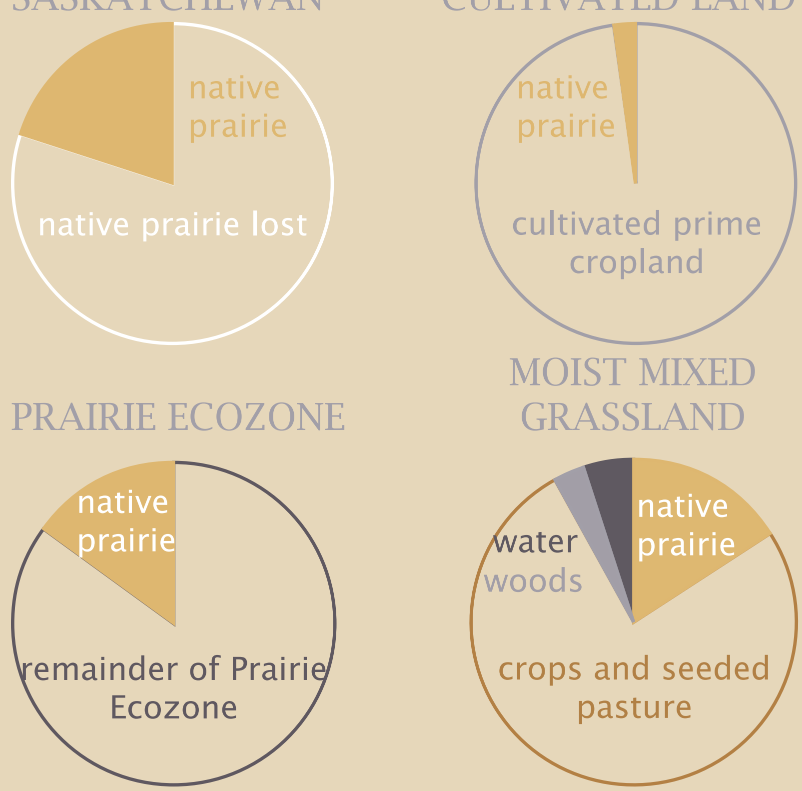


Figure 1.3.02: percentages of land use and landscape features in Saskatchewan adapted from information by Native Plant Society of Saskatchewan (NPSS) 2001

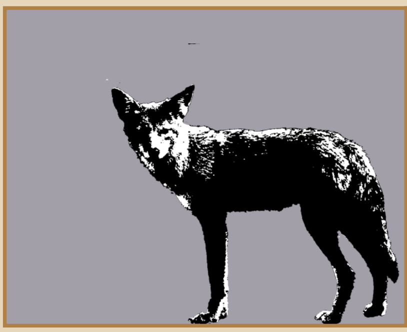


 Figure 1.3.03: coyote

Figure 1.3.04: snowberry

Figure 1.3.05: jack rabbit

Figure 1.3.07: wheatgrass

Figure 1.3.06: bison

Figure 1.3.08: moist mixed grassland ecoregion, adapted from SCDC, 2017

"Saskatchewan is prairie pothole country. Covering nearly 800,000 km^2, the prairie pothole region is composed of the glaciated portions of five U.S. states and southern parts of the three prairie provinces. In Saskatchewan, it includes both the Aspen Parkland and Mixed Grassland Ecoregions, the agricultural areas of the province. A unique combination of climate and geological history has combined to make the prairie pothole region among the most productive waterfowl habitats on the continent. However, the region with its fertile soils, suitable climate, and lack of major physical barriers to cultivation has been greatly transformed since the time of European settlement. Today most of the region has been converted to agricultural production with little of the land remaining unaltered by human activities" (Huel, 2000, p.8).

"The open grassland interspersed with lakes, ponds, creeks, river valleys, shrubs and trees supported indigenous peoples and wildlife including, huge herds of grazing animals and a myriad of birds and insects. These age-old plant communities dominated by grasses are what we refer to as native prairie."

Native Plant Society of Saskatchewan, 2001, p.1

the historic pothole prairie

According to the Native Plant Society of Saskatchewan (NPSS) (2001), the moist mixed grassland is a historic landscape, built over thousands of years. It thrived on succession, adapting to buffalo, fire, and drought. However, the prairie was not continuously being ravaged by disturbances as "periodic fire and grazing followed by rest rejuvenated the land and resulted in a landscape diverse in native plants" (NPSS, 2001, p.3). The disturbance might include heavy grazing by buffalo in one area who may not return for years, or a fire would burn all of the litter that would then take years for enough litter to build up for another fire (NPSS, 2001, p.14).

Native grasslands host a multitude of wildlife and plant biodiversity.

"The outermost and driest wetland zone. Flooding occurs for a short time in spring, much like a temporary wetland. Common plants include northern reedgrass, sedges, wild mint and dock" (Huel, 2000, p.14).

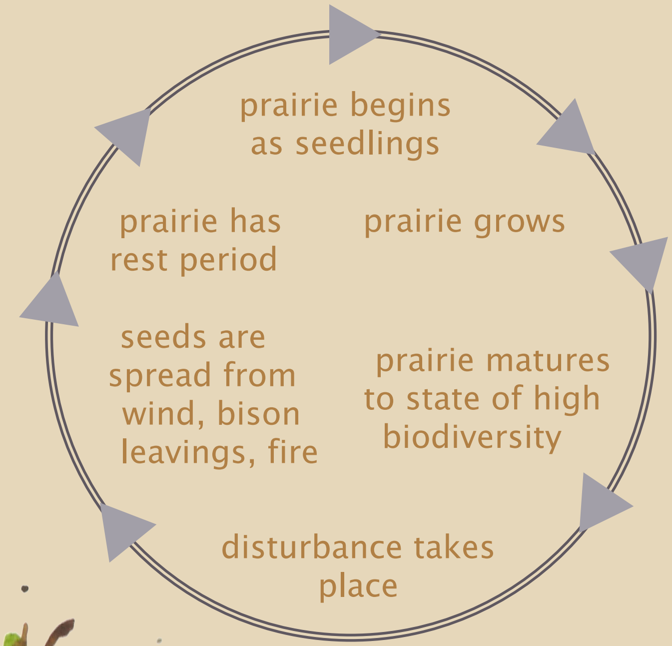
"Normally flooded until summer. Coincides with deepest part of seasonal wetlands. Vegetation includes a mixture of sedges, Baltic rush, spike rush, sloughgrass, whitetop, marsh smartweed, water - plantain and water - parsnip" (Huel, 2000, p.14).

"Flooded with shallow water from spring to fall. Vegetation dominated by emergent vegetation, like cattails and bulrushes. Other common plants include pondweeds and coontail" (Huel, 2000, p.14).

NATIVE GRASSLAND WET MEADOW SHALLOW MARSH DEEP MARSH

Figure 1.3.09: section of a typical wetland – a pothole in the prairie, adapted from information by Huel, 2000, p.14

My interpretation of the cycle of prairie growth.



These disturbances promoted biodiversity and prevented non-adapted, invasive species from taking hold. The success of the prairie ecosystem is also built on the soil composition. The fertile soils are a result of 10,000 years of “organic matter, made up of plants and animals decaying over centuries” that became “the source of the fertility and rich dark colour of topsoil” (NPSS, 2001, p.10) that the prairie depends on for survival.

“Stable areas of open water whose depth may be greater than one meter. Vegetation, if present, is a combination of submerged and floating plants such as pondweeds, coontail and duckweed” (Huel, 2000, p.14)

PERMANENT OPEN WATER

“An important part of a functional wetland system is the surrounding border of vegetation that separates the wetland from adjacent uplands. Permanent vegetation in wetland margins provides wildlife habitat, traps snow and silt,reduces salt buildup on the soil surface, and improves a wetland’s ability to filter and purify water before it seeps into the ground. Plant communities in transition areas usually consist of a mixture of moisture-loving grasses, broadleaved forbes, and shrubs such as willows. Groundwater movement from the wetland can keep these areas green and productive even during the dry summer months” (Huel, 2000, p.16).

WETLAND MARGINS

"It was a land settled by only the most determined people from a variety of cultures. The prairies, once scoured by ice, were scoured again by iron."

Native Plant Society of Saskatchewan, 2001, p.1

present-day impacts

Today one of the greatest challenges to the native prairie is the continual fragmentation and industrialized development of the prairies. Over the course of the last 150 years, the majority of the prairies have been transformed into the agricultural landscape we know today; NPSS estimates that, "in local areas of prime cropland, less than 2% of the original prairie remains" (2001, p.3). The fragmentation is a result of multiple activities: "road building, resource extraction, residential development and cultivation" (NPSS, 2001, p.3). Although not everyone would be concerned about the loss of the native prairie, the agricultural landscape we know today would not

Current conditions have replaced the native grassland with agriculture crops, reducing biodiversity as controlled, monoculture plants out-compete the native prairie.

"When plants in wetland margins are removed by cultivation ... snow trapping is reduced and the wetland is deprived of some of its water supply. Erosion from surrounding cropland can fill in wetland basins and salinity problems develop or increase" (Huel, 2000, p.20).

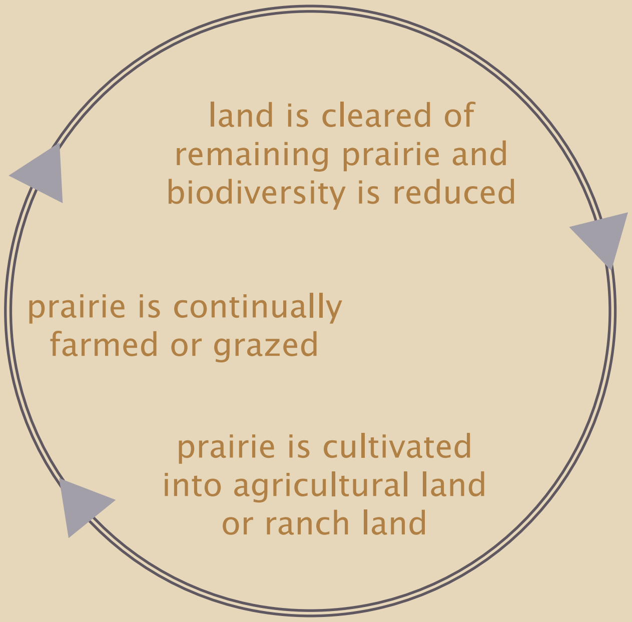
"Temporary and seasonal wetlands are often cultivated during fall tillage operations. If the spring, is dry they may be seeded but often they are too wet and the plants which were not killed by the tillage grow back" (Huel, 2000, p.20)

Because "sloughs and potholes are often viewed as impediments to crop production ... draining and converting wetlands to crop production continues to be the most serious threat facing Saskatchewan wetlands" (Huel, 2000, p.20)

CROP LAND | WET MEADOW | SHALLOW MARSH | DEEP MARSH

 Figure 1.3.10: section of a typical wetland – a pothole in the prairie – with surrounding agriculture, adapted from information by Huel, 2000, p.20

My interpretation of the agricultural cycle
on native prairie grassland.



exist without the previous prairie. The fertile soils have been monopolized by agriculture and ranching: “the plant community ... becomes less diverse and less productive” with poor management and unnatural succession patterns (NPSS, 2001, p.14). Beyond that, invasive and dangerous plants are more able to impact the existing remaining prairie, destroying what little is left (NPSS, 2001, p.14).

“Wetlands reduce cropland acreage, decrease efficiency of field operations, and contribute to crop depredation by waterfowl which can occasionally be extensive. In addition, frequent combinations of low commodity prices and high input costs have put tremendous pressure on producers to increase productivity and reduce costs” (Huel, 2000, p.20).

PERMANENT OPEN WATER

Problems from draining potholes includes:
Erosion “from cultivated areas can transport soil, fertilizers and pesticides to wetlands, filling wetland basins, reducing the productivity of croplands and polluting water supplies.”
Drainage “eliminates wetlands, lowers water tables, increases run-off and erosion and reduces productivity of adjacent areas.”
Cultivation “of wetland margins reduces the capacity of wetlands to trap snow and filter water... Cultivating through temporary wetlands eliminates plants which may provide quality hay” (Huel, 2000, p.21).

WETLAND MARGINS

POTHOLE PRAIRIE FLORA AND FAUNA

adaptations and function

Vegetation plays a primary role in the historic pothole prairie. The Alberta Prairie Conservation Forum (APCF) (2017) suggests that it provided a highly diverse habitat for an abundance of wildlife as the vegetation and large mammals evolved together. The vegetation profile “is a mix of short grasses (e.g. blue grama grass and June grass) and mid-height grasses (e.g. wheat grasses, needle-and-thread, and porcupine grass)” (APCF, 2017).

The vegetation of the prairies adapted to the harsh conditions of Saskatchewan’s climate in a variety of ways. APCF (2017) states that the predominant species -- grass cover -- are often perennials, growing for more than one season and out-competing annual species. Although these adaptations are not the same for all species, they share the same necessary adaptations: wind, drought, sunlight, and cold will affect nutrient and moisture access for all species. The adaptations noted by the APCF (2017) are listed to the right, and further expanded on in *Figure 1.3.11*:

1 Deep or extensive roots;

2 Growing points at or near the soil surface that are tucked in the crown of the plant;

3 Narrow leaves;

4 Small flowers in dense heads that are pollinated by wind;

5 Tough stems and leaves hardened with silica phytoliths (plant stones);

6 Strategies to optimize photosynthesis without losing moisture.

APCF (2017) states that trees and shrubs share some characteristics with perennial grasses: moisture evaporation can cause greater drought stress, leaves may be adapted to prevent further moisture loss, and the root systems adjust for drought and runoff (including sediment build up). Rhizomatic root systems, such as those found in aspen, promote regrowth after a fire through vegetative sprouts (APCF, 2017). Locations that promote trees and shrubs include sheltered areas such as coullees, valleys, and depressions (APCF, 2017).

4 As wind is a dominate driving force on the prairies, the plants adaptations include dense flowerheads that host pollen that is easily spread (APCF, 2017).

5 The erect flower stalks enhance the spread of pollen through upright form and reduces the amount of direct sunlight on the stalks. It may be that the tougher stalks were to prevent rodents from continuously wearing the plants down (APCF, 2017).

3 Slender leaves reduce evaporation and drought stress; oftentimes the individual leaves are rolled or folder that prevent direct sun on the sensitive points of the leaves (APCF, 2017).

2 Growing points tucked in the crown allow for protection from wind, extreme cold, all but the hottest grass fires, and the hooves and teeth of grazers (APCF, 2017).

1 Bunch grasses have a depth of up to four metres. This adaptation allowed for greater moisture and nutrient capture; rhizomatous grasses occupy a shallower region for the same intent (APCF, 2017).

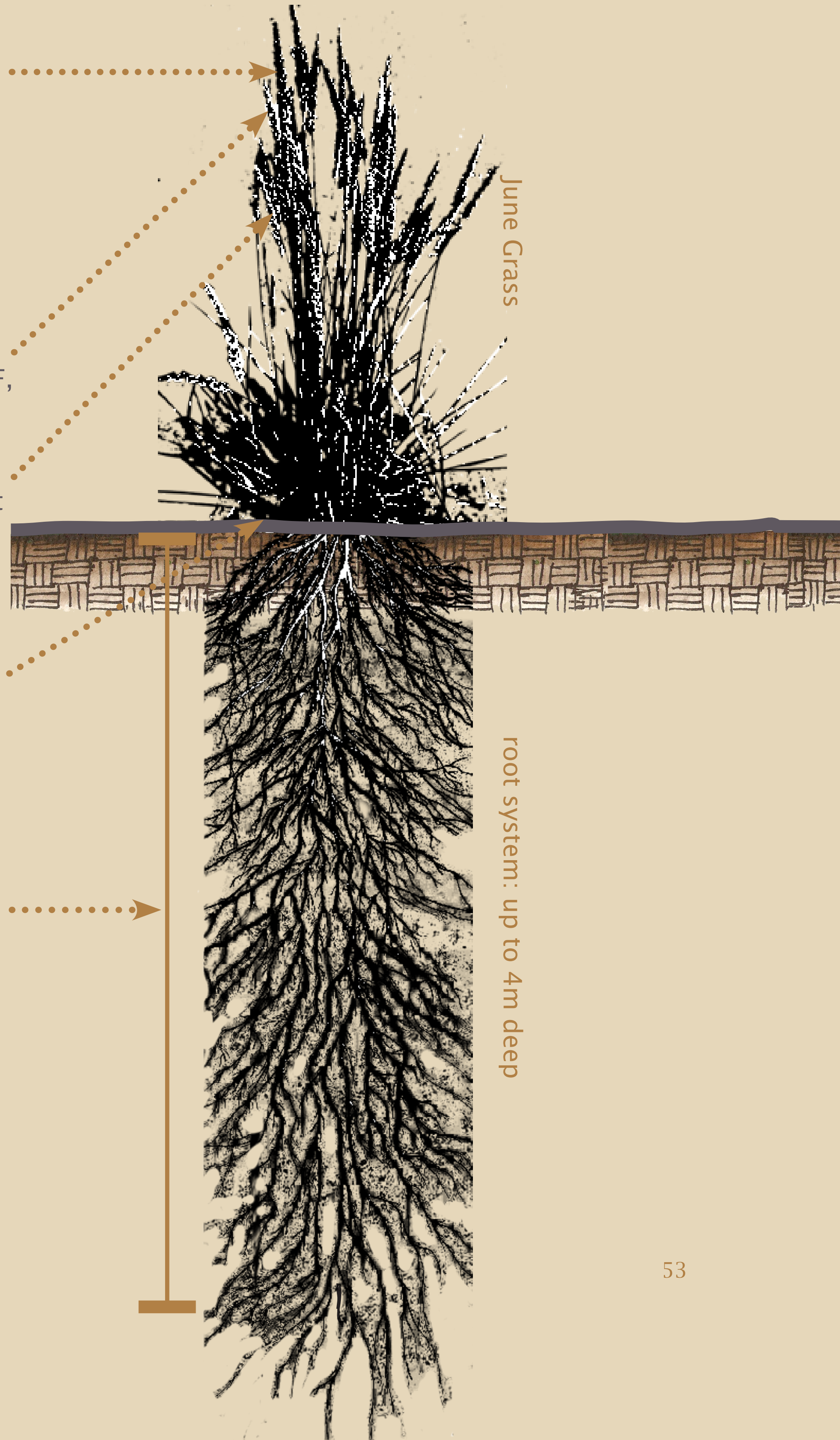


Figure 1.3.11: schematic native prairie grasses and roots

grasses

David J. Wishart (2011) describes grasses as "truly the defining feature of the Great Plains landscape." In his definition of grasses he includes the major food group grains. Grains were domesticated from their wild counterparts as "corn, wheat, sorghum, millet, barley, oats, and rice" are all cultivated versions of wild grasses (Wishart, 2011). Although Wishart (2011) includes these varieties of grasses in his definition, he also references the presence of these grasses in large-scale agriculture: "The belowground community (as well as the aboveground canopy) is radically altered by plowing and the conversion of natural grasslands to agricultural fields in the Great Plains." These alterations affect the soil that is a distinct component of the prairies and has developed the breadbasket of the world title to the prairies. He lists some species of grass that contribute below.

In terms of process, Wishart (2011) succinctly captures the process of the plants that contribute to a healthy and fertile soil profile: "The aboveground portion of grass dies back every year, and the dense, fibrous root system is constantly

Bouteloua gracilis (blue grama) | Buchloë dactyloides (buffalograss) | Andropogon gerardii (big bluestem) | Panicum virgatum (switchgrass) | Sorghastrum nutans (Indiangrass) | Schizachyrium scoparius (little bluestem) | Agropyron smithii (western wheatgrass) | S. scoparius | Bouteloua curtipendula (sideoats grama) | Festuca scabrella (rough fescue)

grass species of the moist mixed grassland according to Wishart, 2011

growing and dying back. All of this results in large inputs of organic matter into the soil. The breakdown of the organic matter supplies nutrients to plants. The presence of the organic matter also increases the nutrient–and water–holding capacity of the soil." He describes this richness as "upside-down forests" due to the greater biomass below ground as opposed to above ground that is capable of supporting the prairie ecosystem (Wishart, 2011). Further to this point, Wishart (2011) considers the trees and shrubs as interspersed within the grass-based matrix. Although they may be visually stronger on the flat plains, they do not compare to the ecological strength of prairie grasses.

My interpretation of the prairie growth cycle.

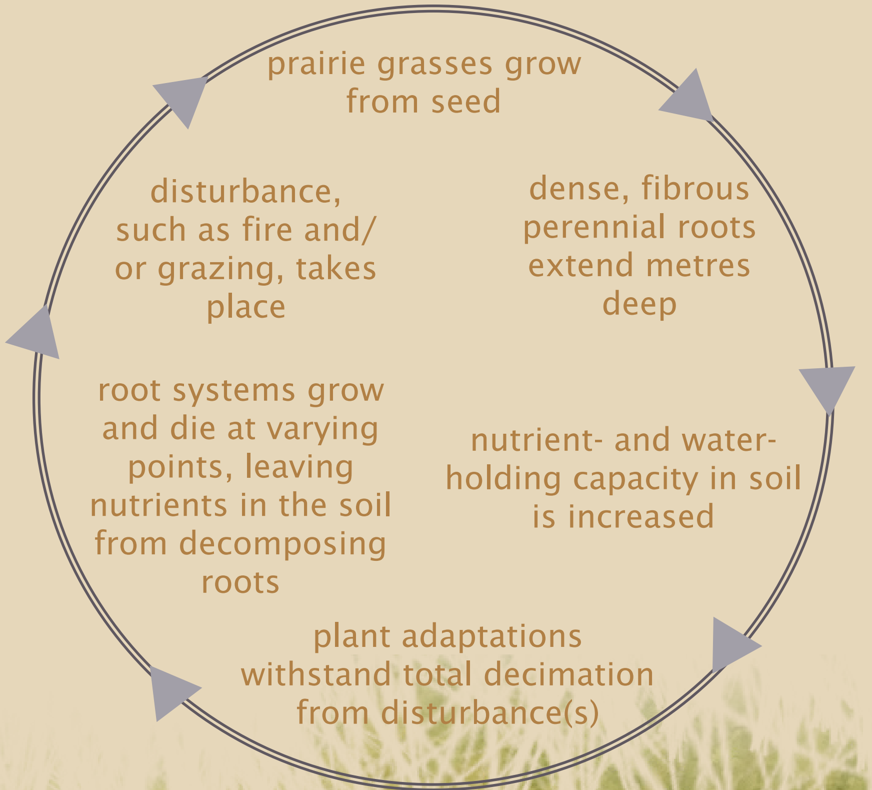


Figure 1.3.12: dense thicket of prairie grasses

contemporary crops

The NPSS (2001, p.3) states: "In Saskatchewan, it is estimated that almost 80% of the prairie has been lost. In local areas of prime cropland, less than 2% of the original prairie remains." In the region of study for this practicum, NPSS (2001, p.6) estimates that there may be only 6% of native prairie left. Up to 75% of the remaining native prairie primarily exists in areas unable to be cultivated: "soil moisture limitations, stones, steep slopes, erosion, salinity, soil structure or flooding" (NPSS, 2001, p.10). In areas where crop production is the primary vegetation, there are not only swaths of land devoted to one species, but also few species in total. "In Saskatchewan, about 70 plant species are farmed for human consumption and the majority (70% or about 50 species) of these are fruits and vegetables produced on a small scale" (NPSS, 2006, p.1).

There are multiple concerns that result from the expansion of agriculture and the reduction of native biodiversity: pests, climate change, and wetland drainage that we do not yet know the full extent of damage over the long-term. As agriculture expands and monocultures increase, "the consequences are most apparent with increased pest problems as crop monocultures expand, replacing the diversity of natural vegetation. The natural predators of these pests decline as local habitats decrease" (Nature Saskatchewan, 2006, p.1). Pests have the potential to wipe out the few species of crops planted; monocultures are dangerous because pests can destroy an entire species if that species has not built a resistance to the pest. However, "agriculture is still a way of life on the prairies—and the pressure to drain wetlands to make room for production and development remains" (DUCs, 2017a). Every wetland loss is another piece of habitat disappeared for wildlife species and the benefits of biodiversity and, in turn, possible pest control. Biodiversity is most notable in the soil conditions: "when soil is rich in biodiversity, reliance on purchased inputs declines, while land productivity and income potential increase" (Nature Saskatchewan, 2006, p.1).

 Figure 1.3.13: durum crop in the region of study in southeast Saskatchewan

According to Saskatchewan Agriculture and Food (2005), farmers can promote future growth for crops by using a crop sequence strategy, used to optimize water and nutrient use, re-introduce nitrogen and phosphorous into the soil to reduce the need for fertilizer, and manage soil nutrient levels (*Figure 1.3.14*). Even with this strategy, comparing root systems showcases the differences in root depth (*Figure 1.3.15*), indicating the lesser length of crop roots and, therefore, input of nutrients into the soil.

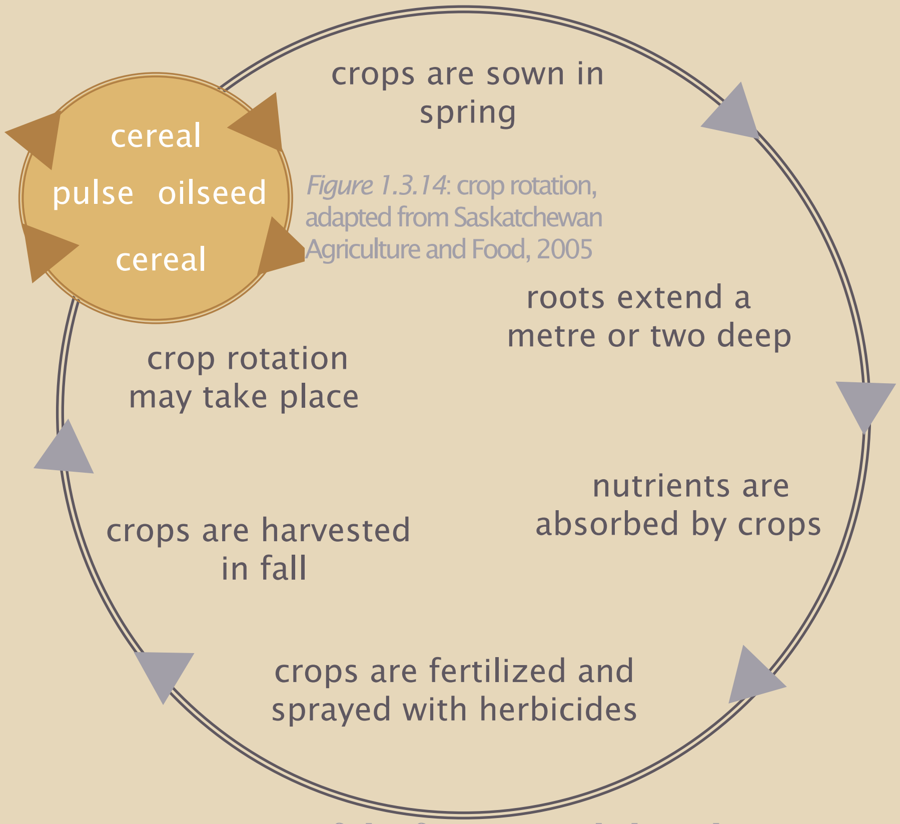


Figure 1.3.14: crop rotation, adapted from Saskatchewan Agriculture and Food, 2005

My interpretation of the farming cycle based on my own experiences.

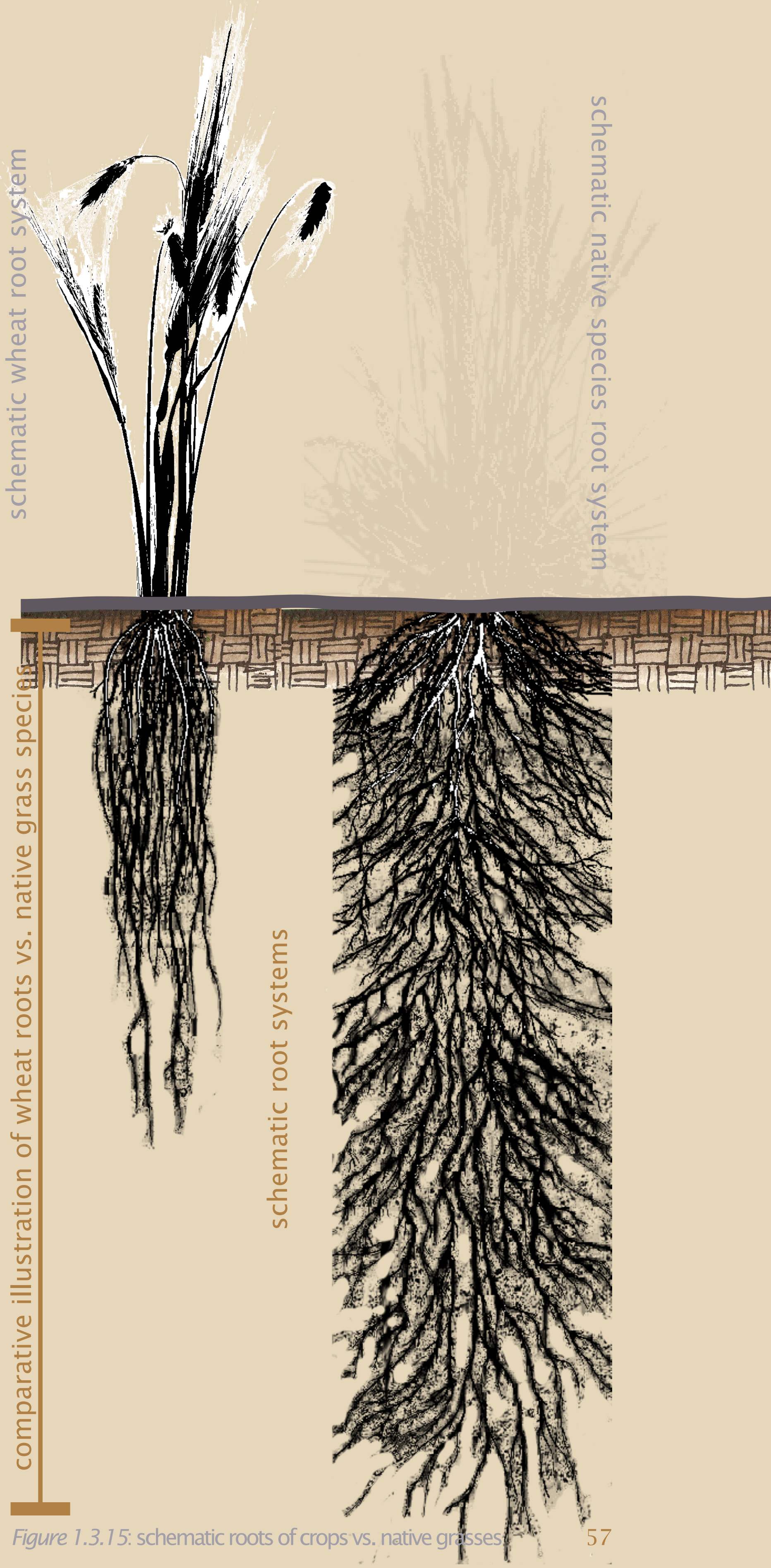


Figure 1.3.15: schematic roots of crops vs. native grasses

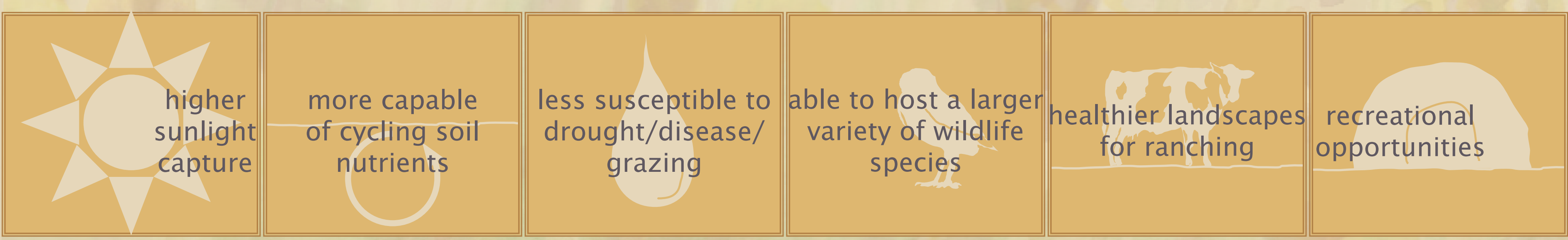
re-establishing native prairie

In the agriculturally dominated landscape of the region, it is worth recognizing the benefits of native prairies (before they potentially disappear) and considering how they could be applied in ever-shifting, anthropogenically modified landscapes. Some benefits are listed below, determined by the NPSS (2001, p.4) and Heidenreich, 2009, p.ii).

The NPSS (2001, p.2) promotes many of the benefits of native prairie based on historical values and uses: “food, medicine, ceremonies, art, tools and weapons” by Native American persons, and furthermore as “recreation, genetic resource, habitat for wildlife and as a benchmark of our past environment.”

Dean J. Nernberg (1993) conducted a study on landscape prairie restoration, focusing on elements such as developing “techniques appropriate to the mixed-grass prairie for collecting, processing, and planting of native grasses, forbs, and shrubs” and the “long-term fire management” (Nernberg, 1993, p.185). This study does not simply promote the re-establishment of native prairie; it also promotes the ‘benchmark’ concept introduced by the NPSS. The sourcing of native species seeds is collected within the region of planting, a promoted practice (Driftless Prairies, 2017). The benchmark concept -- a method of conserving prairie to maintain an patch of native prairie -- can also provide a seed source as well as an example

benefits of re-establishing native prairie (NPSS, 2001, p.4)



of a healthy, functioning native prairie ecosystem; Driftless Prairies (2017) claims that “using local genotype seed is believed to be an imperative to restoration work as it assumes a plant’s ability to flourish in certain environments” while preserving “the plant genetics of a particular area.” It’s not to say that there won’t be challenges with local sourcing; sometimes there are seed sourcing concerns, gene flow, outbreeding and inbreeding, and finding a local seed source (Driftless Prairies, 2017). Local is a subjective term; Driftless Prairies (2017) claims that local can be anywhere from 25 miles to 200 miles from the site. However, to combat Saskatchewan’s varying soil conditions and extreme climate, closer local seed sourcing could prove worthwhile. Although Nernberg’s study is focused on a singular site, it promotes larger scale changes: the study aims to “reduce habitat fragmentation through prairie restoration; rehabilitate native prairie habitat by re-introduction of fire, grazing, and other sustainable management techniques; and control problem, exotic, plant species” (Nernberg, n.d., p.185). Beyond that, it promotes the concept that prairie restoration is interesting, vital, and, most importantly, feasible, particularly for small-scale sites that will relate to the oil well sites of this practicum’s study.

benefits of re-establishing native prairie (Heidenreich, 2009, p.ii)

invasive species on existing oil well sites

The oil well sites, as viewed in *Figures 1.2.08 - 1.2.14*, typically consist of graveled access roads and graveled oil well sites. Gravel has the unfortunate tendency of attracting invasive and noxious plant species as per the Saskatchewan Invasive Plant Species Identification Guide developed by the Saskatchewan Forage Council (SFC) (2010), some of which are listed below. Oil well sites are, by proxy, havens for invasive species alongside the access roads and the circumference of the pump jack site. The introduction of the Saskatchewan Invasive Plant Species Identification Guide (SFC, 2010, p.1) sums up the dangers of invasive species best: "Invasive species are a growing threat to the integrity of native prairie. Native prairie is home to many important and/or rare plants and animals. The plants which make up native prairie work together to store carbon, maintain water and nutrient cycling, and build soil. Invasive species can upset this balance." Invasive species are often found on and in disturbed sites as "haylands, tame forage, gravel pits, riparian areas, roadsides and cropland" are prime locations for invasive species (SFC, 2010, p.1).

This is important because "invasive species [can] modify soils that they occupy in ways that increase their own fitness relative to that of native species"

Bromus tectorum | Bromus japonicus | Artemisia absinthium Tanacetum vulgare | Linaria dalmatica | Linaria vulgaris | Euphorbia esula | Centaurea solstitialis | Cirsium vulgare | Cirsium arvense | Carduus nutans | Knautie arvensis | Hesperis matronalis | Arctium minus subsp. minus | Centaurea maculosa | Acroptilan repens | Centaurea diffusa | Peganum harmala | Gypsophila paniculata | Convolvulus arvensis | Cardaria draba | Malva rotundifolia | Matricaria perforata | Berteroa incana | Chrysantheum leucanthemum | Hieracium aurantiacum

Saskatchewan Forage Council, 2010

INVASIVE PLANT SPECIES

EXAMPLES OF ACCESS ROADS

and reduce native species occupation (Jordan, Larson and Huerd, 2008, p.177). This study, through intensive research on specific varieties, found that the negative effects on native species were not uniform but they were certainly present, concluding in the need for restoration of soils for ecological management strategies (Jordan, Larson and Huerd, 2008, p.186).

As oil well sites are gravel, edged by primarily invasive species, these sites will require intensive remediation to ensure exotic and invasive species do not remain presence in the soil. Nernberg (1993, p.186) discusses his attempts in the study to make invasive species obsolete in the soil: after two years of fire and herbicides, the sites should be safe for native planting installation.

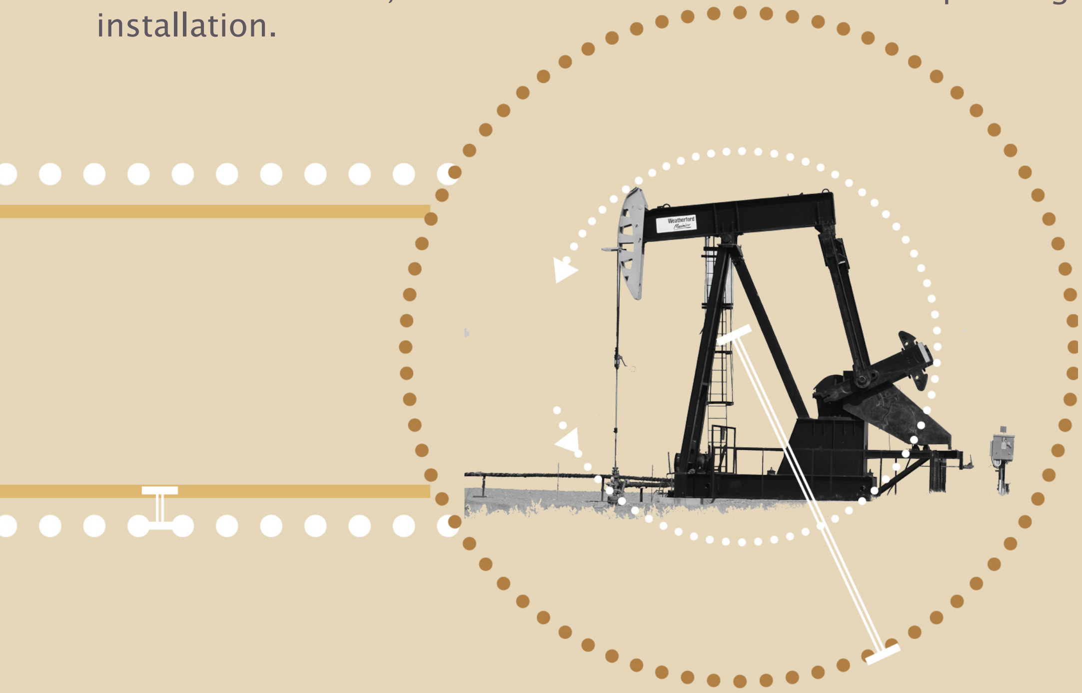


Figure 1.3.16: typical access road where invasive species often occupy, see page 26 for more details

Figure 1.3.17

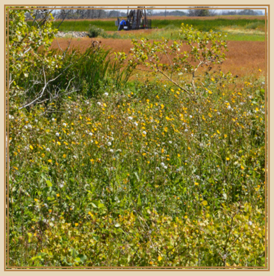
Figure 1.3.18

Figure 1.3.19

Figure 1.3.120

Figure 1.3.21

Figure 1.3.22



Figures 1.3.17, 1.3.18, 1.3.19, 1.3.20, 1.3.21, 1.3.22: invasive weeds along the edges of fields and access roads near the site of study in southeast Saskatchewan

wildlife: symbiotic species and habitat pieces

The prairies host a large range of animal species across the different ecosystems of the moist mixed grass prairie. “The prairie vegetation is vital to the survival of countless wildlife species, many of which have already dropped significantly in number or disappeared” with the cultivation of native prairie (NPSS, 2001, p.4). Part of this is due to anthropogenic influences, while some of the other issues revolve around the co-evolution of plant and animal species. The most well-known example is the influence of buffalo herds and plant evolution; “for millennia immense herds of bison roamed the grasslands, leaving large swaths of prairie grazed and trampled in their seasonal round” (APCF, 2017). The plants adapted to retain growth nodes where grazing animals couldn’t eat, while buffalo moving through the landscape fertilized the prairie soil, creating a symbiotic relationship.

However, European settlement has had its influence on wildlife as much as vegetation. The Alberta Prairie Conservation Forum (APCF, 2017) state that some extirpated species include the grizzly bear and gray wolf, the main predators of bison until European settlement. Other wildlife species have managed to adapt to the prairies and withstand anthropogenic alterations; species such as “elk, deer, coyote and bobcat” spend their lives living in coullees and valleys for shade in summer heat and shelter in the winter cold, migratory birds fly south each year to escape the cold, burrowing mammals take refuge beneath the snow and ground, and many waterfowl species rely on the pothole prairie waterbodies for mating, temporary habitation, and feeding (APCF, 2017). The list below summarizes species that have been most affected by anthropogenic disturbance (Atkinson, 2009, p.95).

extirpated

MAMMALS
Black-footed ferret
Plains grizzly bear
Plains wolf

BIRDS
Greater prairie chicken

endangered

MAMMALS
Swift Fox

BIRDS
Burrowing owl
Piping plover
Sage thrasher

threatened

MAMMALS
Bison

BIRDS
Baird’s sparrow
Loggerhead shrike
Sprague’s pipit

vulnerable

MAMMALS
Plains pocket gopher
Black-tailed prairie dog

BIRDS
Ferruginous hawk
Greater sage grouse
Long-billed curlew

> “ a compelling case can be made for reintroducing the bison as a keystone species, and the swift fox as an extirpated rarity. However, rewilding is expensive and controversial, and can easily become an idealized, romantic myth ignoring reality. Clearly it would be inappropriate to reintroduce the prairie wolf, the plains grizzly bear, and the widespread use of fire, all key features of natural prairie ecosystems.”
>
> Atkinson, n.d. p.110

An often overlooked species affected by native prairie cultivation into cropland are pollinator species that Prairie Pothole Joint Venture (PPJV) (2017) identifies as bees, bats, insects, and birds. Pollinators, such as these, “perform an invaluable service to ecological health around the world, to agriculture production, and ultimately human beings. However, unfortunately multiple sources of data suggest our pollinators are in trouble... their populations are disappearing.” The Manitoba Museum (2014) has a page describing the pollinators they have identified: hummingbirds, insects including bees, moths, ants, butterflies, moths, beetles, and flies. “Although on average the amount of pollen deposited per visit to crop flowers is lower for non-bees than for bees, the high visitation frequency of non-bees to crop flowers compensates for the deficit in per-visit effectiveness and results in high pollination services overall” (Rader et al., 2016). In the case of bees, Pearson (2015) believes their populations are primarily affected by “habitat loss, pesticides, and decreased floral diversity.” Pearson (2015) lists some statistics regarding some concerning figures: 50% of mid-western bees have disappeared in their historic ranges in the United States while other species are believed to be extinct. Peter Derbawka (2011) writes more on conservation and research in Saskatchewan and, by proxy, the moist mixed grass prairie region: fragmentation is a concern for the conservation of wild bee populations as certain species travel only 200m from their nests while others can travel multiple kilometres while other species are specialists, only pollinating from specific flowers and, due to this specialization, proximity will affect this species population.

Figure 1.3.23: collage of species amongst illustrated grasslands

 Figure 1.4.01: an uncultivated area in the region of study in southeast Saskatchewan

1.4 SITE SELECTION + ANALYSIS

intervention for a geographic section

SITE OF STUDY

a section in the Bakken

Now that I have covered the structure of the region ecologically, structurally, and functionally, I zoom in. To promote the alternative land use strategy, it is desirable to locate a site of study that will receive the proposed application of the strategy. In doing this, the strategy is realized in a tangible, comprehensible manner.

The site of study is located within the Bakken, visibly punctuated with oil well pads and access roads. In accordance with the objective to provide a visual interpretation of the region, the scope of study is limited to a geographical site along a paved highway in the midst of the Bakken and moist mixed grassland ecoregion, receiving higher levels of traffic than the surrounding, gravel grid roads. This exposure will reveal the strategy as installed, considering the visual application from multiple viewpoints and perspectives. In a region dominated by vehicular travel, the duration, frequency, and distance between oil well pads will impact the visual element of the strategy.

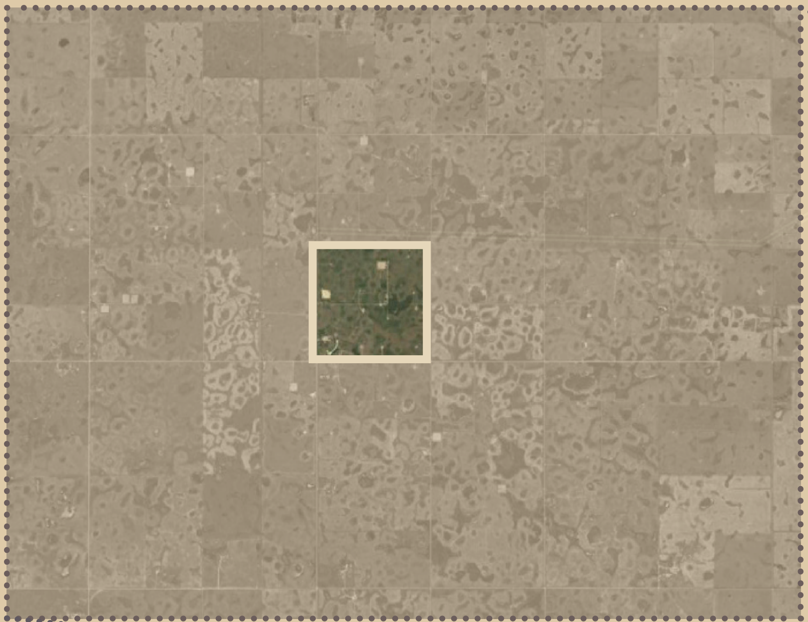
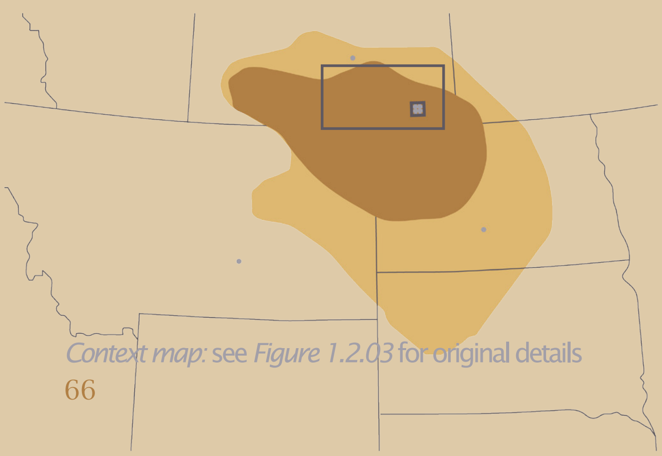


Figure 1.4.02: the section of interest



Context map: see *Figure 1.2.03* for original details

City / Town Boundaries

Rural Municipality

Section Delineations

Highways

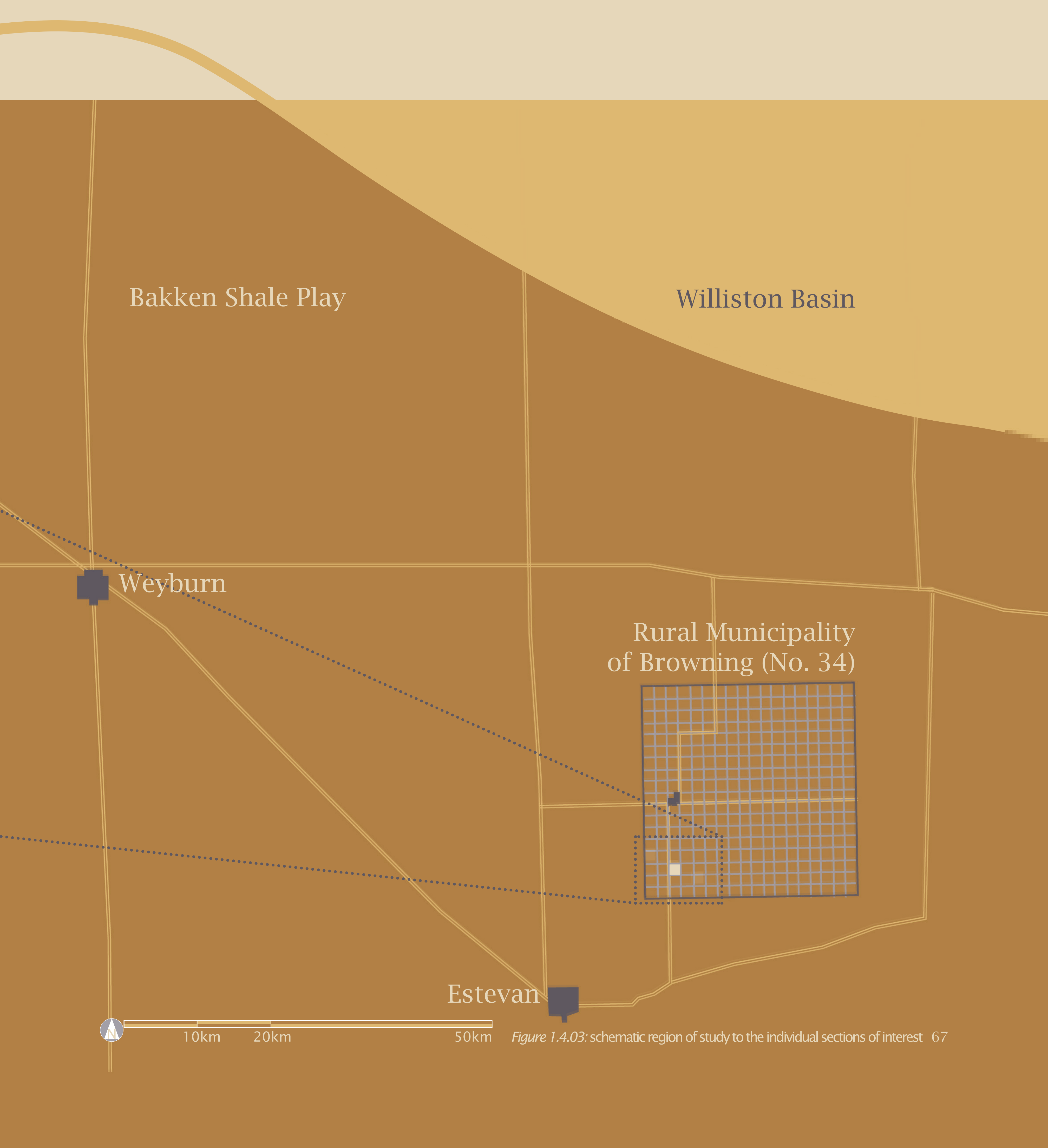


Figure 1.4.03: schematic region of study to the individual sections of interest

a section for an intervention

The site to receive the alternative land use strategy is chosen according to multiple factors, one of the most prominent factors based on the standard section division. Although the landscape is interconnected and ecological systems function across man-made borders, the transportation layout outlines the fragmentation of the landscape. This fragmentation is amplified by land ownership and the function of land that each owner chooses to use: based on aerial observation, fields range from hay to crops to summerfallow to pasture, proven by my travels through the landscape.

In terms of the specific section, it was chosen as a standard representation of sections punctuated with oil well sites. Because the landscape is visibly and structurally similar, this repetition means a singular site can provide the overall, similar elements that can be attributed to a larger region. As a strategic intervention drives this practicum, this repetition will be important for a large-scale intervention, exploiting the similarities. This is done with the expectation that installation will require a more in-depth analysis.

Ideally, this initial site would be located on an organic field in the beginning stages of oil well repurposing. This region hosts multiple organic fields that would not use the same intensity and/or quantity of pesticides, herbicides, and insecticides, allowing for more flexibility in ecologically-based landscape treatment. For now, however, the site is located on a section that hosts multiple pump jacks and has connective corridors, both ecologically-and human-based.

The cultivated areas will be assumed to be crops -- cereal, oilseed, pulse -- as the area hosts the majority of such conditions. Although the uncultivated areas appear as islands that have escaped cultivation, there is no guarantee that they have not been modified in the past. They will, therefore, be considered as the most recent analysis provides.

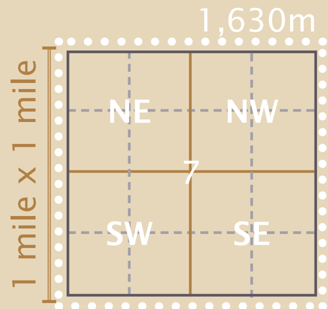
descriptions

Cultivated areas: any portion of land currently dedicated to crop land or hay; highly modified for agricultural practice

Uncultivated areas: any portion of land currently not dedicated to crop land or hay; often wetlands of varying depths and conditions and/or tree copses often amidst agricultural areas

Grid Road

Highway 605



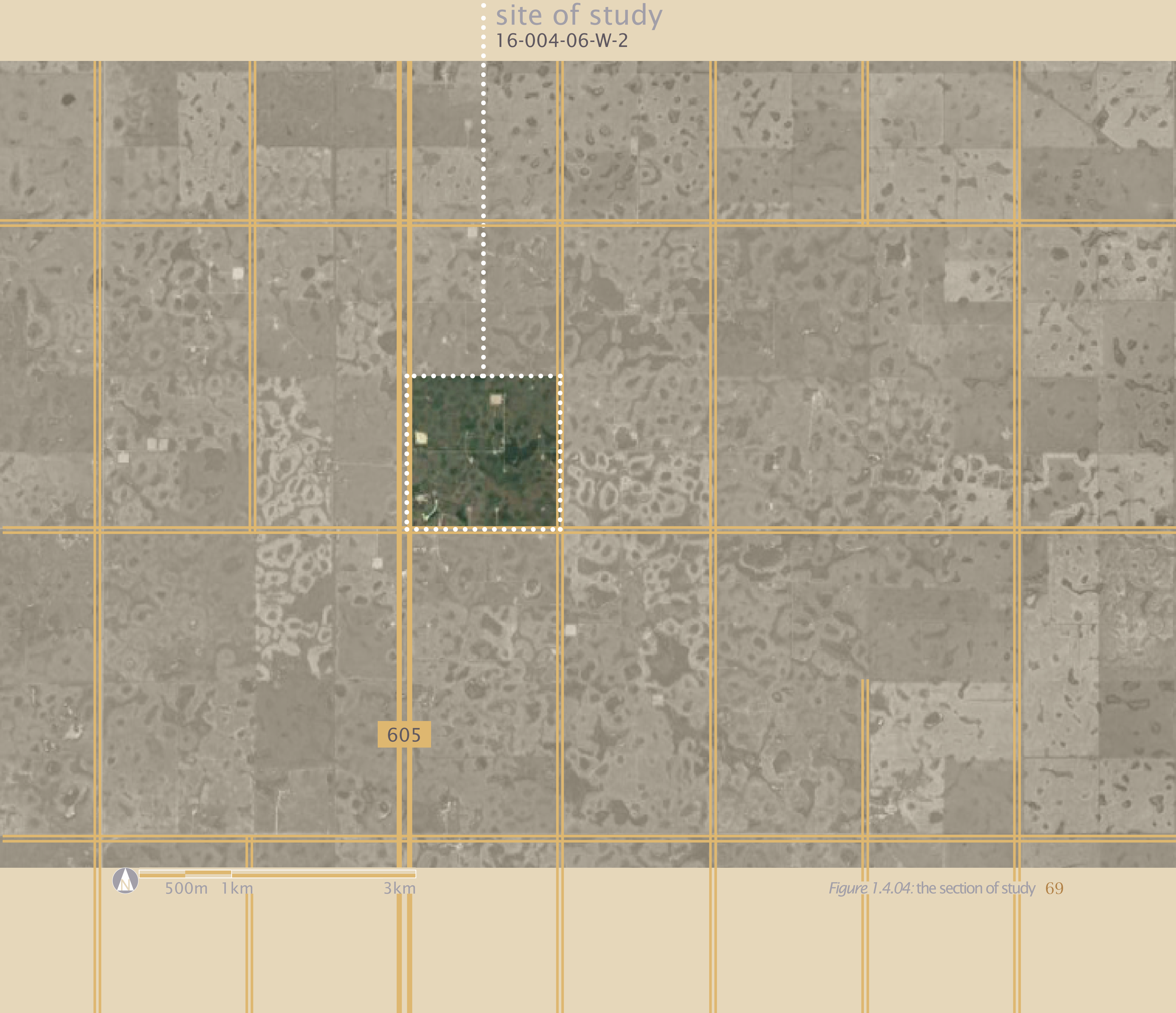


Figure 1.4.04: the section of study

the data

In *Figure 1.4.05*, the Regina, Saskatchewan office of Ducks Unlimited Canada (DUCs) (2017c) provided me with Geographic Information Systems (GIS) data for the wetland areas for three possible sites of study. Each section has three different types of water bodies: swamp, marsh, and shallow/open water (DUCs, 2017c). *Figure 1.4.07* showcases the GIS data in situ, amongst the contour lines (GeoGratis, 2017) and documented oil well sites (Saskatchewan Economy, 2017) that supplements my travels through the region to serve as site analysis.

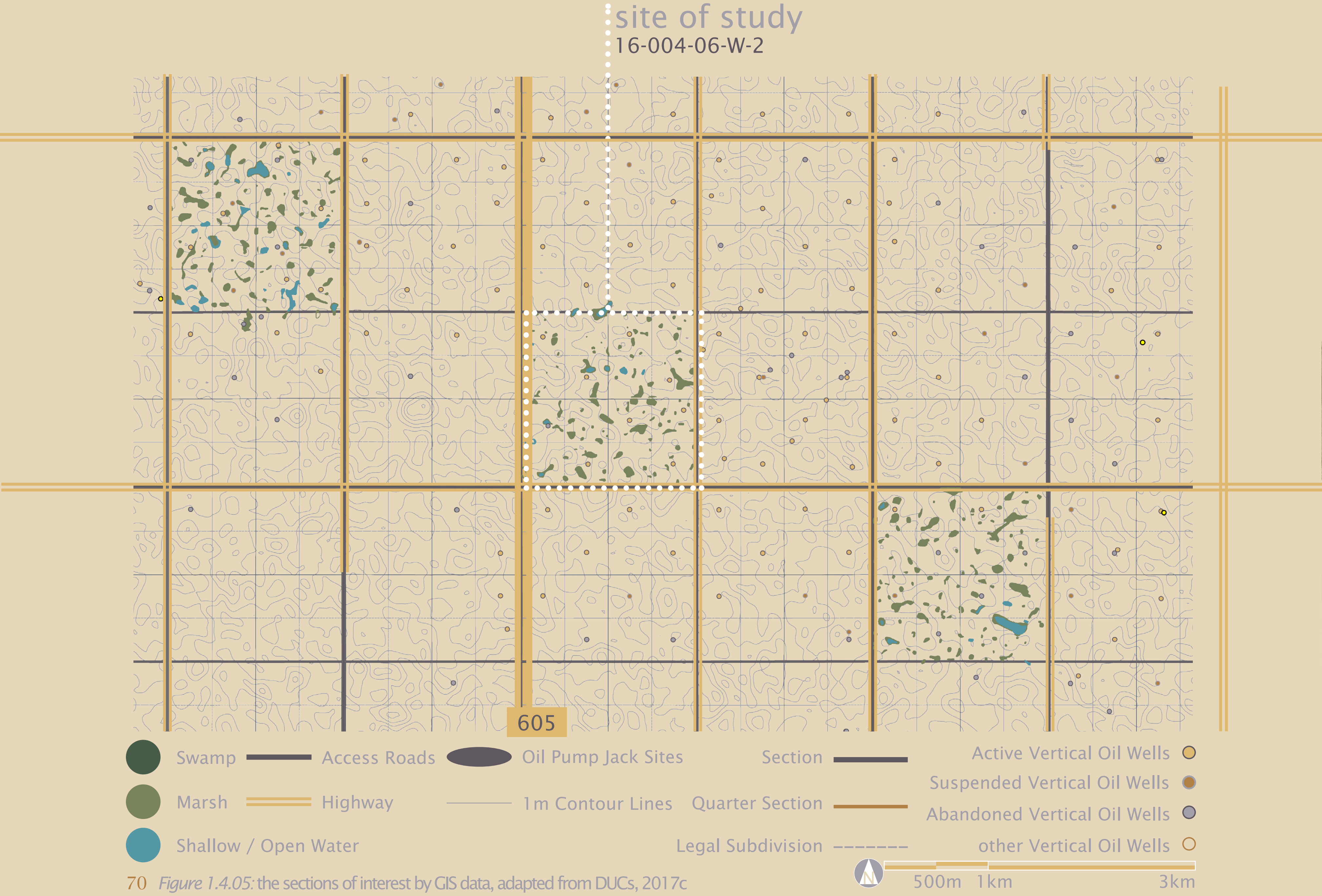


 Figure 1.4.05: the sections of interest by GIS data, adapted from DUCs, 2017c

contour lines (GeoGratis, 2017)

As the contour lines were derived at 1 metre intervals from a shaded DEM (Geo Gratis, 2017), they are not assumed to be wholly accurate nor representative of the depth of the waterbodies (as delineated by the DUCs [2017c] polygons). In turn, they provide an overview of the possible changes in topography on the landscape without providing exact information. This is acceptable for the alternative land use strategy; individual applications will be studied in more detail.

satellite imagery (Google Earth, 2017)

The most recent satellite imagery from Google maps is representative of a singular year, with one historical image to showcase changes in the landscape (see *Figures 1.4.09 - 1.4.11*). This imagery can only represent a yearly conditions, but there are benefits of analyzing imagery of a year with higher precipitation: the topography is more visible because depressions are highlighted through colour, texture, and pattern changes. This imagery is a necessary resource to understand the actual conditions of the landscape from an aerial perspective, accompanied by ground-truthing on the sites.

wetland data (Ducks Unlimited Canada, 2017c)

The wetland data provides a professional interpretation of permanent waterbody features. These areas will be assumed not only as permanent, but uncultivated and unlikely to change unless further modified by landowners. This means that the ephemeral and temporal waterbodies are likely not included in this data set. However, due to the nature of farming, this is acceptable; the ephemeral and temporal waterbodies will vary year by year and, as such, less relevant to a strategic design application (such as this practicum proposes).

According to Ducks Unlimited Canada (DUCs, n.d.), "prairie potholes are dependent on snowmelt, surface runoff, and direct precipitation as sources of water" that affects both the abundance and condition of wetlands across southern Saskatchewan. These variations take place both seasonally and annually; some wetlands are connected to the groundwater system while others are perched above the water table, able to "supply, obtain, or pass water to other, adjacent potholes" (DUCs, n.d.). During spring, the layout of water bodies becomes clear with water-holding conditions dependent on spring runoff, precipitation, and drainage.

Ephemeral wetlands: a couple of days;
Temporary wetlands: weeks, at most;
Seasonal wetlands: 1 - 2 months (DUCs, n.d.).

Some wetlands have longer "hydroperiods," leading to a different classification: "semi-permanent or permanent wetlands, usually retain water throughout the growing season, although their water levels also decline due to evaporation, transpiration, and seepage" (DUCs, n.d.) These areas are often drained as they are considered nuisances for landowners, despite the benefits of wetlands for ecological health (DUCs, n.d.). The images on this page -- Figures *1.4.04*, *1.4.05*, and *1.4.06* -- are actual wetlands near the site of study.

marsh

Figure 1.4.06: a marsh near the site of study

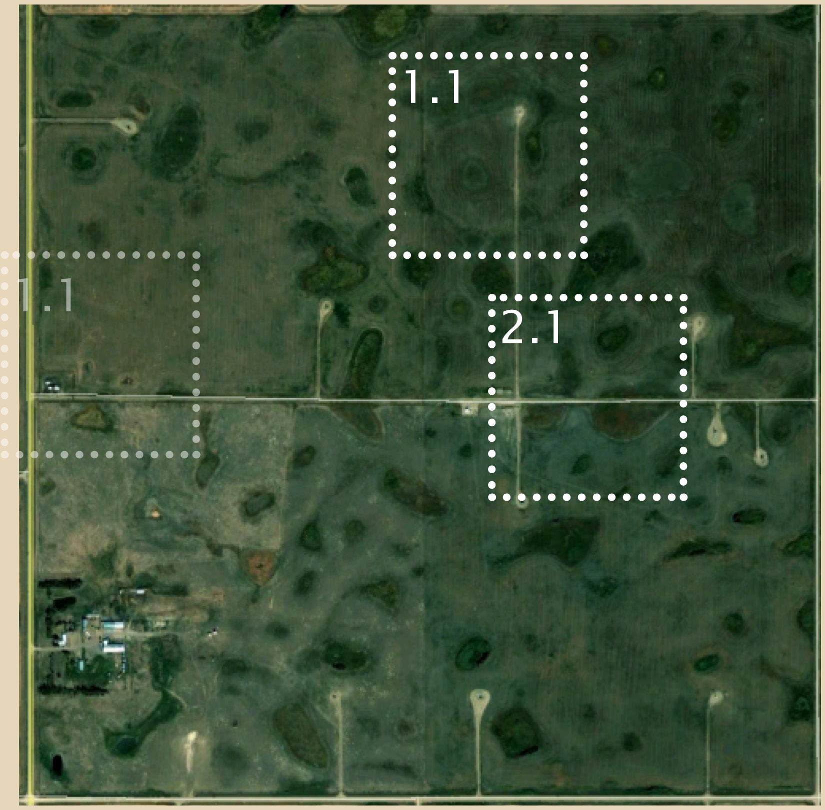
swamp

Figure 1.4.07: a swamp near the site of study

shallow/open water

Figure 1.4.08: shallow/open water near the site of study

2003 satellite imagery



Oldest dating available satellite imagery from
Google Earth (2017): 10 October 2003
Precipitation: 322mm from Nov. 2002 to Oct. 2003
Highest: May 2003 at 104mm
Second highest: April 2003 at 43mm
Month of image (October): 25mm

Figure 1.4.09: 2003 Google Earth imagery (Google Earth, 2017)

2012 satellite imagery

Most recently available satellite imagery from
Google Earth (2017): 14 September 2012
Precipitation: 356mm from Oct. 2011 to Sept. 2012
Highest: May at 89mm
Second highest: June at 62mm
Month of image (September): 11mm
(About Estevan, 2017)

Figure 1.4.10: 2012 Google Earth imagery (Google Earth, 2017)

Using data from About Estevan (2017), the calculated amounts of precipitation reveal that the 2012 imagery appears different via satellite view because there was an increase in precipitation in the months leading up to this image. There is, therefore, more water-based spaces visible on the map in the 2012 satellite image.

The most visible alteration to the section stems from the addition of not only two oil well sites, but two large oil well sites (compared to the size of the other oil well sites in the section). Historically -- 2003 (1.1 of *Figure 1.4.14*) -- to the present -- 2012 (1.2 of *Figure 1.4.14*)-- the area of the oil well sites have been added on flat landscapes with minimal uncultivated areas visible nearby or directly on the sites (*Figure 1.4.14*). Beyond that, the oil well sites only host 1 pump jack each, with no visible storage or extra infrastructural components near to or on the site, limiting other interruptions nearby.

The largest change in uncultivated areas takes place in the center of the east half-section. In the year 2012 (2.2 of *Figure 1.4.14*) the precipitation was higher, causing the area with already existing depressions (2.1 of *Figure 1.4.14*) to infill with water. The area surrounding the detail in 2.2 of *Figure 1.4.14* and located in 2.1 of *Figure 1.4.14* exemplifies the greater impact of flooding outside of the obvious boundaries; the colour change in the aerial view describes an area of different plant growth than the land use further to the south in the same half section.

2003 satellite imagery | 2012 satellite imagery

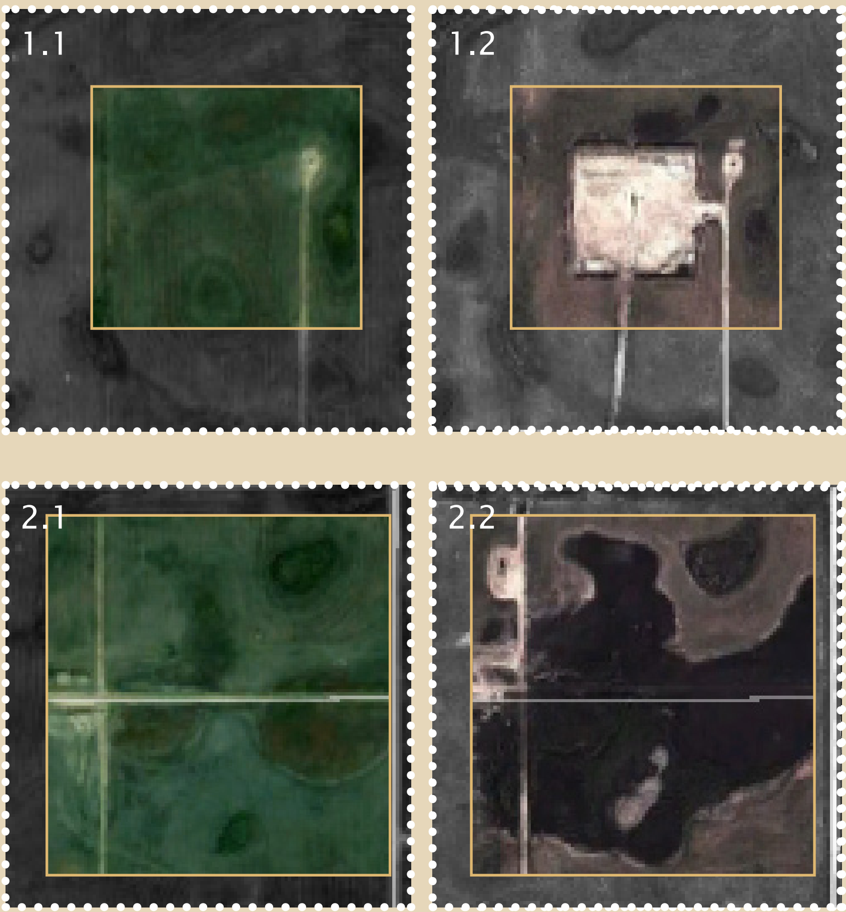


Figure 1.4.11: schematic comparisons, up close (Google Earth, 2017)

250m 500m

In *Figure 1.4.15*, some distinct landscape features appear, denoted by the colour changes from the satellite imagery (Google, 2017). The landscape features may not be visible from the highway and the land, being privately owned, is not accessible otherwise.

Despite the increased water levels, the access road is still visible. This means that the access road must be raised above the surroundings, high enough that it is not flooded despite the surrounding conditions. *Figure 1.4.12* displays a possible example of the visual appearance this takes at ground level.

Figure 1.4.12: example of an access road at a higher elevation than the surrounding, lower conditions

There is, possibly, a man-made drainage corridor between depressions, emphasized here with the increased precipitation in the year of this satellite imagery. *Figure 1.4.13* represents an on-the-ground interpretation of how some drainage corridors appear near the site of study.

Figure 1.4.13: example of a drainage corridor

The uncultivated areas often appear as trees and water-loving vegetation, creating a darker palette on the satellite imagery. Here, *Figure 1.4.14* reveals the effects of increased precipitation: some trees are not able to withstand sitting water and, as such, do not make it through the wet season(s).

Figure 1.4.14: example of an access road surrounding by living and dead uncultivated vegetation

Figure 1.4.15: the site of study satellite image (Google Earth, 2017)

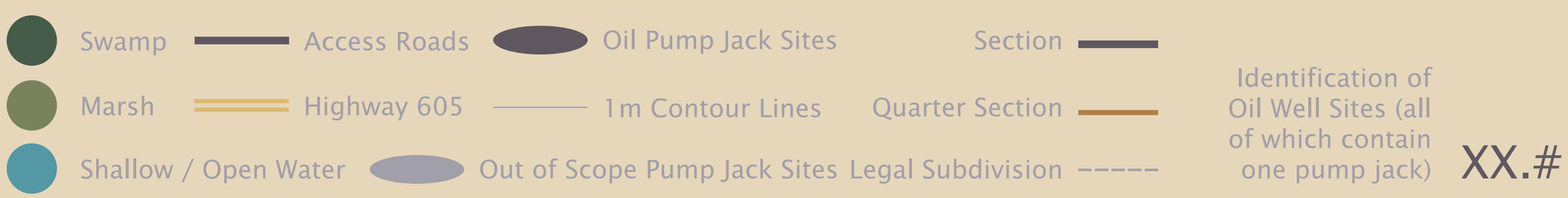
In *Figure 1.4.15*, the contour lines are derived at 1 metre intervals from a DEM image by the Government of Canada (GeoGratis, 2017). Overlaid with the information provided by Ducks Unlimited Canada (DUCs, 2017c), The topography of the site, at 1 metre intervals and delineated in *Figure 1.4.15*, does not easily showcase the uncultivated areas on the site. Some of the marsh and shallow/open water areas appear in topographically insignificant areas. However, other areas are clearly distinguished by both contour lines and DUCs polygons, lending credibility to the permanence of these sites.

The discrepancies between the contour lines and DUCs data references the nature of the pothole landscape: with a landscape lacking in extreme topography, depressions do not have to be deep to hold water, even if only for a short length of time. The DUCs data may also be missing ephemeral and temporary wetlands as part of their data -- because of their impermanence -- and that is where satellite comparisons will provide more information.

The oil well sites move between areas located by DUCs as marsh areas. There are no shallow/open water and marsh spaces that intersect with oil well sites. SE.2 is the only location where an access road distinctly interrupts a DUCs-defined marsh. However, the central primary access road along the west-east quarter-section division impacts DUCs polygons in four locations. This road is particularly disruptive to the uncultivated areas in this section.

The oil well sites do not appear highly impacted by the topography; the contour lines do not interact with the oil well sites as either high or low spaces. Many of them are, however, often located near larger uncultivated areas, primarily marsh polygons as per the DUCs data.

The DUCs data is indicative of an ecological matrix; the patches are the marshes, swamps, and shallow/open water areas, while the open agricultural land, oil well sites, and access roads make up the matrix of inhospitable landscape.



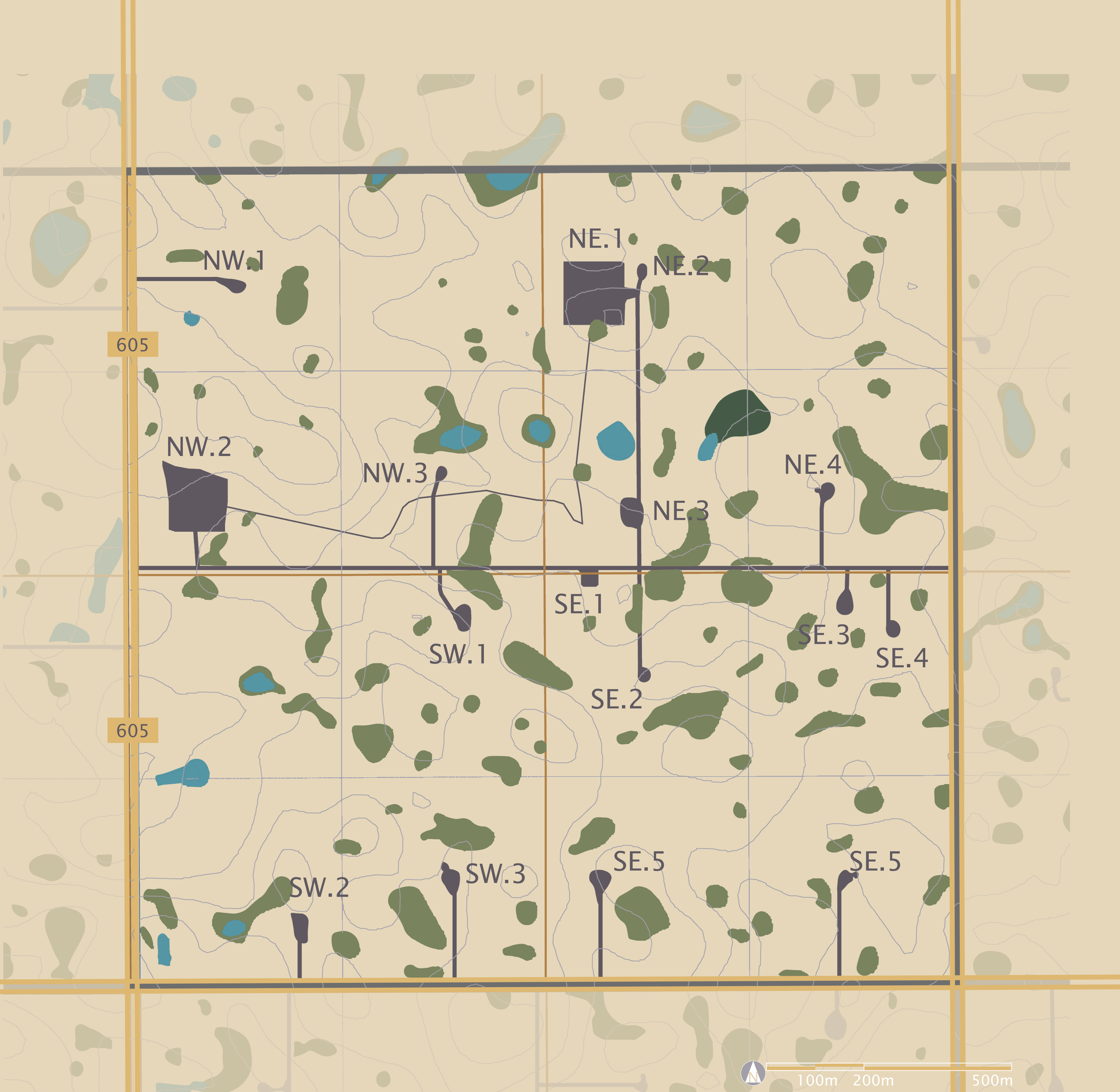


Figure 1.4.16: DUCs polygons (DUCs, 2017c) with contour lines (GeoGratis, 2017) and the surveyed grid (Saskatchewan Economy, 2017)

Figure 1.4.17 accurately relays the relationship between the 2012 satellite image (Google Earth, 2017) and the DUCs data (2017c) from an aerial perspective. It reveals the discrepancies between the DUCs data and the extended boundaries of the wetland areas.

The greatest revelation from this overlay results from the southeast quarter section. Only a portion of that land was able to be farmed (the southeast and southwest legal subdivisions) while the northwest and northeast legal subdivisions have approximately three-quarters and half, respectively, of the area impacted by a wetter soil conditions. This is clear as per the colour, texture, and pattern changes from an aerials perspective. The landowners farming pattern is clear in the southeast and southwest legal subdivisions, and absent in the area consisting of wetter soil.

In the other quarter sections the DUCs data and the darker areas -- representing uncultivated spaces -- overlap with minimal differences. In these quarter sections it is possible to rely on the DUCs data as the most indicative landscape conditions.

The oil well sites do not impact the uncultivated areas, both DUCs and based on the satellite imagery. Many of them exist along the peripheries of uncultivated areas without intruding into those spaces, instead nestling into the outer edges. These periphery areas often feature vegetation, visualized in *Figure 1.4.17*.

Figure 1.4.17: example of the periphery of an uncultivated area

conclusion

Although each layer presents its own level of information, the best understanding can be derived from all three layers as a unit. The most recent satellite images are representative of a single year and are, as such, limiting, but they still provide an aerial view of the landscape in certain conditions. This could be limiting but I intend to use it as an opportunity. A saturated year present the most accurate view of the depressions and seasonally uncultivated areas. Coupled with the information provided by Ducks Unlimited (DUCs, 2017c), the depression occupy a portion of the farmer's landscape that, combined with the visible area of the oil well pads and access roads to be repurposed, will account for a reasonable portion of the broken monoculture matrix.

Swamp
Marsh
Shallow / Open Water
Access Roads
Highway 605
Out of Scope Pump Jack Sites
Oil Pump Jack Sites
1m Contour Lines
Section
Quarter Section
Legal Subdivision
Active Vertical Oil Wells
Suspended Vertical Oil Wells
Abandoned Vertical Oil Wells
other Vertical Oil Wells

Figure 1.4.18: DUCs polygons (DUCs, 2017c) with contour lines (GeoGratis, 2017) and the oil well sites and surveyed grid (Saskatchewan Economy, 2017)

2 … TO GREEN …

post-industrial language and programs

POST-INDUSTRI-RURAL

a landscape architect's role

I refer to abandoned and decommissioned oil well sites as post-industrial sites although they are not legally classified as such. Luis, Burley and Panagopoulos (2011), Braae (2015), and Kirkwood's Manufactured Sites (2003) stress the importance of reintegrating post-industrial sites in an *urban* fabric. Although these writings are in-depth and promote a variety of means to accomplishing such a task, they tend to promote large-scale sites on or in highly populated areas. But the sites of interest in this practicum are rural. They are out of sight (out of mind?), affecting fewer people, and, because Canada has so much land, I believe we have not yet attained that status of requiring clean-up for large scale sites to accommodate more development.

Kirkwood (2003, p.xii) claims that the last twenty years have seen an increase in federal initiatives and legislation that addresses the history of post-industrial sites on and in the land, particularly as "the diminishing number of 'greenfield' sites available for development" has shifted our design efforts to "redevelopment and reuse." But Canada still contains perceived available land, particularly in Saskatchewan where open spaces and limitless skies define the landscape. We have the space to use and abuse natural resources with less direct concern for the environmental ramifications such as "the remaining pervasive pattern of hazardous substances found in the soils, groundwater and within the fabric of ... infrastructure left standing on-site" (Kirkwood, 2003, p.4). Regardless of the amount and type of land, Braae (2015, p. 150) believes that "ethics are clearly linked with ecology and to restoring the regenerative processes of nature as a compensatory act that makes amends for the negative impact of development, and here especially industrialization, on the environment." This is as applicable in urban landscape as it is in rural landscapes, despite an often urban-focused conversation.

When we consider the rural landscape, we may envision "an array of colors and forms, a rich diversity of open space and managed cropland, clustered ranch or farmstead structures and small communities in harmony with each other and the landscape" (Coen, Nassauer and Tuttle, 1987, p.4). Southeast Saskatchewan is often viewed by this definition, an area separate from the city with a pleasantly distorted, humble view of the inhabitants and their lifestyles. But the rural landscape is shifting, quietly, imperceptibly, but shifting: land ownership, new development, management patterns, additional structures, bigger equipment, erosion, soil depth (Coen, Nassauer and Tuttle, 1987, p.4) are all factors.

Figure 2.0.01 references the changes in farm size and farm operators across Canada; with fewer operators and larger farms, there could be significant effects on land planning, management, and stewardship, which this practicum will address.

“Understanding the rural landscape as an ecological system that includes natural and human-made systems is necessary to manage change. Managing change, or integrating development into the rural landscape, requires a careful examination of land use alternatives and consideration of conservation goals.” Coen, Nassauer and Tuttle, 1987, p.33

Coen, Nassauer and Tuttle (1987) call for a greater investment by landscape architects in these changes, from academia to public to private practice, supporting conservation and planning and all of the requirements in between (1987, p.40). Although it may vary from the traditional urban knowledge landscape architects have and require an alternate role, “to truly affect change in the rural landscape, we must supplement our traditional skills with knowledge of the particular ecological, economic, and cultural factors that shape rural landscapes” (Coen, Nassauer and Tuttle, 1987, p.35). Coen, Nassauer and Tuttle ask: “What if landscape architects became more active in their local conservation districts or other organizations in every county that have a direct impact on the rural landscape?” (1987, p.41).

This question will thread throughout the remainder of this project as a means of establishing a suitable design strategy, framing the necessity of landscape architects to work within the layers of stakeholders and land users.

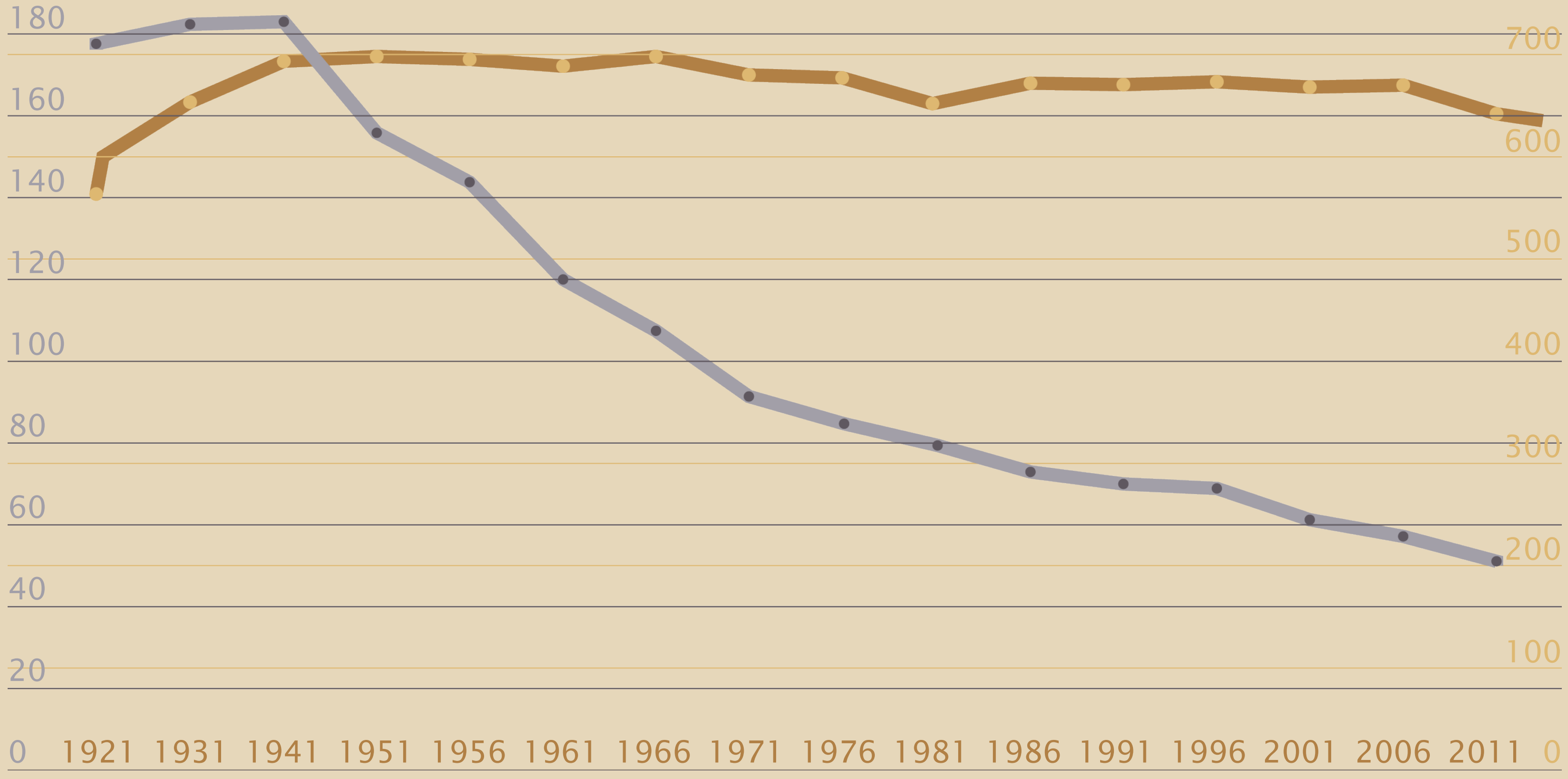


Figure 2.0.01: the comparison of farms to farmland ratio over the last (approximately) 100 years (Statistics Canada, 2011)

 Figure 2.1.02: the infrastructure of an abandoned oil well site near 16-004-06-W-2 in southeast Saskatchewan

2.1 POST-INDUSTRIA-LINGO

re-everything

language of post-industrial procedures

The surface of abandoned and decommissioned oil well sites are barren during and post-production, but this does not mean they must stay that way. The impact on the greater landscape is minimal from an oil well site-by-site basis: small, contained, organized. But they can be re-cultivated, reprogrammed to persist in the future as a new productive capability. When I see these small sites dotting the landscape, I don't see areas that need to be re-vegetated or re-cultivated into cropland -- there's enough of that already. What I see are sites that farmers have adjusted to, working around these interruptions in their agriculture-scape, little pockets of producing land that could be repurposed in new ways, new ways that exist on the same sites and do not introduce more disruptions to a farmer's field.

To design a post-industrial, alternative land use strategy in southeast Saskatchewan, I begin my search by locating what exists for post-industrial site management.

How are they managed?
Who determines how they are managed?
What guidelines and regulations exist?

The regulatory role of the Government of Saskatchewan begins the conclusion to these questions; in terms of environmental management, the government will play a key role defining the requirements and enforcing the regulatory environmental reconstruction of post-industrial sites in the oil and gas industry.

key documents in this section:

Oil and Gas Conservation Regulations, 2012 — Government of Saskatchewan, 2015c

Detailed Site Assessment Requirements — Government of Saskatchewan, 2015a

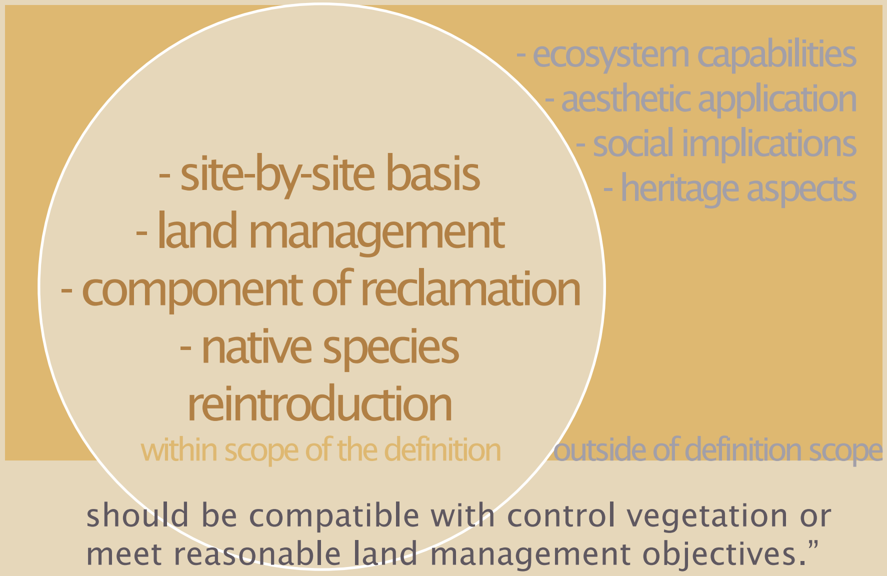
Saskatchewan Upstream Petroleum Sites Remediation Guidelines — Saskatchewan Petroleum Industry/Government Environmental Agency (SPIGEC), 2009

The Government of Saskatchewan (2015c, p.41) Oil and Gas Conservation Regulations, 2012, (OaGCR, 2012) requires: "On completion of abandonment of a well, the licensee or the operator shall:

> (a) conduct an environmental site assessment in a manner specified by the minister;
> (b) decommission the well site to standards specified by the minister;
> (c) reclaim the well site to standards specified by the minister; and
> (d) reclaim any area that is beyond the boundaries of the well site and that, in the opinion of the minister, has been damaged, contaminated or otherwise adversely affected by the operations of the well."

The detailed requirements for reclamation are then governed by the Government of Saskatchewan's (2015a, p.5) Detailed Site Assessment Requirements (DSAR) document: requirements differ for cultivated lands, grasslands, peatlands, and forests requiring varying methods and materials for landscape (drainage, erosion, material), soil (quantity, distribution, quantity), and vegetation (species, density, bare areas). "The focus of this document is with respect to the second part of the reclamation definition or the physical restoration of the site once it has been decontaminated and remediated" (Government of Saskatchewan, 2015a, p.4). Remediation requirements are then located elsewhere, in the Government's of Saskatchewan's (SPIGEC, 2009) Saskatchewan Upstream Petroleum Sites Remediation Guidelines (SUPSRG*).* The DSAR (Government of Saskatchewan, 2015a, p.4) further states: "It is important to recognize that restoration is impacted by construction practices, by operational management during the life cycle of the site and by practices used during the decommissioning, remediation and restoration processes."

Notably, remediation / restoration / revegetation / reclamation are not interchangeable, but there is little in the way that clearly defines the differences between the words, particularly when there are three primary documents structuring the necessary processes that lead to oil well treatment post-decommissioning and abandonment.



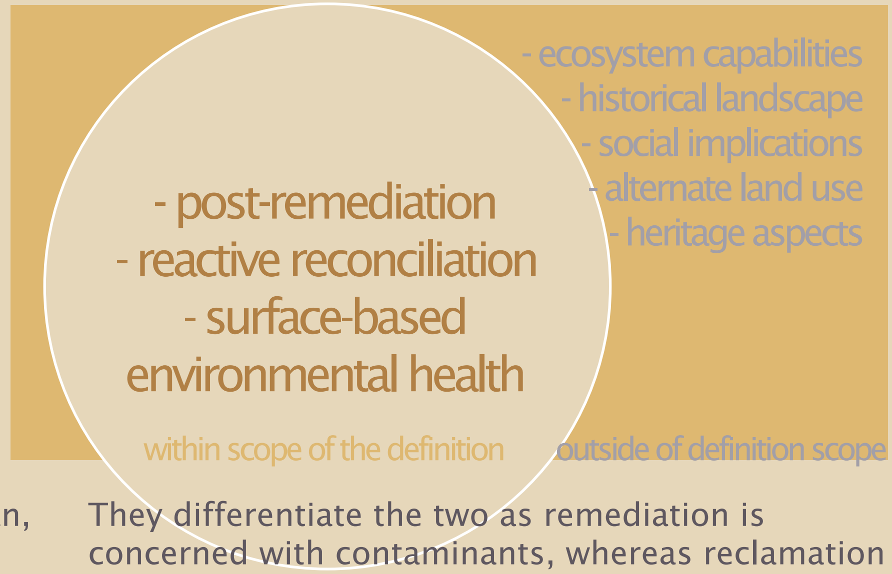
1) re-vegetation

The seemingly most straight-forward of the definitions in this section, re-vegetation is the simplest concept in terms of treating a post-industrial site. Re-vegetating is not a component that stands solo from the process of treating sites, but a part of many of the methods. For example, as part of restoration, the definition from the SUPSRG, "restoration refers to the physical reclamation process involving recontouring, replacing topsoil, and re-vegetating to restore the surface of the land to its equivalent land capability" (SPIGEC, 2009, p.4). Re-vegetation is also mentioned in regards to reclamation: one of the objectives in the OaGCR, 2012, states "re-contouring, landscaping, replacing or replenishing the topsoil and re-vegetating the surface of the soil so that it is compatible with its surroundings" (Government of Saskatchewan, 2015c, p.9). In both of these cases, re-vegetating becomes a component of treating the site, but the re-vegetation process itself is more complex.

The DSAR (Government of Saskatchewan, 2015a) delves into detail regarding the re-vegetation requirements for reclamation standards for different land use designations: cultivated lands, grasslands, peatlands, and forest. As this practicum is focused on the re-vegetation of agricultural land, I will start there. The DSAR's (Government of Saskatchewan, 2015a, p.15) "vegetation parameters for cultivated lands" addresses the Plant Species Composition as: "Re-vegetation species and species composition should be compatible with control vegetation or meet reasonable land management objectives." This means that re-vegetation strategies must take place on a site-by-site basis, evaluating the control vegetation, i.e. immediately surrounding vegetation, as a starting point for the reclamation addition of vegetation. The document continues to discuss the assessment criteria for control vegetation: plant health, plant height, plant density, bare area, weeds and undesirable plants; the summary of these charts is that the control plants must be healthy, represent the majority of the areas, weeds must be identified as noxious/ invasive (see page 60), and what formulas to use in the determination of these regulations (Government of Saskatchewan, 2015a. pp.16-17).

The main difference in re-vegetating grasslands (under the designated land uses as compared to the others) is the recommendation that "at the time of reclamation the salvaged soil should be replaced as evenly as possible across the site and the use of native species is encouraged to re-vegetate native grassland" (Government of Saskatchewan, 2015a, p.18). It is worth noting that the OaGCR, 2012, and the SUPSRG do not mention re-vegetation in their documents beyond the definition supplied in the first paragraph of this page. It would appear, based on that information, that re-vegetating is a surface treatment connected to land use as opposed to overall land health. The following pages may offer more clarification in the way of re-vegetating necessities and characteristics.

2) reclamation



The OaGCR, 2012, (Government of Saskatchewan, 2015c, p.9) defines reclamation as:
"the process of:

> (i) decontaminating, excavating, removing, sequestrating, encapsulating, immobilizing, attenuating, degrading, processing or treating the contaminants in the soil or water in a manner so that, in the opinion of the minister, the contaminants no longer pose a threat or risk to human health, public safety, property or the environment; and
> (ii) re-contouring, landscaping, replacing or replenishing the topsoil and re-vegetating the surface of the soil so that it is compatible with its surroundings."

This definition hosts the necessary processes required by the Government of Saskatchewan to reclaim decommissioned oil well sites. The DSAR states that a "successful site reclamation will result in a site that is consistent in terms of land usage and vegetation with that of the surrounding area" (Government of Saskatchewan, 2015a, p.4). Although this definition seems clear, the time associated with this process is not mentioned. How long must one maintain the site in a state of reclamation?

Other industries also use the term reclamation. According to an article regarding Alberta's industrial land (Powter et al., 2012), there is often confusion between reclamation and remediation. They differentiate the two as remediation is concerned with contaminants, whereas reclamation is concerned with the surface of the land. Similar to Saskatchewan's outlines, however, concerns are raised when the first objective -- for example, (i) decontaminating... -- sounds similar to the definition of remediation. To clarify matters, Alberta's requirements state that contamination must be addressed prior to reclamation and, as such, that "decontaminating" is a part of the remediation components (Powter et al., 2012).

Reclamation differs, therefore, by focusing on the surface land after decontamination or, in other words, remediation. It would appear that reclamation requires remediation to be considered fully reclaimed, but remediation does not require reclamation. As with the elements of post-industrialism studied so far, time reveals itself a component of post-industrial landscapes throughout the process. "Traditionally, reclamation was emphasized more than conservation" or, in other words, "the program was reactive rather than proactive" (Powter et al, 2012, p.48). The reactive nature of reclamation is not a negative prospect, however, it is simply an adjustment that requires more steps to reaffirm resource management. Although this is a much more straightforward understanding of a linear timeline, it is worth understanding what condition I can expect abandoned oil well sites to be in upon Acknowledgment.

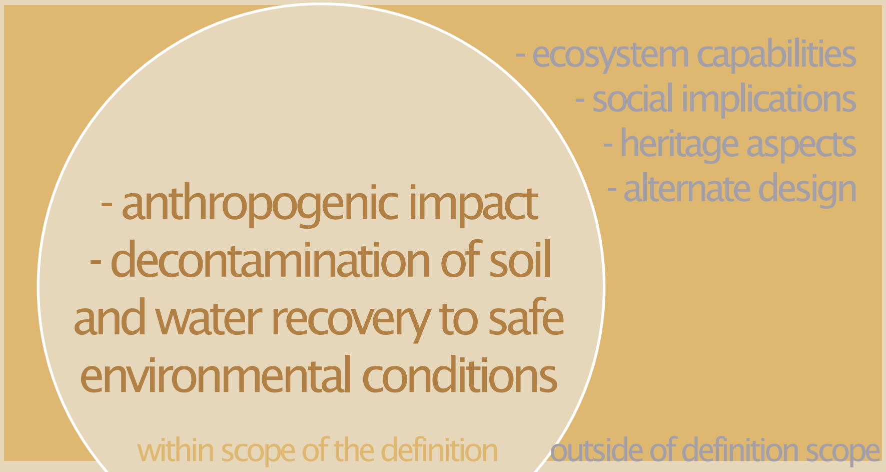
3) restoration

According to the SUPSRG (SPIGEC, 2009, p.4), "restoration refers to the physical reclamation process involving recontouring, replacing topsoil, and re-vegetating to restore the surface of the land to its equivalent land capability." This definition sounds almost identical to the definition of reclamation, excepting the end component: equivalent land capability. Equivalent land capability "is the ability of the land to support various land uses, similar to - but not necessarily identical to - the ability that existed prior to an activity being conducted" (SPIGEC, 2009, p.4).

We will recall from before that the definition of reclamation is the same excepting the equivalent land capability component. Instead, the OaGCR, 2012 (Government of Saskatchewan, 2015c, p.9) completes the definition with "... that it is compatible with its surroundings." Compatibility is quite different than equivalent land capability. The article referring to Alberta's practices clears this differentiation up; restoration refers to "the exact same landscape, vegetation and ecological functions" as opposed to reclamation which is "an emphasis on returning usable land that provides a net benefit to landowners and society in general" (Powter et al., 2012, p.48). The article notes that reclamation is a more suitable method in large-scale post-industrial landscapes as larger projects are more likely to significantly alter the landscape, making it nearly impossible to mimic the previous landscape function (Powter et al., 2012, p.48).

The OaGCR, 2012 (2015c, p.4) works to ensure the "restoration criteria that will ... [result] in reclaimed sites which are stable and have little risk of impaired capability." This implies that restoration is one component of reclamation but, based on the various definitions, I am inclined to believe it is a branch of reclamation or, perhaps, an extension of reclaimed possibilities.

Interestingly, the OaGCR, 2012 (Government of Saskatchewan, 2015c) does not refer to reclamation when clarifying the differences compared to restoration. Instead, it focuses on the conceptual differences between remediation and restoration, highlighting the necessity of remediation to assist in restoration. Therefore, remediation is necessary for restoration, but restoration is not necessary for remediation. Restoration versus reclamation is particularly relevant to agricultural landscapes. If, for example, a site is restored within an agricultural field, it should be capable of producing the same quality of crop as the surrounding space (if it assumes the equivalent land capability determination). If, however, it is under the definition of reclamation, it would imply that the land must be able to support crops or any other activity that promotes a net value. In regards to individual oil well sites, it would be difficult to differentiate the quality of crops on an individual, site-by-site basis. Applied to many sites, however, the differences may be noticeable but unlikely in the vast expanse of farmer's crops.

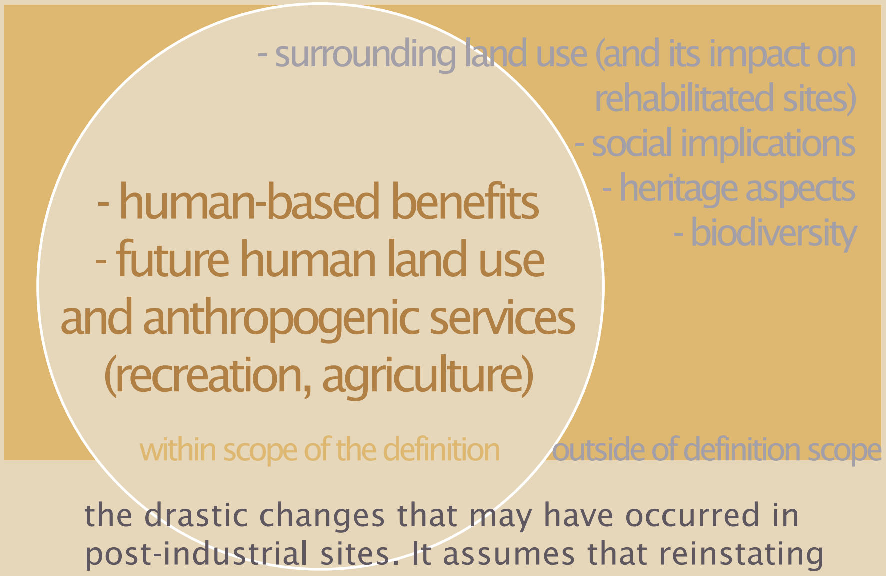


4) remediation

The Saskatchewan Petroleum Industry/ Government Environmental Agency (SPIGEC) created the Saskatchewan Upstream Petroleum Sites Remediation Guidelines (SUPSRG) to address all oil well infrastructure. It is broken into steps: “Planning: remediation plans;
Remediation: remediation approach and criteria;
Restoration: physical reclamation” (SPIGEC, 2009, p.1). As part of the Remediation step, the document goes on to further state that Environmental Assessments (Phase 1 and Phase 2) are required “to establish a high level of due diligence in order to protect oneself from purchasing or selling a contaminated property, to minimize the financial and civil liability associated with the contaminated sites and to exercise good environmental citizenship” (SPIGEC, 2009, p.2). These are complex procedures and require a professional body to conduct the assessments and, so, will not be addressed in further detail in this document.

Remediation, by definition, “refers to the decontamination of the soil or water to provide protection to human and environmental health. Therefore, the goal of remediation is not to remove every grain of contaminated soil but to achieve a safe level of remediation which protects human and environmental health” (SPIGEC, 2009, p.4). In order of process work on the landscape, the Alberta regulations state: “generally, the regulatory scheme expects that remediation will be completed before reclamation starts to ensure lands do not have to be re-disturbed after reclamation to address contamination (Powter et al., 2012, p.48). Although this may seem logical, it is noteworthy because the process of reclamation is longer, more complex, and, possibly, more important to the environment as it addresses toxins and anthropogenic impacts in the greater landscape scheme. According to the SUPSRG, the criteria for remediation rests on the land use designation: agricultural, forest, residential, and subsoil (SPIGEC, 2009, p.5).

As this practicum is concerned with the agricultural zones of Saskatchewan’s prairies, I will include the definition: “soil means the soil horizon(s) that are used, or potentially used, for growing crops or tending livestock and includes agricultural lands providing habitat for resident and transitory wildlife as well as native flora” (SPIGEC, 2009, p.5). Once this distinction is made, it is worth noting that “the agriculture soil remediation criteria are considered the most cautious clean-up criteria and they are designed to be protective in essentially all situations” (SPIGEC, 2009, p.5). This is good news for this practicum’s future design strategies; with an ensured depth of remediation, the sites should be, essentially, cleared of any high impact anthropological remnants on and in the oil well sites and, therefore, the landscape as a whole. With these guarantees in place, the more intensive considerations of remediation such as phytoremediation will not need to be an installed component of landscape renewal.



5) rehabilitation

Of the documents listed so far -- OaGCR, 2012, DSAR, and SUPSRG -- I have not encountered the term rehabilitation, and yet I know this term to be a common one for post-industrial site treatment. After a more thorough search, it appears that these three documents do not contain the word rehabilitation in any tense. An article regarding surface mining provides a suitable explanation of rehabilitation: “Rehabilitation tackles site as human-service provision, either by making use of the area for agricultural related activities, targeting the production of e.g. food, or for developing infrastructures in which the end-point would be either green-spaces (such as parks) or the built-environment (such as housing/industry)” (Lima et al., 2016). This definition differs by being the first to allocate human benefits -- outside of land use designation -- as the primary means of re-using the post-industrial landscape. It implies that land once used by people can continue to be used by, and for, human consumption in one form or another.

However, the Society for Ecological Restoration (SER) (2004, p.12) argues that “rehabilitation [has] a fundamental focus on historical or pre-existing ecosystems as models or references, [and] emphasizes the reparation of ecosystem processes, productivity and services.” Although this definition is valid, it appears idealistic in the realm of post-industrial. If a historical or pre-existing ecosystem is the model or reference as stated, this definition does not take into account the drastic changes that may have occurred in post-industrial sites. It assumes that reinstating old ecosystems is desirable. Beyond that, if a post-industrial site exists in the midst of operation industrial sites, is this a proper use of the term rehabilitation? At what scale must these sites be to define rehabilitate under this definition?

For example, in the context of southeast Saskatchewan, the oil well sites are almost all in the midst of fields. To “rehabilitate” these sites to “historical or pre-existing ecosystems,” when they are surrounded by concurrent agricultural processes, may be an idealistic means of re-establishing historic species when the surrounding conditions are not supportive of such establishment.

This definition is compared to restoration: “the goals of restoration also include the re-establishment of the pre-existing biotic integrity in terms of species composition and community structure,” instead of focusing on the larger ecosystem productivity (SER, 2004, p.12). Although the Government of Saskatchewan does not use this definition, it is valid in its explanation. Instead of limiting the definition to what must be done (recontouring, etc.), it establishes what those actions will do. It does not, however, focus suitably on the surrounding ecosystems in much the same way the rehabilitation definition proved inadequate for the abandoned oil well sites.

6) conservation

According to the article concerning Alberta's industrial sites, conservation is "the planning, management and implementation of an activity with the objective of protecting the essential physical, chemical and biological characteristics of the environment against degradation" (Powter et al., 2012, p.43). The document goes on to discuss conservation and reclamation as key comparative aspects of post-industrial sites. These two methods may work together, but may also function as separate entities. If conservation and reclamation are planned as interweaving conditions, then "conservation focuses on protection and salvage of the soil resource for future reclamation" (Powter et al., 2012, p.48). If, however, the two methods are not planned but one comes after the other: the "emphasis on immediate compensation to mitigate the impact of habitat loss due to industrial disturbances ... [will be done] in addition to reclamation" (Powter et al., 2012, p.48).

Conservation has grown in popularity: "with more awareness of habitat fragmentation, biodiversity and cumulative impacts, minimizing the overall industrial footprint has become a greater concern" (Powter et al., 2012, p.48). Despite this, landscape conservation is not mentioned in the OaGCR, 2012, (Government of Saskatchewan, 2015c) the DSAR (Government of Saskatchewan, 2015a), or the SUPSRG (SPIGEC, 2009) as a necessary approach to landscape treatment. The Government of Saskatchewan does, however, have a conservation sector in land management: Conservation Easements. According the introductory page of the Government of Saskatchewan (2013) conservation component of the Environmental sector, "conservation means many things. Preserving natural habitat. Retaining elements of historic or archaeological significance. Protecting the quality of our air, water and soil." More specifically, "a conservation easement is a voluntary legal agreement between a landowner and a qualified conservation agency. Under this agreement, the landowner continues to own and manage the land with benefits to both the landowner and the environment" (Government of Saskatchewan, 2013). The list of organizations includes thirteen organizations across Saskatchewan that are able to designate conservation easements, including all levels of government (Government of Saskatchewan, 2013).

As conservation is not a part of the conversation within government-mandated post-industrial treatment, a simple link is not clear. As of now, conservation does not belong in post-industrial treatment and, subsequently, in this chapter; it is disconnected from post-industrial altogether. **The challenge for land stewardship, then, is to link conservation and post-industrial treatment, with or without government regulations.** When considering the repurposing of oil well sites for an alternative land use strategy, conservation post-industrialism must consider a new set of factors, particularly if it is to be integrated into the timeline of pre- and post-industrial treatment.

the definitions dissected

Figure 2.1.02 reveals the relationship between the terms, their differences, similarities, and connections across time. As I am tackling a specific post-industrial condition -- abandoned oil well sites -- in a specific region -- southeast Saskatchewan -- it seems worthwhile to understand what conditions exist and, more importantly, what conditions do not. It mediates the strategic design possibilities through logic; as a form of site analysis, I now know what to expect on abandoned and decommissioned oil well sites after the oil companies have completed their legal responsibilities.

These linguistic turns of phrases will reveal themselves as important later in this document. Remediation, for example, guarantees environmental health according to federal standards as well as provincial regulations. Re-vegetation, reclamation, rehabilitation, and restoration appear more subjective, the expectations requiring a consideration of the direct surroundings as opposed to the greater landscape, all acknowledging human use and benefit as a part of their definition.

A simple break down of these definitions highlights the differences of each word, focusing on the necessary language to move forward with the alternative land use strategy.

Remediation requires Canada-wide regulated environmental assessments where “the goal … is not to remove every grain of contaminated soil but to achieve a safe level of remediation which protects human and environmental health” (SPIGEC, 2009, p.4).

Following this step is **reclamation**, “landscaping, replacing or replenishing the topsoil and re-vegetating the surface of the soil so that it is compatible with its surroundings” (Government of Saskatchewan, 2015c, p.9).

“**Restoration** refers to the physical reclamation process involving recontouring, replacing topsoil, and re-vegetating to restore the surface of the land to its equivalent land capability” (SPIGEC, 2009, p.4).

Re-vegetation is the “species and species composition [that] should be compatible with control vegetation or meet reasonable land management objectives” (Government of Saskatchewan, 2015a, p.15).

In summary, the process for oil well treatment is to return the site to as close of conditions –both environmentally and economically – as immediately prior to oil well installation, regardless of the historic landscape and function that once existed.

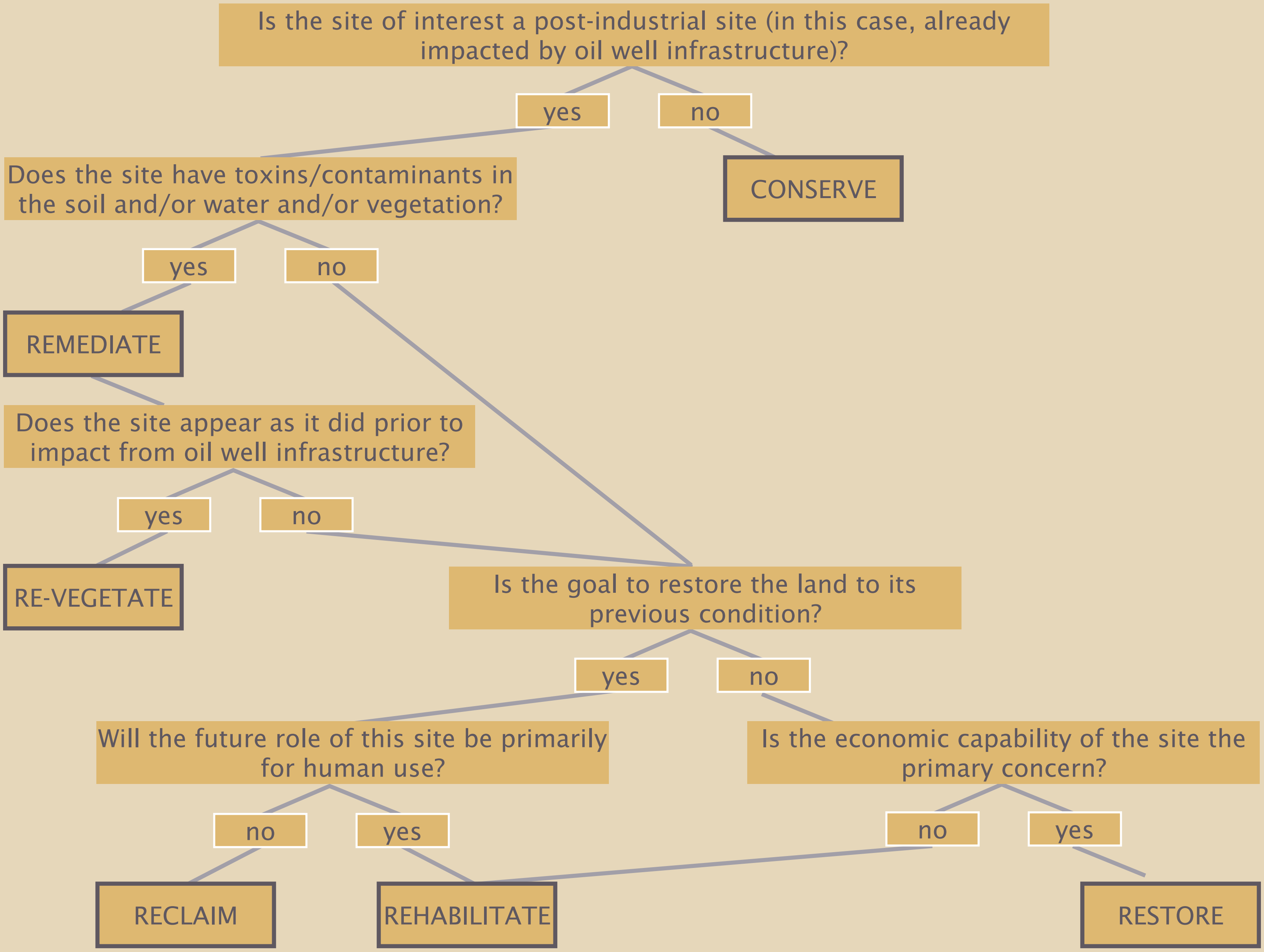


Figure 2.1.02: my interpretation of a chronological understanding of the language of post-industrial treatment

 Figure 2.2.01: a wetland on the edge of a field near 16-004-06-W-2 in southeast Saskatchewan

22 POST-INDUSTRIAL PROGRAMS?

Saskatchewan's conservation organizations

re-programming landscape through landscape programs

The Government of Saskatchewan (2013) focuses on the conservation of landscapes through conservation easements between landowners and a certified organization; these certified organizations are able to hold easements:

"All levels of government

Ducks Unlimited Canada
Meewasin Valley Authority
Ministry of Environment
Nature Conservancy of Canada
Nature Saskatchewan
Rocky Mountain Elk Foundation
Saskatchewan Archaeological Society
Saskatchewan Parks and Recreation Association
Saskatchewan Watershed Authority
Saskatchewan Wildlife Federation
Wakamow Valley Authority
Wascana Centre Authority."

The Government of Saskatchewan (2013) website states: "The donation of a conservation easement may be viewed as a charitable gift by Canada Revenue Agency. The value of the gift is the appraised difference between the land's value with the conservation easement and the best land-use value without the easement." They further say that "it is an opportunity for the landowner to create a legacy for future generations" (Government of Saskatchewan, 2013). These benefits appeal to both the financial and emotional side of those considering conservation easements on their land.

This list of organizations provides a starting point, but conservation easements are just one method of viewing environmental protection initiatives. A brief online search reveals a host of Saskatchewan organizations that aim to protect, enhance, and promote the environment. Although this document has, so far, primarily revolved around legal requirements, there are other interests in southeast Saskatchewan's highly modified landscape. There is a strong conservation base, ranging from national to provincial, with multiple organizations promoting various strategies for native prairie conservation. Some opportunities reflect land use and land management focused

around elements more than monetary value and financial gain. Some benefit the environment without placing the sole burden on the landowner but offering them compensation for their efforts, their inconvenience, their generosity. This will be further explored in the following pages.

One of the primary conservation organizations in Saskatchewan is the Saskatchewan Prairie Conservation Action Plan Partnership (SK PCAP), an organization that represents "producers, industry, provincial and federal governments, non-government organizations and research and educational institutions" who share a common vision for prairie conservation (SK PCAP, 2014, p.10). The Partners strive "to work together to deliver prairie conservation activities that represent shared objectives and that benefit the social, cultural, economic and ecological fabric of Saskatchewan" (SK PCAP, 2014, p.4). SK PCAP believes that there is a strength in unifying multiple collectives across a broad spectrum of management and planning organizations.

The first Guiding Principle is "The Power of the Collective. The PCAP Partners believe that more can be accomplished by acting together than by acting alone. The PCAP Partnership brings diverse groups together to speak with one voice and to work together under a common vision for prairie conservation" (2014, p.16). Although landscape architecture is not mentioned as a part of prairie conservation, I refer back to page 82 and the ability of landscape architect's to contribute to rural landscape. SK PCAP'S goals can be adapted for this practicum, using landscape architecture to promote alternative land use strategies for sites that have not been considered as repurposed sites. **The recognition and application of these guiding principles must encourage the various stakeholders in conservation -- government, volunteer, landowners -- to recognize the potential of repurposed oil well sites. Due to the broad nature of landscape architectural study, it can use the principles laid out by SK PCAP to repurpose the oil well sites.** Conservation easements, as laid out by the government, are a starting point, but further evaluation will reveal more land use options.

Figure 2.2.02: a harvested field near 16-004-06-W-2 in southeast Saskatchewan

Ducks Unlimited Canada (DUCs)

Ducks Unlimited Canada (DUCs), "Partnering with landowners is a true win-win. [Their] resources and programs help restore and protect Canada's land and water, and can become an integral part of a landowner's long-term management plan. [DUCs] offer specialized resources for different regions of Canada, based on conservation needs and landowner priorities." All information on this page is summarized and quoted from the DUCs website (2017b).

Conservation Easements

Available exclusively in the prairie provinces, DUCs has established conservation easements for landowners looking to add conservation aspects to their property. DUCs states: "While maintaining ownership, you make a commitment to conserve the natural integrity of the habitats agreed upon by you and DUC, by limiting the amount and type of development that can occur." This legal partnership ensures the greatest level comfort and productivity for both parties.

FlexFarm

The newest program, FlexFarm promotes the productivity of the entire agriculture property. If certain areas are not as productive as others, DUC's asks "As a grain farmer, you get paid for the canola, wheat or corn you produce. Why not get paid for the natural commodities your land also provides such as flood retention, carbon sequestration and nutrient removal?" Still in the early stages, DUCs is conducting test studies in three rural Saskatchewan locations at this time.

Wetland Restoration

Available all across Canada, this program recognizes existing wetlands that have been drained or altered on private property. This program is "focused on restoring naturally occurring water levels of drained and altered wetlands. These projects are combined with other programs such as conservation easements and forage conversion to maximize the benefits of your land." DUCs then offers to provide appropriate technical assistance to do the job properly, followed up with the suggestion that there may be financial compensation for those engaging in this program.

Forage Program

Less relevant to, perhaps, cropland, the Forage Program still offers significant benefits to those in the agricultural region. "Whether you are a landowner who has cattle, leases your land out for grazing, or wants to convert cultivated acres to perennial cover" you'll be "enhancing areas that can serve as safe nesting habitat for waterfowl and other wildlife" "while diversifying your land use for your farming operation." The financial incentives offer money back on forage seed purchase, and the located regions of interest include all of this practicum's region.

Nature Conservancy of Canada (NCC)

"The Nature Conservancy of Canada (NCC) is the country's largest national land conservation organization. Since 1962, [they] have helped to protect more than 2.8 million acres (1.1 million hectares) across the country. [Their] conservation process has been fine-tuned over decades of on-the-ground work, and continues to evolve to meet our changing needs." All information on this page is summarized and quoted from the NCC website (2017).

Natural Areas Conservation Program

"The Natural Areas Conservation Program (NACP) is a partnership to accelerate the rate of private land conservation and protect important natural habitat in communities across southern Canada." This program is structured as a unique PPP, a public-private partnership that works with conservation organizations such as DUCs, the Government of Canada's Environment and Climate Change sector, and private land owners such as farmers and ranchers. The "habitat protected under the NACP connects or enhances corridors to existing protected areas such as national parks, national wildlife areas and migratory bird sanctuaries," connecting endangered land across Canada for multiple at risk and endangered species.

The Conservation Process

NCCs conservation experts lead on-the-ground work, ensuring efficiency and effectiveness at all scales:

ecoregions

NCC identifies their Canada-wide planning strategy at this scale as "conservation blueprints," identifying "those areas where the biodiversity is greatest, but so is the threat." This is a large-scale initiative that focuses on planning.

natural areas

A subset of ecoregions, natural areas are ground-level initiatives. "Once we [NCC] have identified and assessed the species and habitats we want to conserve, we come up with specific strategies to conserve or restore their health over a five-year period" through "conservation agreements, land donations, [and] purchases."

projects

This is where the public witnesses NCC's work: NCC determines if they must acquire the land, form a partnership/conservation easement, or if a donation is possible. Once established, the management plan takes the form in identifying an initiative: what species/habitat are they trying to conserve/restore? What land use activities will support this goal? What threats exist in and around the land? Once the goals are initiated, staff will continue to measure success through annual monitoring.

"We treasure this small portion of the natural world that is temporarily under our care. Becoming members of Stewards of Saskatchewan and Rare Plant Rescue further inspires us to learn more about this land we call home and assists us in spreading the message of the importance of conservation of the natural world with friends, neighbors and visitors."

Rare Plant Rescue Participant with Nature Saskatchewan, 2017a

Nature Saskatchewan

Another not-for-profit organization, Nature Saskatchewan operates under the belief that the "prairie region, as well as its biological diversity, is one of the most endangered landscapes. Active stewardship by landowners is essential to the conservation of the remaining prairie landscape since most of southern Saskatchewan's grasslands (native and tame) are privately owned." All information on this page is summarized and quoted from the Nature Saskatchewan website.

Conservation Easements

Nature Saskatchewan promotes the use of conservation easements, much in the same way the other organizations in this document do. They delve into the legal and monetary connections, highlighting the enforceable expectations of the landowner to maintain the natural conditions.

Stewards of Saskatchewan (Nature Saskatchewan, 2017a)

Nature Saskatchewan promotes the idea of individual land stewardship: "The prairie region, as well as its biological diversity, is one of the most endangered landscapes. Active stewardship by landowners is essential to the conservation of the remaining prairie landscape since most of southern Saskatchewan's grasslands (native and tame) are privately owned." Through the use of "flagship species" -- at risk species that direct programming initiatives -- there are five voluntary stewardship programs that rural landowners and managers can participate in: Operation Burrowing Owl, Shrubs for Shrikes, Plovers on Shore, Stewards of Saskatchewan banner (multiple at risk species), and the Rare Plant Rescue. Although each of these programs focuses on a different species (or multiple species), "the goals of [all] the programs are to conserve habitat, raise awareness and provide support to agricultural producers, enhance prairie habitat for species at risk, and search for and monitor target species at risk populations." These programs will also benefit other species and habitats as the crossover between species and habitats spans many individual wildlife and plant requirements.

PlantWatch (Nature Saskatchewan, 2017b)

"PlantWatch, part of the suite of NatureWatch programs, is a Canada-wide network of volunteers who record the blooming times for common plant species in their province. Information collected by PlantWatchers is a valuable tool to track how and at what rate climate change is taking place across the nation." Nature Saskatchewan promotes becoming a "citizen scientist" on their website as this program supports climate change analysis. In Saskatchewan, 18 plant species are "watched" to "better understand how common plants are responding to climate change [and] where and at what rate our climate is changing."

Saskatchewan Wildlife Federation (SWF)

The SWF believes "Saskatchewan is blessed with an abundance and variety of wildlife, but since settlement began, we've lost more than 75 percent of our natural landscape to urban and agricultural development... The effect on wildlife was devastating and many species were declining as their habitat was rapidly being destroyed... fortunately there is something we can do to preserve what we still have for [the] future" (SWF, 2017b). All information on this page is summarized and quoted from the SWF website.

Conservation Easements (SWF, 2017a)

SWF promotes the addition of conservation easements on private property as "conservation easements are a great way for land owners to set aside wildlife habitat but retain ownership of their land." To establish a conservation easement on private land, SWF has made the process simple: "landowners identify ... a portion of their property that is good wildlife habitat that they would like to place a conservation easement on." SWF then ensures an assessment is completed "and based on the number of acres that qualify as wildlife habitat the SWF will pay the landowner 25% of the appraised value" to establish the easement. The easement then becomes a part of the property title to ensure it is held as a conservation easement in perpetuity. Although the landowner controls access to the property, they are not allowed to alter the landscape from its natural state.

Wildlife Tomorrow (SWF, 2017b)

SWF has established this private stewardship program to conserve and maintain wildlife populations within Saskatchewan: "The purpose of the program is to preserve habitat in its natural state for all species of wildlife, and to recognize the landowners that support this conservation effort by setting aside a few acres of their land for wildlife use." This is not a formal program; it is a "gentleman's agreement and may be canceled at any time." The website lists suitable parcels of land that can be recognized as a part of this program. Each parcel has some minor guidelines in place based on "its value as habitat for wildlife."

Slough: "any water body that is one acre or larger with sufficient depth to retain water throughout a normal year. Nesting cover is not required but does enhance the value of the water body significantly."

Abandoned farmsteads: "in areas that are intensively cultivated, these locations may be the only islands of habitat left for our wildlife."

Undeveloped Road Allowances: SWF notes that "a typical 66 foot undeveloped road allowance that hasn't been cleared or put to another use could provide eight acres of wildlife habitat per mile."

Alternative Land Use Services (ALUS)

Alternative Land Use Systems (ALUS) Canada “helps farmers and ranchers restore wetlands, reforest, plant windbreaks, install riparian buffers, manage sustainable drainage systems, create pollinator habitat and establish other ecologically beneficial projects on their properties. What’s more, ALUS provides annual payments to ensure the ongoing stewardship of each ALUS project. For over a decade now, ALUS Canada has been building excellent relationships within agricultural communities while perfecting its unique mechanism for delivering conservation outcomes from Canada’s rural acres” (ALUS, 2017b). All information on this page is summarized and quoted from the ALUS website.

Vision (2017a)

ALUS Canada takes pride in their eight guiding principles, and here I have reduced them to the most relevant for this practicum so far:
1. Farmer-delivered: farmers are the single, largest group of private landowners in Canada and, as such, have the ability to positively impact climate change and biodiversity loss across Canada.
2. Community-developed: the program is delivered by local representatives to ensure each program is customized, appropriate, and well supported.
3. Integrated: ALUS operates their programming and support within larger objectives (such as government and other existing conservation programs).
4. Science-based: the support system includes tested technical administration to ensure that each design is appropriately and sustainably implemented and continually managed.

I have diluted the options to these choices because I believe that they represent gaps in the current administration, as analyzed in the preceding pages regarding government administration: those documents are meant for companies and organizations, not the individual farmer.

Program Overview (2017b)

Most importantly, perhaps, is that “the ALUS program provides a financial incentive for producing valuable ecological services on Canadian farmland.” “What’s more, ALUS provides annual payments to ensure the ongoing stewardship of each ALUS project.” This program supports a wide range of initiatives: “clean air, clean water, flood mitigation, climate adaptation, carbon sequestration, species at risk habitat and support for our native bees and pollinators.” The flexibility of, perhaps, choosing which initiative to support and receiving compensation is an exciting prospect.

Saskatchewan Prairie Conservation Action Plan (SK PCAP)

The Saskatchewan Prairie Conservation Action Plan (SK PCAP) (2017a) "Partners believe that more can be accomplished by acting together than by acting alone." The SK PCAP, therefore, operates as "an action-orientated organization" with a desire "to achieving measurable results that contribute to the goals of the Partnership" (SK PCAP, 2017a) All information on this page is summarized and quoted from the SK PCAP website.

Principles of the SK PCAP Partnership

(SK PCAP, 2017a)

This organization functions through eight guiding principles:
1. The Power of the Collective: "brings diverse groups together to speak with one voice and to work together under a common vision for prairie conservation."
2. Partnerships: "possible and desirable for groups with diverse interests and needs to find mutually agreeable solutions [for] prairie conservation."
3. Sustainable Use of Prairie: "a working landscape that can include people and their livelihoods as a positive part of the ecosystem."
4. The Intrinsic Value of Prairie: "prairie ecosystems and the species found within them have intrinsic value, beyond any human use."
5. Engaging People: "learning about and experiencing the prairie ... to promote conservation."
6. An Integrated Approach: "ecological, socio-cultural, and economic interests"
7. Adaptability: "adapt to new knowledge with enthusiasm and creativity."
8. Commitment to Action: "clear implementation plans and commit to achieving measurable results."

Taking Action for Prairie (SK PCAP 2017b)

SK PCAP, primarily an educational resource, "has developed a new curriculum-supported, action-orientated environmental education program" that "The objective of the program is to increase awareness and appreciation of the native prairie ecosystem and its conservation through the development and implementation of an Action Project by each grade after program delivery." They offer curricula that directly correlates with the new Science Curriculum for three elementary school grades:

Grade 6: Diversity of Life to SK PCAP's Cultural Goal: Native prairie is a valued part of our culture and identity as Saskatchewan people
Grade 7: Interactions with Ecosystems outcomes to SK PCAP's Ecological Goal: Native prairie ecosystem health and biodiversity are conserved and restored as part of a functioning landscape
Grade 8: Water Systems on Earth outcomes to SK PCAP's Economic Goal: Sustainable uses of native prairie improve the livelihoods of Saskatchewan people.

applying programming to southeast Saskatchewan

According to the Prairie Pothole Joint Venture website (2016), "eighty-five percent of the land in the Prairie Pothole region is privately owned. Thus, landowners play an essential role in wildlife habitat conservation in the region." The sheer number of prairie conservation based organizations and their subsequent initiatives indicate the desire for native grassland in the heavily cultivated areas of Saskatchewan, as recognized in the previous pages of this section. DUC's (2017b) FlexFarm program, ALUS's (2017) mission statement, NCC's (2017) conservancy programming, SWF's (2017a) conservation easements, and Nature Saskatchewan's (2017a) Stewards of Saskatchewan program all encourage individual land owners to support and promote prairie conservation.

DUC's (2017b) recognizes the necessity of working with multiple, varying levels of land ownership to accomplish conservation goals: "Land purchases and landowner agreements protect remaining habitat" while working "with industry and government will help to conserve another 3.5 million acres through responsible policy." By accessing varying levels of ownership and policy building, DUC's is working to ensure that their goals are being met through cooperation with individuals to organizations to government bodies; they are, in many ways, covering all their bases.

Conservation, however much an active initiative, is also a passive activity. Conservation promotes a pause in time on anthropological influence, maintaining species at a status quo. In turn, 'conservation' cannot be the goal of this practicum: the areas of interest -- abandoned oil well sites -- are heavily altered, small sites that encompass little square footage and require intensive rehabilitation before they can be considered functioning points of biodiversity in the agricultural landscape. However, as I am proposing a repurposing in the function of the site, perhaps the post-post-industrial site will offer potential with these programs.

Thus, I conclude this section with the beginnings of a programming proposal relative to a design strategy. Many of the initiatives for promoting native prairie conservation take place on land that is unused by farmers or as part of a larger scheme.

These elements are relative to oil well sites; despite the smaller size of each site, they can encompass a large area all together and, potentially, provide islands of refuge amongst the cultivated cropland. Assuming that remediation of the land becomes a part of the design, programming possibilities established by these organizations could be used in the establishment, maintenance, and study of reclaimed oil well sites in southeast Saskatchewan. By accessing the goals and strategies proclaimed by Saskatchewan conservation organizations, a design for oil well sites can be reasonably proposed as a component of these initiatives. It is not necessary to structure an entirely new programming possibility; successful and well-researched initiatives that have been influenced and researched by teams of knowledgeable professionals exist. By applying some of the goals, structures, and frameworks of these relevant organizations and initiatives, abandoned oil well sites can be considered as invaluable pieces of land. They can go from black (oil) to green (native revegetation) to gold (compensation for landowners) if an appropriate design strategy is put in place. This challenge will be addressed through the remainder of this practicum, creating a design that is both beneficial and compensated for landowners.

> “Active stewardship by landowners is essential to the conservation of the remaining prairie landscape since most of southern Saskatchewan’s grasslands (native and tame) are privately owned.”
>
> Nature Saskatchewan, 2017a

Figure 2.2.03: an oil well pad punctuates a dessicated field of lentils ready for harvest near 16-004-06-W-2 in southeast Saskatchewan

3 TO GOLD

design strategy | repairing the prairie apiary

 Figure 3.1.01: a wetland on the edge of a field near the sections of interest in southeast Saskatchewan

3.1 THE BEES

agriculture, apiaries, and ‘a-bee-tats

MIND THE GAP: REPAIRING THE PRAIRIE APIARY

the design strategy

The Government of Saskatchewan regulations do not use a term I believe relevant in the treatment of oil well sites: reparation. **Re-vegetation, remediation, restoration, rehabilitation, etc., all cover the requirements of what to do once an oil well site is no longer being used, but they fail to recognize the previously existing conditions**.

This is why the design is entitled with the term 'repairing.' It does not hold the legal responsibilities associated with the previously explored governmental language; it is an average word, a word that will resonate with people who will not read complicated legal documents and specifications. It will appeal to those who have had anything broken that he/she felt was worth fixing, worth re-establishing value. It is a word that does not require multiple definitions to connect the tangible ability of the words to an action. It is a word with an element of time; what once was, should be again. It values the previous in relation to the present, recognizing the relation between the two.

This is why pollinators -- specifically bees -- have been identified as a gap in the agricultural landscape of southeast Saskatchewan. Although there are many ways that one might approach treatment of the oil well sites, this strategy addresses native bees as an axis for change. **Repairing the Prairie Apiary is, therefore, one possible application of the regional strategy. The oil well sites will be repurposed to promote the (re) establishment of native bee populations.**

"Declines in managed and native pollinator populations all over the world have increased the urgency to research and protect these pollinators and their services as they are important for both our wild and agricultural plant communities."

Freitas et al., 2016, p.28

To repair the prairie apiary, certain objectives will be met.

1 To supply appropriate nesting homes for native bee species

2 To revegetate the repurposed oil well pads and access roads to provide suitable forage and nesting needs for native bee species

3 To consider conservation and management as an integral part of long-lasting, efficient repurposing

repurposing the abandoned and decommissioned oil well site

As this practicum has revealed, the repurposed oil well sites are uniquely located and structured within private lands, creating patches amongst the matrix of monoculture fields. With further restructuring, they host a realm of opportunities otherwise inaccessible due to the constructed nature of private land ownership. The images throughout this document have revealed pump jacks popping up in the midst of uncultivated areas, alongside wetlands, through marshes, and within crops. It is possible, therefore, to repurpose these sites as a means of punctuating the monoculture matrix created by agricultural crops.

access roads

This practicum also recognizes the impact of the access roads that accompany oil well pads. The pump jacks, scattered throughout the landscape, still need to be accessed and, as such, the access roads create that connection. However, as I have determined the oil well pads can be repurposed, so, too, will the access roads as a component of the well sites. Although they interrupt the landscape they travel through, they also create connections from one point to another, breaking up the agricultural matrix similarly to oil well pads but in a linear, connective manner.

keystone processes and the contribution to food security

Although I often consider the buffalo as the iconic keystone species on the prairie grasslands, bees are gaining recognition as a worldwide keystone species. The Xerces Society (2003, p.4) defines pollinators -- of which bees are included -- as a keystone species, “species upon which the persistence of a large number of other species depends: they are essential to the reproductive cycles of most flowering plants, and thus to the ecosystem itself, supporting plant populations that other animal and bird species rely on for food and shelter.”

The bumble bee (*Bombus* sp.) is particularly prominent as a keystone species in the European countries (Pywell et al., 2006), but as research continues to build our knowledge of native bee species, the more we understand their invaluable contribution. Perhaps this is an important distinction: **it is less that bees are a keystone species but, instead, that the process of pollination is a keystone process.** Bees are, therefore, not keystone species but a key, worldwide, ecosystemic process.

According to The Xerces Society (2003, p.4), “it is with particular alarm that scientists from nearly every continent have been documenting dramatic declines in [pollinator] populations in recent decades.” Chapter two of The Xerces Society (2003) Pollinator Conservation Handbook asks the crucial question: why care?

To start, “approximately one out of every four mouthfuls of food and beverage that you consume required the presence of a pollinator” and “are directly or indirectly responsible for many of our medicines, dyes, beverages, and fibers” (The Xerces Society, 2003, p.6-7). Beyond that, pollinators have value far beyond the economic. The Xerces Society (2006) notes that pollinators are crucial to the life cycle of herbaceous trees and shrubs, ground-nesting bees affect water movement and soil texture, and pollinators feed mammals and birds through fruit production.

The recognition of declining bee populations is spurning a movement that promotes easy-to-install, quick fix methods for urban gardens that

definitions

Pollinating: “the transfer of pollen from the producing anthers to the receptive stigma and it is an essential step for the sexual reproduction of flowering plants.” If affects not only quantity, but quality of the yield. (Freitas et al., 2016, p.17)

Native bees: “come in a wide range of sizes and colours, from tiny sweat bees less than a quarter of an inch long to bumble and carpenter bees bigger than an inch;” many are hairy yellow and black strips while others “may be dark brown, black, or metallic green and blue, with stripes of red, white, orange, yellow, or even mother of pearl” (Vaughan et al., 2007, p.6)

> “Science and common sense tell us that species exist in an extremely complex web of interconnections such that, when a single species is removed, scientists cannot always predict the consequences. However, there are natural interactions between species so fundamental that the loss of one of the species will clearly be disastrous for the other. Pollination is one such process.”
>
> Michener, 2003, foreword

install both nesting sites (bee homes) and foraging material (flowers). Although this is an effective method for the diversity of urban settings, different methods must be applied to the scale of mass agricultural areas. Southeast Saskatchewan, featuring prominent monoculture fields and a focus on productive landscape, must recognize the contribution of bees if large-scale change is to be made.

Isaacs et al. (2016, p.114) in their article “Farm-tailored measures to sustain and enhance pollination services” state: “As the human population grows, the need for more productive use of available farmland will also increase, making it essential that pollen limitation does not constrain yields.” The need for food security considerations could be a motivator for farmers to consider promoting bee populations as a result of their practice. Although first world countries are not as likely to be affected, this is a short-term perspective that, depending on environmental conditions and climate change, could very quickly become a concern. But how should food security be considered in the form of agricultural organization? Tscharntke et al. (2012) acknowledge that there is a debate surrounding agricultural practice: is “segregating land for nature from land for production (land sparing), or integrated with production and conservation on the same land (land sharing or wildlife-friendly farming)” a more efficient method? This dichotomy does not adequately address other components such as cultural ecosystem services. In developed countries, “the public has to a large extent identified habitat destruction, increased use of agrochemicals, and landscape-wide structural simplification as unwanted” (Tscharntke et al., 2012). This promotes a wildlife-friendly land use, a greater diversity in the biological components of an already simplified agricultural landscape.

This argument does not solve the hunger question, but it does create some basis for this practicum. **This practicum takes the stance that there are available sites for wildlife-friendly farming and must be considered to provide the most effective habitats.** Not only will it address cultural ecosystem services, but it will focus on the integration of wildlife within agriculture, specifically pollinator populations. As farmers could be the key drivers of this change, “concepts aiming to sustain multifunctionality of landscapes, integrating food production and conservation of both openland and forest species” (Tscharntke et al., 2012) should be considered.

ha-bee-tats in agriculture

“The prairie grasslands of Canada are home to at least 387 bee species. This represents almost half (i.e., 48%) of the bee taxa reported for Canada and over 90% of the total recorded from the three Prairie Provinces of Alberta, Saskatchewan, and Manitoba. The Prairies Ecozone thus represents one of the most diverse and important areas supporting bee diversity in the country, with 23% of the bee species listed not found anywhere else in Canada” (Sheffield, Frier, and Dumesh, 2014, p.427). With an extensive agricultural habitat, limited studies on grassland bee species, and the knowledge that bee populations are suffering throughout the prairies, “native and/or restored grasslands could serve as important reservoirs of native pollinators for future crop pollination needs” (Sheffield, Frier, and Dumesh, 2014, p.430).

When it comes to bee populations in agriculture, Roubik and Gemmill-Herrin (2016, p.134) state: “Biologically simplified large farms, which surpass the flight ranges of pollinators, constitute their own, isolated environment. Their central areas are least likely to benefit from pollinators living nearby. As their area increases, it does so more than the perimeter.” Simply put, the interior of planted fields are generally undesirable for bee species. Those areas are not receiving the benefits of pollinators, and there is less space for bee populations to live. Despite the monoculturistic organization of the agriculture prairies, bee species manage to persist. Do we know how many and/or what species have become extirpated or extinct? Not definitely. But Creswell (2016, p.157) notes that pollinator species are often able to survive on the leftover pieces of land: small areas remain undisturbed long enough for bees to nest, roadside flowers bloom long enough to provide the necessary pollen, or areas are population sinks.

Creswell (2016, p.157) also notes the primary inhibitors to sustainable bee populations stems from three distinct issues:

1 There are not enough flowers for forage and/or the timing is not consistent with the bees needs.

2 The ground-nesting of bee species are not positively in sync with tillage, mowing, and harvesting schedules of farmers.

3 Pesticides can have devastating effects on pollinator populations as the chemicals infiltrate both their bodies and the plants they feed on.

“Current concerns about pollinator losses underscore the importance of understanding the patterns of diversity of native bees within agricultural regions and how to conserve these patterns and the services of bees” (Sheffield, Frier, and Dumesh, 2014, p.430). For bee species, flowers for forage is not so simple as planting a mix of wildflowers and expecting the bee species to thrive. In agricultural zones, then, forage preferences for survival and thriving of bees must be addressed through new interventions that recognize the need to strategically plan for a variety of bee species.

"Sustainability is an ideal, situated between certainties and economic incentives. One scheme may be relatively more suitable than another. Certainly, only nature itself is sustainable, and it never favours monospecific stands of any living thing. Because is relentless, the great buildings of humans, even though solid for millennia, erode and disappear. Among living things the process quickens. Pests and competing plants seem to overwhelm human solutions to obtaining acceptable agriculture or silvicultural yields. Sustainable cultivated schemes are therefore gauged in terms of years, no centuries or millennia."

Roubik and Gemmill-Herren, 2016, p.147

It is worth recognizing the benefits of not just native bee populations, but the habitats they need to survive. Vaughan et al. (2007, p.9) recognizes that there are benefits to the local ecology

1 promoting pollinator habitat along the edges of cultivated areas such as drainage ditches "can reduce erosion of farm soils" and prevent unnecessary cleaning out of water-logged areas growing emergent species;

2 these water-logged areas are also capable of cleaning pesticides and fertilizers if the appropriate plant species are growing;

3 native species planting can supplant invasive weed species over time, reducing the herbicide use, resources, and time to maintain these areas. - this habitat can support other wildlife

4 standing dead trees, such as snags on the edge of water-logged areas, can provide homes for bird species such as owls and raptors, both of whom assist in rodent population control

5 appropriate native plantings will support beneficial insects including "parasitic wasps and predaceous beetles" that can "help reduce the number of pest insects on a crop" (Vaughan et al., 2009, p.9). All the while, these areas will host native bee populations, sharing habitats and mutually benefiting one another.

polylectic

bees that are "floral generalists who will gather pollen from many kinds of flowering plants"

oligolectic

"bees collect pollen from a small group of closely related plants, perhaps a single plant family or genus"

monolectic

bees that "gather pollen from just a single species or flower"

The Xerces Society, 2003, p.24-25

Figure 3.1.02: foraging needs for bees, adapted from Xerces Society, 2003, pp. 24-25

problems with pollinators today

The greatest contributors to declining populations:

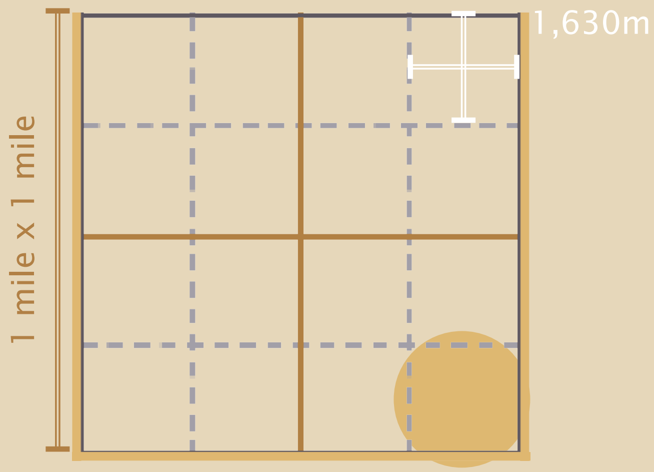
1 the loss and fragmentation of habitat;

2 the degradation of remaining habitat;

3 pesticide poisoning

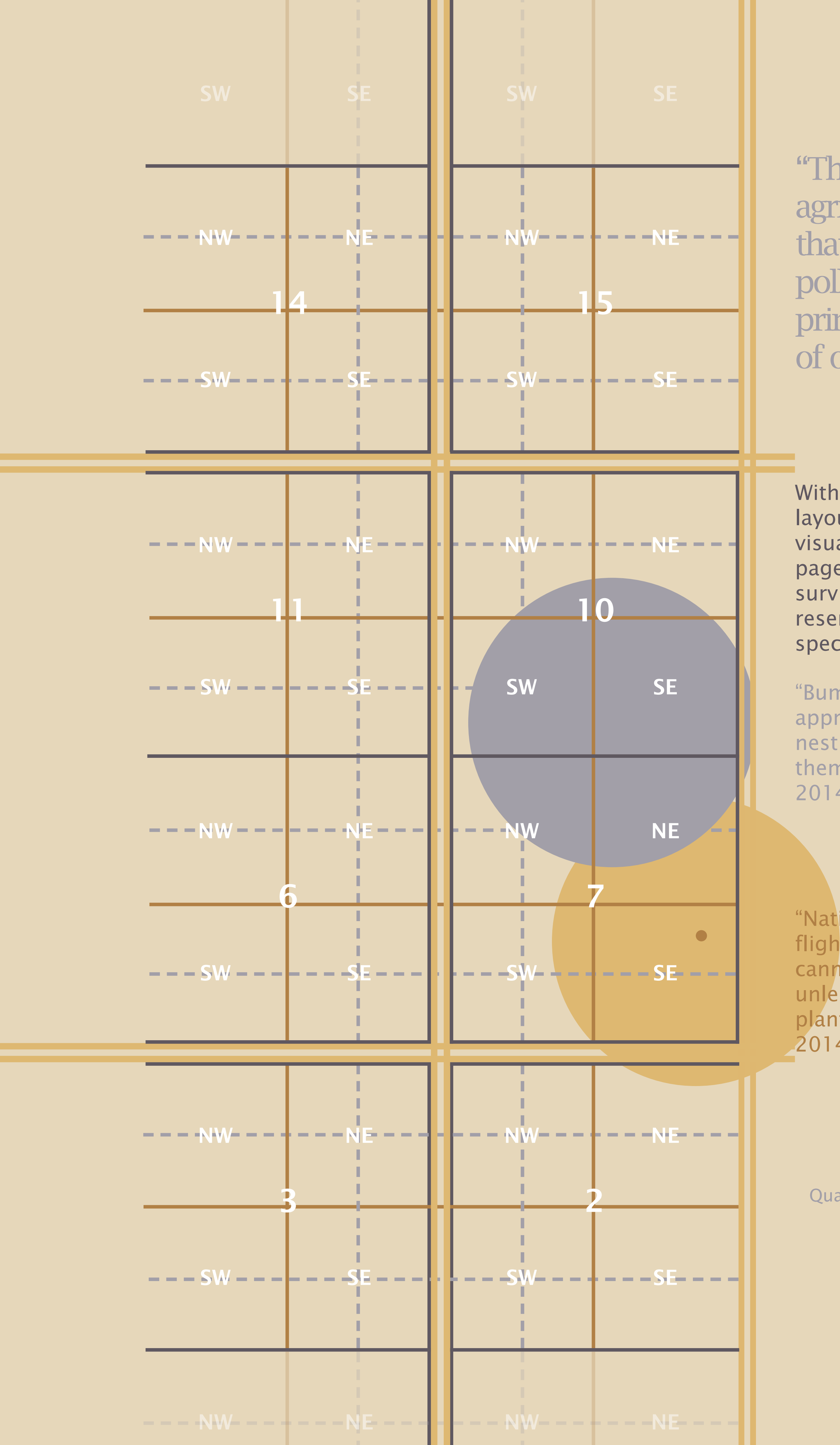
(The Xerces Society, 2003, p.4).

Sasha Chapman (2013) writes extensively on the contributors to bee population loss. As alluded to above, pollinators are highly affected by distances and fragmentation. This concern proves particularly true in the southeast region of Saskatchewan where large sections of land are devoted exclusively to the monoculturistic plantings of agricultural crops. "As new technologies come to market, farmers are finding ways to make every bit of land yield more crops—and to eradicate the flowering weeds that may compete with them but might also sustain native bees" (Chapman, 2013). This would not be as concerning if bee populations could survive from monoculture plantings. Southeast Saskatchewan features fields on fields of flowers that would be a pollinator's dream, but only for a couple of weeks during the blooming period. "Wild pollinators that do establish nests in the middle of large fields fare poorly; while they can gorge on nectar during blooming, they starve once the blossoms die off" (Chapman, 2013). Without other feeding locations, the bees have little chance of finding a location that promotes long-term survival.



Based on my observations from my father's farm and travels throughout southeast Saskatchewan, fields are often planted by quarter sections, equaling 160 acres, but as equipment grows larger, so can the fields. In terms of agriculture, the linear construction of field boundaries and available open space promotes efficient farming practice. However, these sections also promote monoculturistic planting that may or may not have pothole prairie remnants -- sloughs -- as a component of the landscape. What happens when the pieces of uncultivated areas in these fields are occupied by crops?

 Figure 3.1.03: recalling the surveyed structure of Saskatchewan (see page 15)



“The irony is hard to ignore: agriculture, the very industry that depends most on pollination, might be the prime suspect in the demise of our pollinators.”
Chapman, 2013.

With a typical southeast Saskatchewan layout resembling the structure visualized to the left and drawn from page 14, bee populations struggle to survive. There are no spaces legally reserved for conservation or pollinator-specific habitat areas.

“Bumble bees ... can travel approximately one mile from their nest, the longer distance allowing them to forage on more plants” (Holm, 2014, p.15).

“Native pollinators are ... limited by flight distance (200 feet - 1 mile) and cannot access all plants in large fields unless nesting habitat and forage plants are strategically located” (Holm, 2014, p.38).

So far, the identification of issues with pollinators in today's agriculture has made the situation seem bleak; there is not enough forage or nesting sites or they are being destroyed, and populations are diminishing at rates that the implications are not yet fully known to us. However, The Xerces Society (Vaughan et al., 2007) has created a booklet, Farming for Bees: Guidelines for Providing Native Bee Habitat on Farms, that addresses interventions that promote the biodiversity and management strategies needed for bee population maintenance. Vaughan et al. (2007, pp.4-5) believe that small changes to increase pollinator populations is not a difficult task: "subtle changes in farm practices can involve identifying and protecting nesting sites and forage; choosing cover crop species that provide abundant pollen and nectar; allowing crops to go to flower before plowing them under; or changing how pesticides are applied in order to have the least negative impact on native bees." Native bees, therefore, override the importance of the well-known bumblebee.

1 Native bees are very efficient: they are more active in colder and wetter weather and their 'buzz pollination' promotes greater cross-pollination;

2 Native bees are diverse and stable: the decline of one species may be balanced by other species filling the gap in productivity;

3 Native bees may provide additional revenue: consumers may buy from bee-friendly farms (Vaughan et al., 2007, pp.8-9).

This chapter clearly recognizes the benefits, but without the proper due diligence native bee species cannot survive. Whereas honey bees often have the help of humans to retain stable populations -- think: bee keeping and honey production -- native bees do not have such assistance. They are, instead, dependent on their own resources and available environments. How, then, can populations not only be managed, but supported to thrive and retain stable populations with multiple inhibitors?

"Farming has traditionally never been a solitary operation; it has been carried out over millennia by communities of people. An ecosystem perspective recognizes that the regenerative aspects of agriculture occur on the level of whole farming systems, at the watershed and/or landscape or community level."

Roubik and Gemmill-Herren, 2016, p.143

1 habitat loss + fragmentation

"The configuration of habitat patches, which changes with the degree of fragmentation, and 'simplification' of cultivated areas might ... affect foraging movement and dispersal of bees and thus impact their populations" (Isaacs et al., 2016, p.115). As this document already recognizes, populations *are* being affected. Therefore, the reduction of fragmentation is the best means of promoting bee species. However, as agriculture is a livelihood, particularly in the southeast region of Saskatchewan, it is not realistic to expect farmers to modify their productive land to exclusively promote bee populations.

To mitigate this, Vaughan et al. (2007, p.15) recognize the benefits of peripheral areas not only for their forage and nesting sites, but because "these linear patches of habitat likely provide a corridor along which bees and other beneficial insects can migrate more quickly through the agricultural landscape." Due to the nature of the fields, as witnessed in southeast Saskatchewan, these linear corridors may be some of the singular most effective means of reducing the all-consuming agricultural landscape. When assessing the fragmentation of the agricultural landscape, however, it is worth understanding that "many studies of landscape context that report simplified landscape are referring to proportion of cultivated versus semi-natural habitat rather than directly assessing landscape pattern" (Isaacs et al., 2016, p.116). This means that the **average farmer does not need a highly specific skill set to implement de-fragmentation habitat**.

possible action

The site analysis recognizes that there are uncultivated areas to be found, even in the highly modified landscapes of southeast Saskatchewan. The opportunity exists to capitalize on these available spaces, considered unusable by landowners and sitting vacant of productive purpose. This is a generalization; many potholes serve as valuable habitat for waterfowl, but the interests of this practicum lie elsewhere.

Figure 3.1.05: a wetland edged by a harvested crop near the sites of interest in southeast Saskatchewan

2 degradation of remaining habitat

"Although most farmers cannot control the larger landscape surrounding their fields, they do have control of how those fields and their borders are managed" (Isaac et al., 2016, p.117). Those borders are often ideal locations for bee populations: areas left untilled including "woodlots, stream banks, utility easements, and conservation areas, as well as unused land around farm buildings and service areas" can all support the necessary foraging and nesting habitats of bees (Vaughan et al., 2007, p.15).

Vaughan et al. (2007, p.15) have two recommendations regarding these areas: leave the areas alone and prevent pesticide spray, and do not till fields fencerow to fencerow. Vaughan et al., (2007, p.18) recognize the benefits of utilizing partial habitats: some sites around a farm may only be suitable for one component of pollinator habitat -- forage or nesting. These sites are still useful, so long as they are fairly close to one another. Together, the two (or more) sites are able to provide all that native bee species need. This is a positive means of approaching farming areas. The example located in the Vaughan et al., (2017, p.18) booklet discusses areas that periodically flood. As these areas are suitable for neither cultivation or bee ground-nesting, forage plants can still be installed in these areas. So long as a home is provided nearby, **farmers can promote bee habitat by re-purposing periodically flooded areas into bee foraging sites, supplemented with a simple home**.

possible action

There are multiple organizations in Saskatchewan (see: Chapter 2: ... to Green ...) that wish to promote the retention and maintenance of remaining native habitat left in Saskatchewan. With this in mind, it is possible to not only retain the remaining habitat, but consider methods that might assist in enhancing these areas to become more productive. The possible imbalance of invasive species to native species is a cause for concern to not only conservations, but land owners who must fight a constant battle against the invasive species.

 Figure 3.1.06: drainage ditches can be mistaken for wetlands

3 pesticides + herbicides + insecticides

One of the greatest concerns for pollinators is the effect of pesticides on populations; even if forage and nesting sites are provided, it will not help bee species if they die due to chemical application. Vaughan et al. (2007, pp.32-33) recognize two effects: lethal effects are often a result of bees contacting plants with applied pesticides, and sub-lethal effects are the behavioural changes (such as navigation, behaviour alterations, paralysis) from direct contact or toxins in the nest.

Vaughan et al., (2007, p.33) have some recommendations if insecticides must be applied: reduce the amount of insecticide both in quantity and by a schedule (identifying issues rather than following the recommended calendar). They also remind farmers to be aware of the chemical drifting onto the adjacent habitat; to counter this, apply sprays close to the ground and keep pesticide-free buffers. It is also important that the farmers consider the timing of application. Insecticides “should never be applied to a crop in bloom, or to adjacent blooming plants. It is also important to remember that the native bees that pollinate a crop may be foraging on cover crops or adjacent flowers before and after a crop comes into bloom (Vaughan et al., 2007, p.34). If the farmer uses insecticides that are less toxic to bees, they may apply over flowers when the pollinators are not foraging, “such as in the late evening, immediately after bees stop foraging for the day” and when the weather is warmest and dew is not present (Vaughan et al., 2007, pp.34-35).

possible action

This will be the most challenging consideration of all: some land owners, specifically farmer’s, rely on various -cides to manage undesirable species. However, the southeast region of Saskatchewan contains some organic fields. It is in these spaces that pollinator habitats could be immediately promoted, establishing stable populations. The risk is that they may inhabit surrounding non-organic fields but clever interventions may reduce this as a concern for devastation.

Figure 3.1.07: a crop with few to no weeds is often sprayed heavily with –cides

WHO BE THE BEES?

nesting needs and prairies species

social nest-building bees

“Social bees live in colonies, which are defined as having at least two adult females -- there may be many more -- who live in the same nest and share the work of preparing and provisioning it. Usually, one of them is the egg-laying queen and the others are workers” (The Xerces Society, 2003, p.25).

Nests of Social Bees
“Bumble bees and social sweat bees have in common that they live in annual colonies founded in the spring by an individual queen after she wakes from hibernation” (The Xerces Society, 2003, p.25).
Bumble Bees (genus *Bombus*): “The newly emerged bumble bee queen locates and nests within a dry cavity, perhaps in an abandoned mouse nest or under a tussock of grass. ... The queen ... lays her eggs, and then forages for nectar and pollen to feed her first brood of larvae. After a month or so the larvae pupate and emerge as worker bees. These worker bees do most of the work of constructing the nest and foraging, and once they are active the queen can use her energy to lay eggs” (The Xerces Society, 2003, pp.25-26). The colony grows over the summer “until late in the season, when a generation of new queens and males are produced, emerge, and mate. As fall arrives, most of the bees -- including the old queen -- die, leaving only the newly mated queens to overwinter and establish new colonies the following spring” (The Xerces Society, 2003, p.26).
Sweat Bees: “nest in underground tunnels. In general, the emerging female digs a burrow in which she excavates brood cells, provisions them, lays her eggs, and rears her offspring, who then become her workers. Sometimes, however, two or more sister females will found a communal nest in the spring, in which one lays eggs that the others tend” (The Xerces Society, 2003, pp.26-27).

Foraging of Social Bees
“Social bees are polylectic. To sustain the colony and feed the larvae through the spring and summer, they must gather food from flowering plants over an extended period.” So long as there are suitable nesting sites, “they can adjust to the parade of plant communities that results from seasonal and habitat changes” (The Xerces Society, 2003, p.27).

Life Cycle of Social Bees
According to The Xerces Society (2003, p.104), “most bumble bees and sweat bees die at the end of summer, leaving only the fertilized queens to hibernate. The queen bumble bee does not hibernate in her nest, which by then is likely to be moldy and maggot-infested; rather, she survives the winter by burrowing into soil or finding shelter in leaf litter or behind bark.”

solitary nest-building bees

According to The Xerces Society (2003, p.18), “about three-quarters of the bee species native to ... Canada are solitary nest-building bees. After mating, there is typically no further contact between the female and other bees as she proceeds to locate, prepare, and provision her nest.” There is a range of nesting habits amongst solitary nest-building bees, however, which will be reviewed below.

Wood Nesting Bees

“Many wood-nesting species use abandoned beetle burrows ... in standing dead trees or limbs, but some chew out the soft central pith of dead, dry stems and twigs.” Although there are some specialized needs, including specific insect galls and hollow stems, “all of these nesting sites ... are dry and relatively warm, and offer protection from predators and parasites” (The Xerces Society, 2003, pp.19-20).

Leafcutter bees (genus *Megachile*): “line the whole [brood] cell with pieces of leaf or flower petal, using their mandibles to cut particular sizes and shapes to fit different parts” (The Xerces Society, 2003, p.20).

Mason bees (genus *Osmia*): “make [cell] walls with mud or leaf pulp” (The Xerces Society, 2003, p.20).

Carpenter bees (large: genus *Xylocopa*; small: genus *Ceratina*): “use wood fibers scraped from the walls of the tunnel to form dividers of ‘particle board’” (The Xerces Society, 2003, p.20).

Masked bees (genus *Hylaeus*): “divide the tunnel into cells using a cellophane-like substance secreted from special glands” (The Xerces Society, 2003, p.20).

“Each of these bees use the same materials to seal the nest entrance when it is finished as they use to line the nest” (The Xerces Society, 2003, p.20).

Ground-nesting Bees

“Ground-nesting bees dig in nests in bare or partially vegetated soil that, depending on the species, varies from flat ground to vertical banks. Inside the nests there is also a range of configurations, from a single short tunnel to complex, branching tunnel systems.” (The Xerces Society, 2003, p.21).

Polyester bees (genus *Colletes*): “secrete from abdominal glands a cellophane-like material to create a complete waterproof lining for the cells, separating them from the soil” (The Xerces Society, 2003, p.21).

***Perdita* bees**: “leave the cells unlined” (The Xerces Society, 2003, p.21).

Alkali bees: “two hundred or more females may nest in a single square yard, each bee tending to a separate burrow” (The Xerces Society, 2003, p.18).

Mining bees: “each nest is marked by a short entrance turret” (The Xerces Society, 2003, p.22).

Foraging of Solitary Bees

“In general, solitary bee species are polylectic” but “some species are more selective. ‘Oligolectic’ bees collect pollen from a small group of closely related plants, perhaps a single plant or genus.” (The Xerces Society, 2003, p.24). “‘Monolectic’ bees are more specialized still; they gather pollen from just a single species of flower” (The Xerces Society, 2003, p.25).

Life Cycle of Solitary Bees

“For most bees, pupation and overwintering needs are both served by the nest. Solitary bees spend most of the year in their brood cells, passing through the stages of egg, larva, and pupa. They emerge in the spring or summer and spend only a few weeks active as adults. Some species of solitary bees, such as small carpenter bees, emerge at the end of the summer and overwinter as adults, usually in their original nests” (The Xerces Society, 2003, p.104).

how far can bees fly?

To apply pollinator habitats on the oil well sites, the site analysis must take a specialized turn. The analysis of the sites as it exists so far covers the basics: topography, land use, anthropogenic elements. However, pollinator habitats require a specific set of necessities: food and forage. These are not addressed in the site analysis section of the site of study (Chapter 1.4) because, quite simply, it is not a driving force of current, focal section use.

Therefore, **the application of the regional design strategy must account for the needs of the bees.** As stated earlier, this is only one possible alternative land use strategy for future abandoned oil well sites, but the theoretical and technical study are a necessity. The application of an alternative land use strategy would be limited by incomplete information without specialized site analysis. The site analysis as completed in Chapter 1.4, although representative of an 'average site' within the region, fails to study the sites beyond a general analysis; it shares some information, but not enough to promote the best habitat for pollinators.

As these sites are shifting landscapes that vary each year in the amounts of water on site, the arable land, landowner usage, and crop plantings, it is difficult to anticipate the land surrounding the proposed pollinator sites (the oil well sites). It is, however, possible to anticipate the treatment of the pollinator sites as connected to the landscape surrounding them. Although the crops will only have a couple of weeks to provide forage for pollinator species with the mass blooming schedule, they need not be impediments on the landscape in the 'tween time. With smart farming practice, conservation of uncultivated areas (and perhaps some enhancement), and a vested interest in climate change and food security, these sites can exist in harmony with the surrounding cultivated landscape.

It is necessary to anticipate the needs of pollinator species both in proposed nesting sites and forage areas. As popular as the honey bee is as a symbol of pollinator species, the native bee species are drivers of pollination in Saskatchewan. Understanding that their needs are limited to smaller flight distances drastically changes the possible interventions and the required surrounding landscape: uncultivated areas become havens amidst the cultivated areas, promoting a different view of productivity that often gets lost in the farmed landscape. **Too often, the uncultivated areas are viewed as unproductive but with proper enhancement and revelation, they can be viewed as meaningful, required areas for the landscape's health and ecosystem services.**

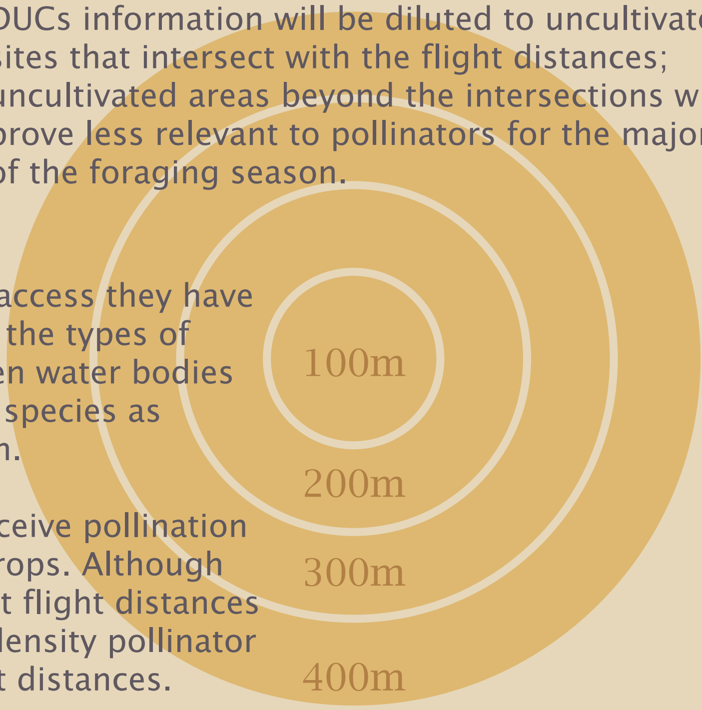
The site analysis is just the beginning of promoting healthy native bee populations, but it is a crucial step. Without understanding the unique conditions in the landscape, particularly from a patch and matrix perspective, the possibility of promoting bee populations and convincing farmers that it is a feasible venture will fall flat. The site analysis must, then, include bee-specific site analysis.

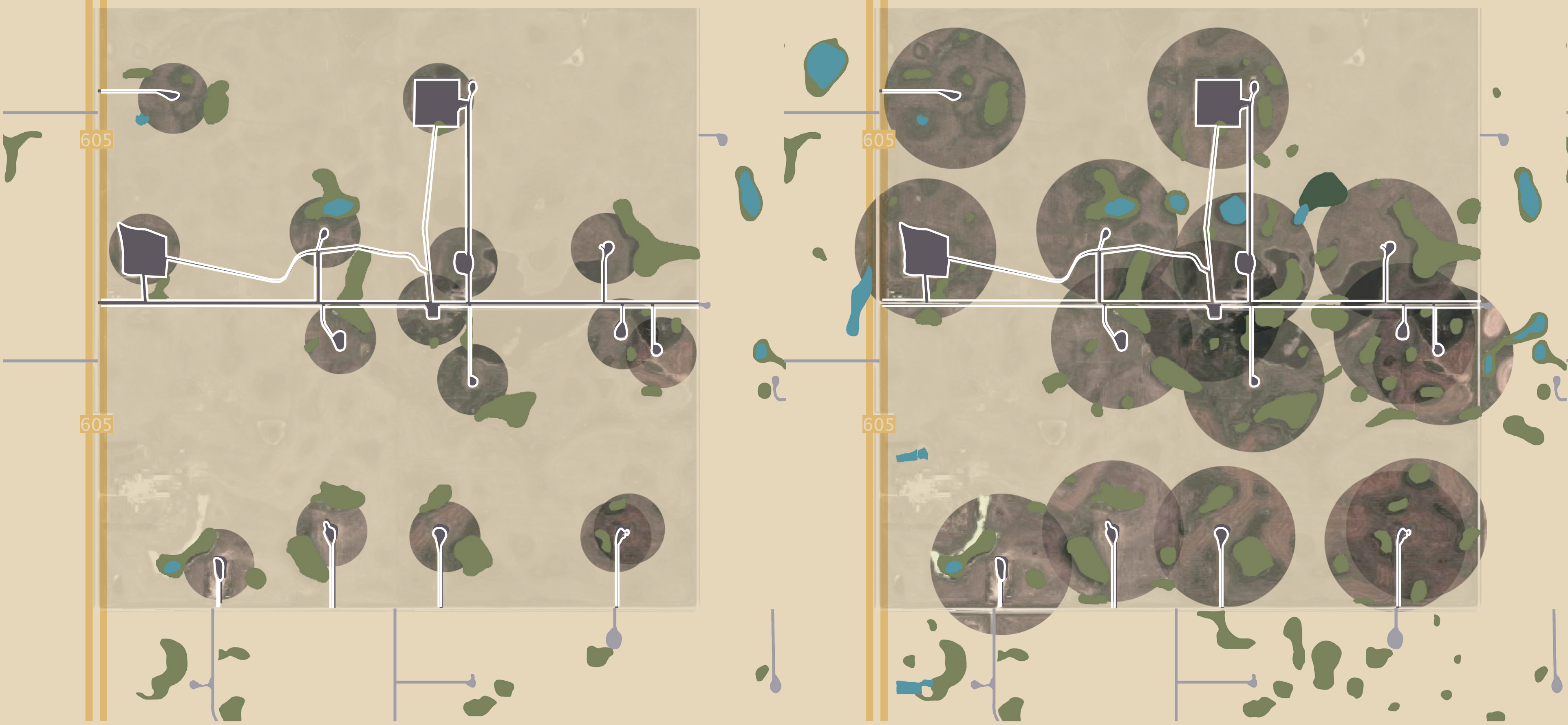
Based on *Figure 1.3.04* in *the problem with pollinators today* page, the analysis for bee population promotion will study short-range flight distances that will account for various species. Although the individual species are not listed as part of this practicum, there are maximum ranges that native bees can fly from their nesting sites and, as such, must be accounted for in the study of an individual site intervention. **The flight distances are represented by outward concentric circles at 100m, 200m, 300m, and 400m diameters and will cover a variety of native species that fly at short, short to mid, mid to long, and long flight range distances, respectively.** The purpose of this exercise is not to identify individual habitats for individual species so much as it is a means of site analysis: **the uncultivated areas will prove important due to the relatively small size of oil well sites in the vastness of fieldscapes and the ecological stepping stones that form as uncultivated areas between the oil well sites.**

In *Figure 3.1.08*, the flight distances will radiate outward from the center of the oil well sites, referencing the future repurposing of those sites. They will be overlaid on the Ducks Unlimited Canada (DUCs, 2017c) maps for the site of the intervention (16-004-06-W-2), and further broken down with the satellite imagery of the sections via satellite view (Google Maps, 2017). This specialized site analysis identifies what conditions exist, their relation to one another, and what elements need be considered to promote the perception of a different productive land use. The DUCs information will be diluted to uncultivated sites that intersect with the flight distances; uncultivated areas beyond the intersections will prove less relevant to pollinators for the majority of the foraging season.

The further the flight distances per species, the more access they have to forage and nesting sites. It is necessary to consider the types of uncultivated areas, however: for example, shallow/open water bodies likely will not have the same variety of flowering plant species as marsh sites with a higher standing water concentration.

The flight distances also indicate the areas that will receive pollination benefits during the blooming periods of agricultural crops. Although these concentric circles radiating outwards do not limit flight distances by all pollinators, it does indicate a pattern of higher density pollinator practices by accounting short to short-mid range flight distances.





Native bee species are not limited by anthropogenic boundaries, despite the overwhelming impact they have on the landscape. For short-range flight distances, the direct surroundings are of utmost importance, particularly in the way of uncultivated areas that will provide additional forage space.

100m diameter

Species with further flight distances will have more uncultivated areas available to them. This is beneficial to native bee species so long as these areas are available. In years of higher precipitation, the connections will be increased between patches as the uncultivated areas are larger. Without, the patches will be subsumed by the matrix.

200m diameter

50m 100m 250m

Existing Well Pads and Access Roads

Shallow / Open Water

Swamp

Marsh

 Figure 3.1.08: DUCs (2017c) polygons are overlaid with satellite imagery (Google Earth, 2017) extending in concentric circles from identified oil well sites

The proportion of patches to matrix is more visible the larger the flight ranges. There is significantly more cultivated area to uncultivated area with fewer connections between sites; often, the patches remain solely as patches, small and isolated with varying precipitation conditions.

With the largest flight ranges, the bees can access resources beyond the fields. In theory, this is beneficial, but when fields are adjacent to other fields, the space is still limited. It is, therefore, necessary to use the oil well sites to the greatest possible extent.

300m diameter

400m diameter

Oil Pump Jack Sites   Highways   Access Roads   5,750 linear kilometres of access road

“Ranging in length from about a sixteenth of an inch to more than an inch, ... [native bees] vary in colour from dark brown or black to red or metallic green and blue; some have stripes of white, orange, yellow, or black; and some even have opalescent bands. Their common names include plasterer bees, leafcutter bees,

The oil well sites can act as a home base, providing specific nesting and forage sites. However, due to the small scale of the oil well sites, they can host <u>some</u> nesting and <u>some</u> forage space, but the uncultivated areas nearby will provide additional resources. It is this relation between the uncultivated areas and oil well sites in *Figure 3.1.08* that is made visible.

According to Heather Holm (2014, p.42), “The loss of habitat is very disruptive to pollinator populations and it can create an imbalance between effective pollinators and ineffective pollinators, with more of the latter. **In a smaller, fragmented landscape, there is a risk of pollinator inbreeding due to small pollinator populations.**” As witnessed by the increase in flight distance from 100m to 200m, the landscape is still fragmented but with an increase in available foraging and nesting space. Holm (2014, p. 42) goes on to present a solution: by “connecting or enlarging fragmented landscapes by reintroducing native plants can increase the survivability of pollinators and reduce the pressures associated with invasive species and competition.” As visible in *Figure 3.1.08* , the oil well sites are often near to uncultivated areas as per DUCs polygons (2017c), but they often overlap with depressions as indicated by the satellite imagery (Google Earth, 2017); the darker colours represent depressions and the associated vegetation. The uncultivated areas increase drastically for pollinators that can fly farther distances (*Figure 3.1.08*). The uncultivated areas will act as important stepping stones but, as indicated in *Figure 3.1.08*, shorter flight distances will suffer. As a result, the access roads can be used as the necessary connections between oil well sites, uncultivated areas, and other access roads. These linear patches will break up the monotony of the monoculture matrix and decrease the effects of habitat fragmentation.

Holm (2014, p.39) states: “the natural layout of an agricultural site can also determine where the best pollinator habitat can be incorporated. ... Within these tracts, long narrow corridors can be planted with pollinator-specific native plants. Incorporate nesting materials such as plant debris, rock piles, standing dead trees, downed logs and leaves. Combined with areas of bare ground, these materials provide valuable nesting sites in the corridors.” Fortunately, the natural layout of oil well sites and their access roads are naturally structured with long corridors. The materials, however, will have to be considered according to the sites; as of now, the access roads are packed gravel infused with some invasive species.

The access roads, despite their inappropriate materiality for bee populations, contain some conditions that Holm (2014, p.38) recommends: “marginal, open, sunny areas such as grassed waterways, ditches around fields or riparian edges are good sites to create pollinator habitat by adding forage plants.” Generally, “forage and nesting sites for native pollinators develop from mason bees, carder bees, digger bees, and carpenter bees, reflecting the many ways they build nests. Others are named after a particular behaviour: sweat bees lap up perspiration for salt; bumble bees hum loudly as they fly; cuckoo bees lay their eggs in the nests of other bee species; and honey bees, an introduced species, make and store honey."

The Xerces Society, 2003, p.16

the protection or enhancement of existing natural habitats" (Holm, 2014, p.38). As *Figure 3.1.08* indicates, there is an abundance of uncultivated areas, but yearly precipitation will have an impact on how much area and how many patches are available. With the surrounding land use subsumed by agricultural crops, there is always the risk that shallow/open water areas and marshes will be drained or that land users will have no interest in enhancing the sites.

Beyond that, "most ground-nesting bees prefer to nest in slopes or exposed banks" (Holm, 2014, p.35). To protect and encourage these sites, Holm (2014, p.35) recommends sites "provide areas of bare soil and protect existing nests from disturbances such as tilling, plant removal, or compaction." With the varying levels of water and arable land each year, management must account for the retention of ephemeral and semi-permanent areas. As alluded to on the previous page, "**most native bees nest in the ground**." However, "the *precise* conditions needed by [specific] ground-nesting bee species are not well known" (Vaughan et al., 2007, p.25). However, Vaughan et al. (2007, p.25) list some guidelines that can create successful ground-nesting bee nest sites that, "when the conditions are right, a cubic foot of soil can contain hundreds of nest cells, each cell containing a bee that will emerge the following year" (Vaughan et al., 2007, p.26):

1 Maximize untilled ground: use spaces that are not impacted by farmer tilling;

2 Semi-bare ground: "clear some of the vegetation from a gently sloping or flat area that is not under cultivation" but "well drained, in an open sunny place, and, where possible, on a south-facing slope;"

3 Soil piles: excavate soil and stabilize with grasses and wildflowers (Vaughan et al., 2003, p.25).

Ground-nesting bees are not the only bees that require site maintenance. Some species, such as leafcutters and masons, are wood- or tunnel-nesting bees (Vaughan et al., 2007, p.27). Holm (2014, p.35) recognizes that "standing dead trees (snags) provide excellent nesting habitat for native pollinators. ... Logs lying on the ground are also used for nesting sites." In terms of human intervention sites, materials such as wooden blocks with multiple holes drilled in of different sizes and bundles of stems or straws can be installed (Vaughan et al., 2007, pp.27-28). These, however, will require more consistent maintenance to keep clean and prevent spread of pathogens and diseases. They should, however, "be mounted in a location that receives morning sun, but has some protection from the extreme midday summer heat. Generally, the nest entrances should face southeast ... and be erected at least four feet above the ground ... and fastened securely so that they do not move in the wind" (Vaughan et al., 2007, p.28).

BEE TOWERS

artificial wood-nesting bee homes

As the site analysis and flight distances indicate, bees are either losing nesting sites or unable to reach them. By repurposing the oil well sites to host bee homes, the strategy will create these much-needed sites and materials.

The intervention is simple: towers will be constructed to host wood-nesting bee homes.

Within a sparsely treed landscape, wood-nesting native bee species have fewer options to create safe homes. Coupled with people's desire to remove dead and broken trees for aesthetic reasons, wood-nesting homes are even fewer. The strategy requires certain conditions to be filled to prove effective.

artificial bee homes

"Native bees nest in a variety of habitats, so it is possible to provide additional nesting habitat with a few simple techniques" (Holm, 2014, p.34). This strategy applies tried-and-true wood-nesting bee building methods that stems from inexpensive and easily sourced materials. By using simple, modular design constructs, these bee homes can be easily built. Inexpensive and easily sourced materials such as untreated wood blocks, logs, and hollow stems can be found and/or donated. The hollow stems can be safely established into recycled gathering pipelines or hollowed out logs, depending on pipeline and/or untreated wood logs availability.

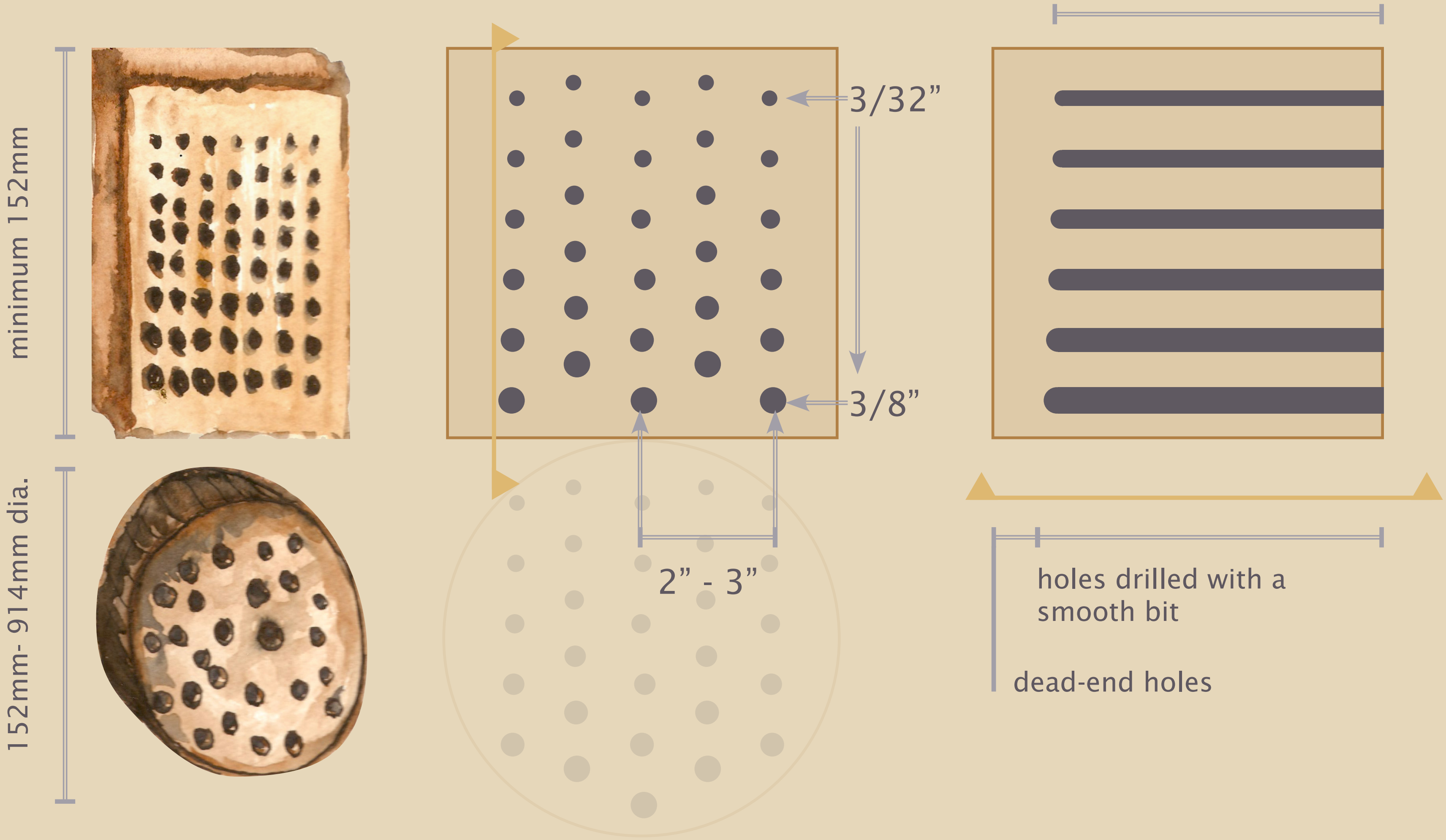
bee boards

"Cavity nests can be constructed by drilling holes in a block of untreated wood. Drill long, dead-end holes between 3/32" and 3/8" in diameter into a 6"x6" board, sparsely-spaced (two to three inches apart). Use larger-sized holes when incorporating liners. Mason bees ... and leafcutter bees ... commonly use these bee boards for nesting" (Holm, 2014, p.34). This method requires some maintenance: "It is important to clean bee boards with a 3:1 water-bleach solution or replace liners every two years to prevent disease and pathogen transmission. If cleaning or liner replacement is not feasible, a better alternative is to provide natural, less concentrated cavity-nesting sites in standing dead trees, perennial plant stems or downed logs" (Holm, 2014, p.34).

hollow or plithy plant stems

"Many native perennials and shrubs have hollow or pithy plant stems. Cut perennial plant stems down in late spring leaving 18" of stubble as potential nesting sites. Hollow stems can also be bundled together in small bunches (5-10 stems, 6" long) and hung horizontally in a location that receives morning sun and afternoon shade, away from vegetation" (Holm, 2014, p.34). Some possible plants include Spotted Joe Pye Weed (*Eutrochium maculatum*) and elderberry shrubs (*Sambucus canadensis*) (Holm, 2014, p.34).

bee blocks



hollow stems

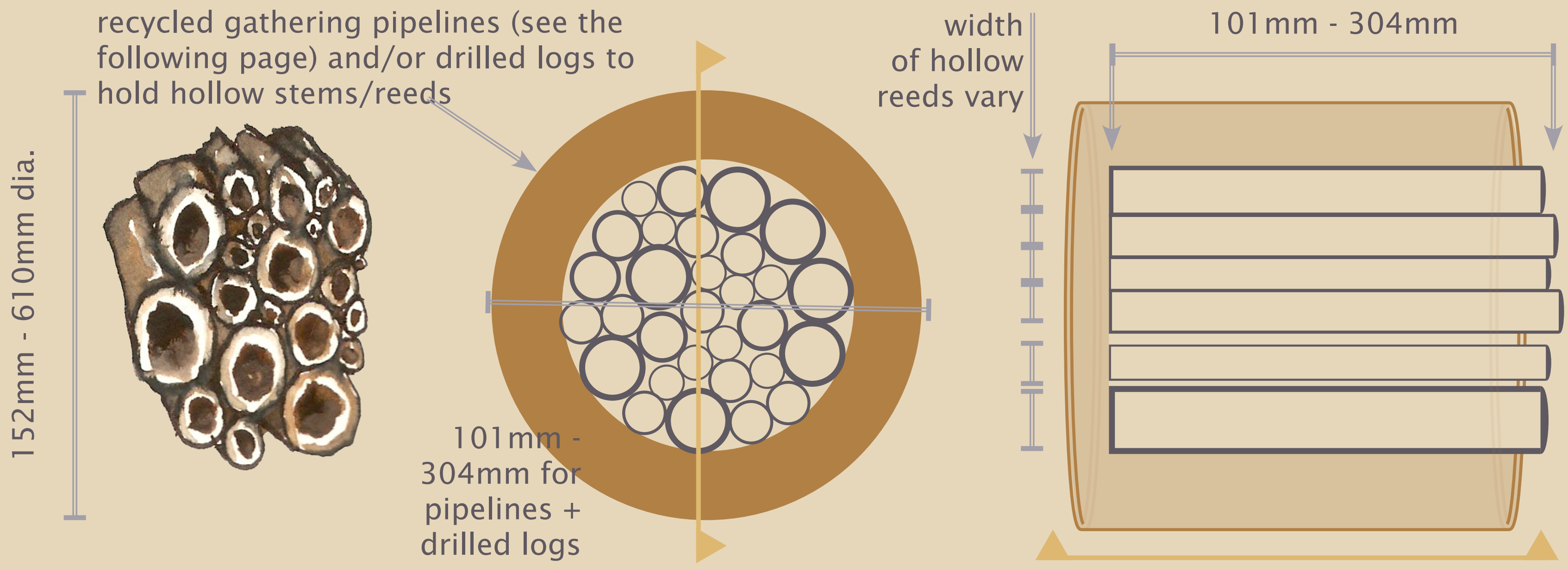


Figure 3.1.09: diagrams are derived from information provided by Holm, 2014, p.34

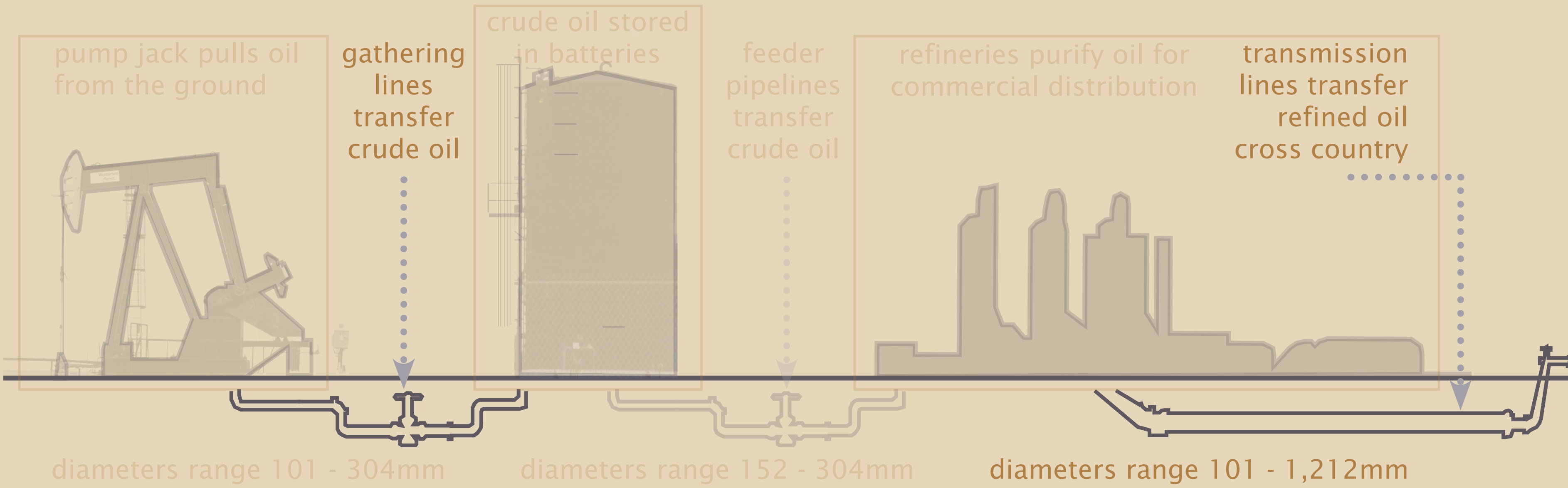
bee towers

The landscape of southeast Saskatchewan is often windy and, with scarce tree growth, there is little relief. The artificial bee homes, in turn, require a solid material that can withstand the elements. Steel pipelines are capable of this and, by using recycle pipelines, less waste will be created in bee home construction.

The insertion of the bee homes can vary in placement and organization, so long as the minimum indicated area is filled. With modular constructs, the bee homes can be replaced.

The recycled pipelines of choice are transmission lines (see *Figure 1.2.04* for more). According to the Canadian Energy Pipeline Association (2015), transmission lines vary from 101mm diameter to 1,212mm diameter, with the majority ranging from 254mm to 457mm diameter. Although the exact width is not important, the recycled transmission lines for this intervention must be between 457mm to 1,212mm to host enough interior space to insert bee homes. The height is addressed on pages 138-139.

The pipelines will then be cut in half length-wise and sterilized, creating a hollowed opening that will be surrounded on three sides for the protection of the inserted bee homes. They will be installed similar to a power pole, with a certain percentage required below ground and with appropriate support.



 from *Figure 1.2.04:* the process of oil from pump jack to people's use, information and imagery adapted from Canadian Energy Pipeline Association, 2015

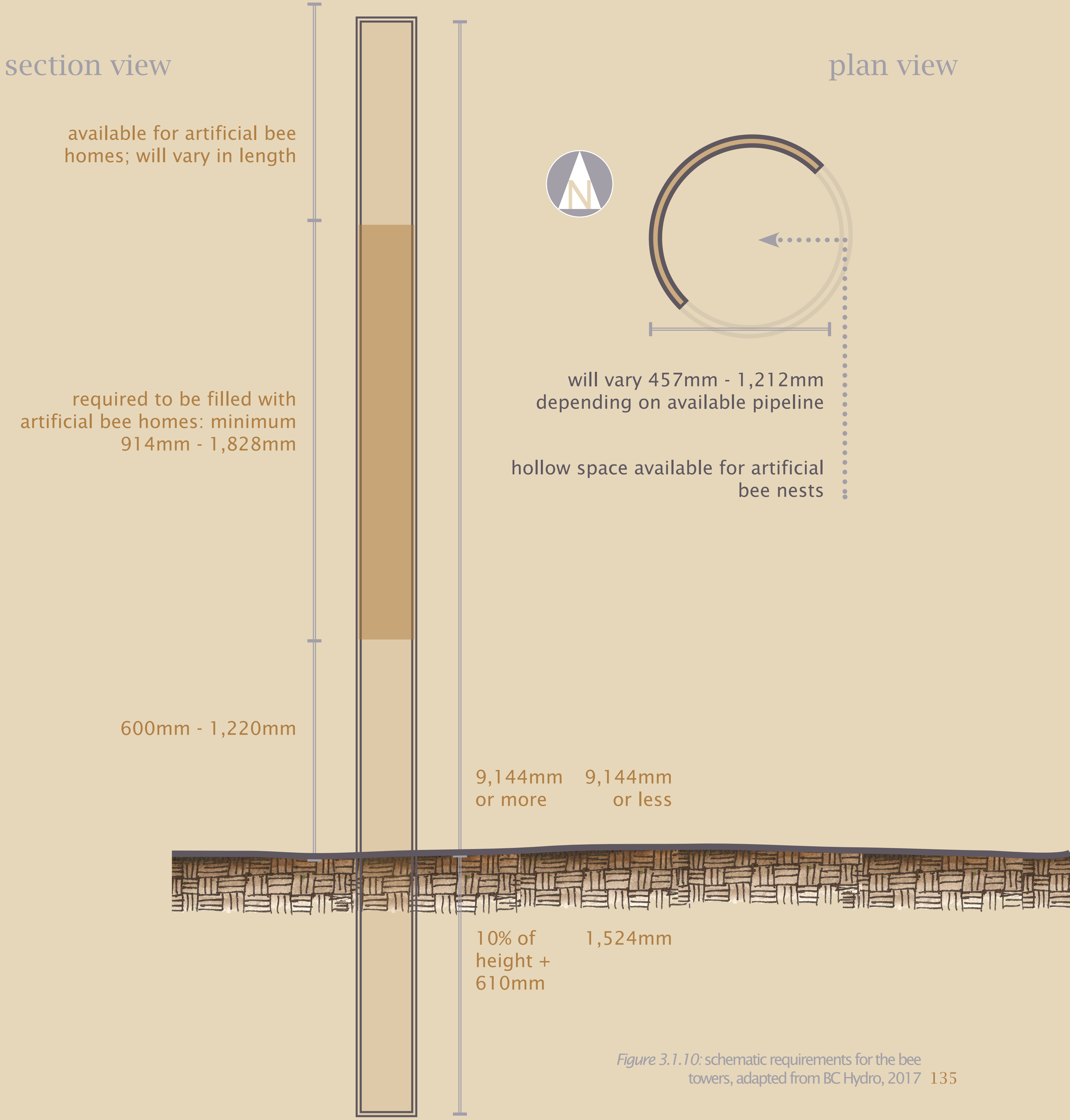


Figure 3.1.10: schematic requirements for the bee towers, adapted from BC Hydro, 2017

bee towers with bee homes

When the artificial bee homes and towers are installed and completed, the towers will provide a variety of nesting sites for a multitude of native bee species. As the intent is not to focus on any singular species, the promotion of multiple homes is desirable.

The towers are not intended to look the same. Each tower may host a different organization and amount of bee homes and this is acceptable, so long as the minimum requirements are met. The bee homes may vary on amount and placement due to availability of supplies, but with a modular construct and set pipe diameters, it will be less difficult to meet these requirements.

To view the effectiveness of the applied alternative land use strategy, it is possible to witness the bee nests building over the course of the warm seasons. As nests are built in the holes in the bee boards and the hollow of plithy plant stems bundles, “the wood-nesting female [bee] will seal it before she leaves. The seal is generally made with the same materials used for the nest, such as leaf pieces” (Vaughan et al., 2007, p.29), filling the dark holes with a green cap. By simply viewing the wood blocks over the course of a season, it is easy to visualize the success of the bee tower installations and the accompanying habitat. Over time, the natural materials in the bee towers may decay, but this is acceptable; other wildlife species may occupy the towers.

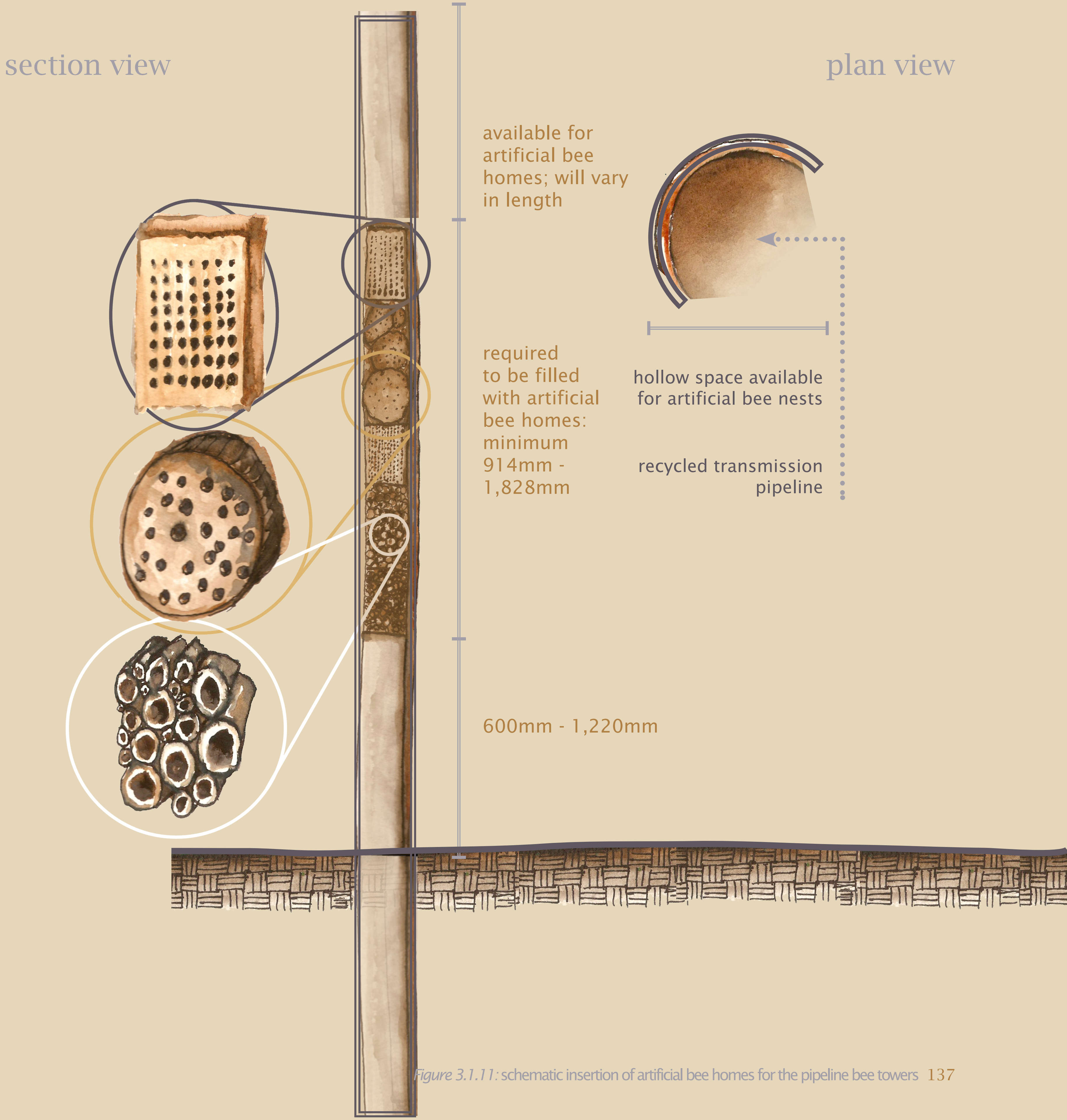


Figure 3.1.11: schematic insertion of artificial bee homes for the pipeline bee towers

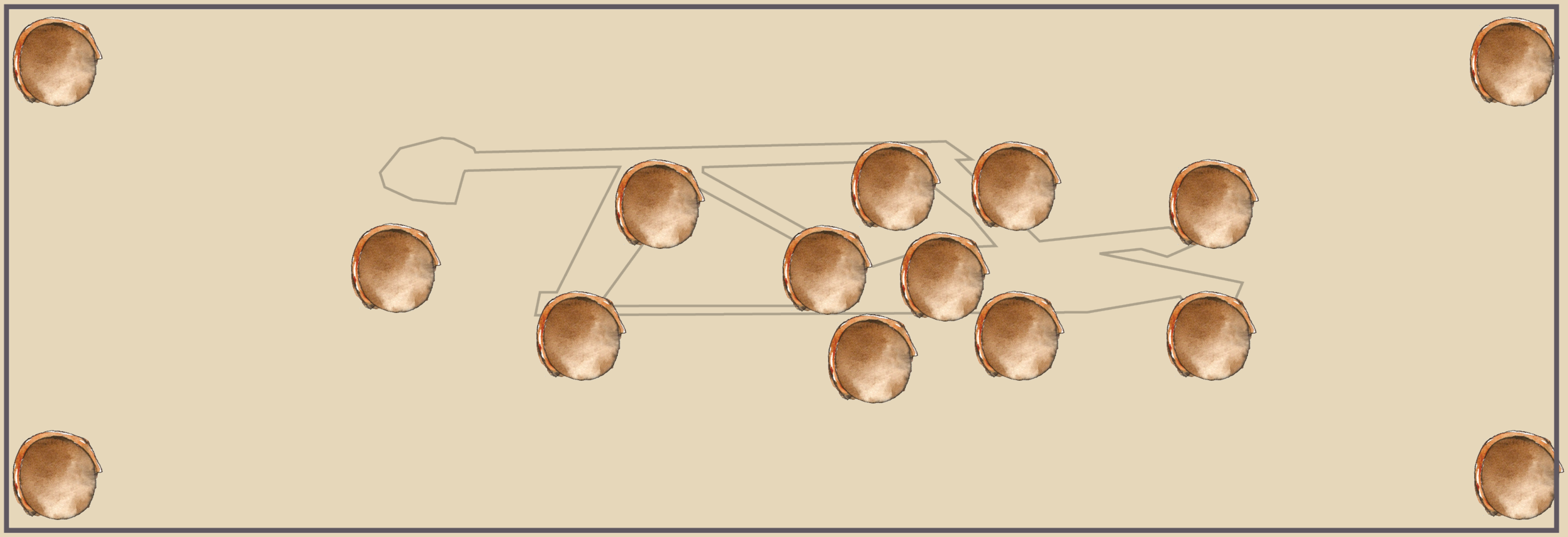
bee towers organization

The bee towers will not be placed at random on the repurposed oil well sites. Instead, they will be used as markers of past infrastructure.

The heights of the bee towers will reflect some of the heights of the pump jacks components, organized to create density where the thick supports of the pump jacks once existed. In turn, there are voids between the bee towers where there would have been voids in the structure of the pump jacks. A minimum of ten bee towers must be present per previous pump jack site to showcase the scale of the now-removed pump jack.

They will be limited to the footprint of the pump jack and the outer edges of the fencing that surrounds the pump jack. Although the pump jack itself is not retained, the preservation of the site and the allusion to the visual impression of the vertical elements will retain that strength of repetition that stands so strongly against the horizon from the previously located pump jacks. The upright, cylindrical structures will have similarities to the structures of the power poles that follow grid roads and provide power to the outlying communities, but upon second glance the bee towers, with a differing texture, will stand separate in clumps laid across linear paths.

diagrammatic plan



diagrammatic section -- pump jack footprint

Figure 3.1.12: diagrammatic organization of the bee towers on a repurposed oil well site

 Figure 3.2.01: an uncultivated area appears before a pump jack on the horizon near 16-004-06-W-2 in southeast Saskatchewan

32 RE-VEGETATING

flowers and flights and forage delights

REGULATIONS AND MODIFICATIONS

post-industri-oil to productive green infrastructure

The bee towers are necessary to provide homes for native bees, but without food and nest-building supplies, they will prove ineffective. As the oil companies disrupted the fields with the original oil infrastructure, they are responsible for repairing these spaces as well (Fortugno, 2004).

Although the Government-mandated requirements outline necessary remediation, restoration, and re-vegetation standards, modified standards can be adopted by government regulations for oil companies to account for bees as part of the overall landscape health and productivity. All of the post-production oil well sites will have to meet the government regulations laid out in Chapter 2.1 with the process summarized in *Figure 2.1.02*. *Figure 3.2.02* lays out the required procedures and, more importantly, the conditions that the oil well sites must legally be brought to post-production.

When observing oil well sites for alternative land use strategies, the steps in *Figure 3.2.02* describe the necessary procedures evaluated by the Government of Saskatchewan regulations (2015c). However, **alternative land use strategies questions the necessity of using the provided definitions for the processes beyond 'remediation' in *Figure 3.2.02*.**

Remediation is required for the environmental health and removal of dangerous contaminants from sites. This steps is appropriate to retain; based on standards from the Canadian government (see page 91), remediation essentially ensures the previous industrial land is toxin-free. As re-vegetating is a part of the design strategy to promote bee populations, environmental health must be assured prior to any alterations to the site(s).

Conservation, where possible, is also a suitable step. As the pump jacks exist in varied locations, conservation must be considered on a well-by-well basis as part of the surrounding conditions. If any toxins or contaminants have spilled into uncultivated areas, it must be remedied prior to the oil companies completing their legal obligations.

The remaining steps will be reviewed for their ability to promote bee populations (see *Figure 3.2.03*). It is not that the steps are irrelevant, but that they may not be suitable in their current form. The oil companies, responsible for the treatment of the site post-decommissioning, will have legal responsibilities but, with careful reconsideration, the responsibilities could shift to manage the health of the larger landscape through bee population encouragement.

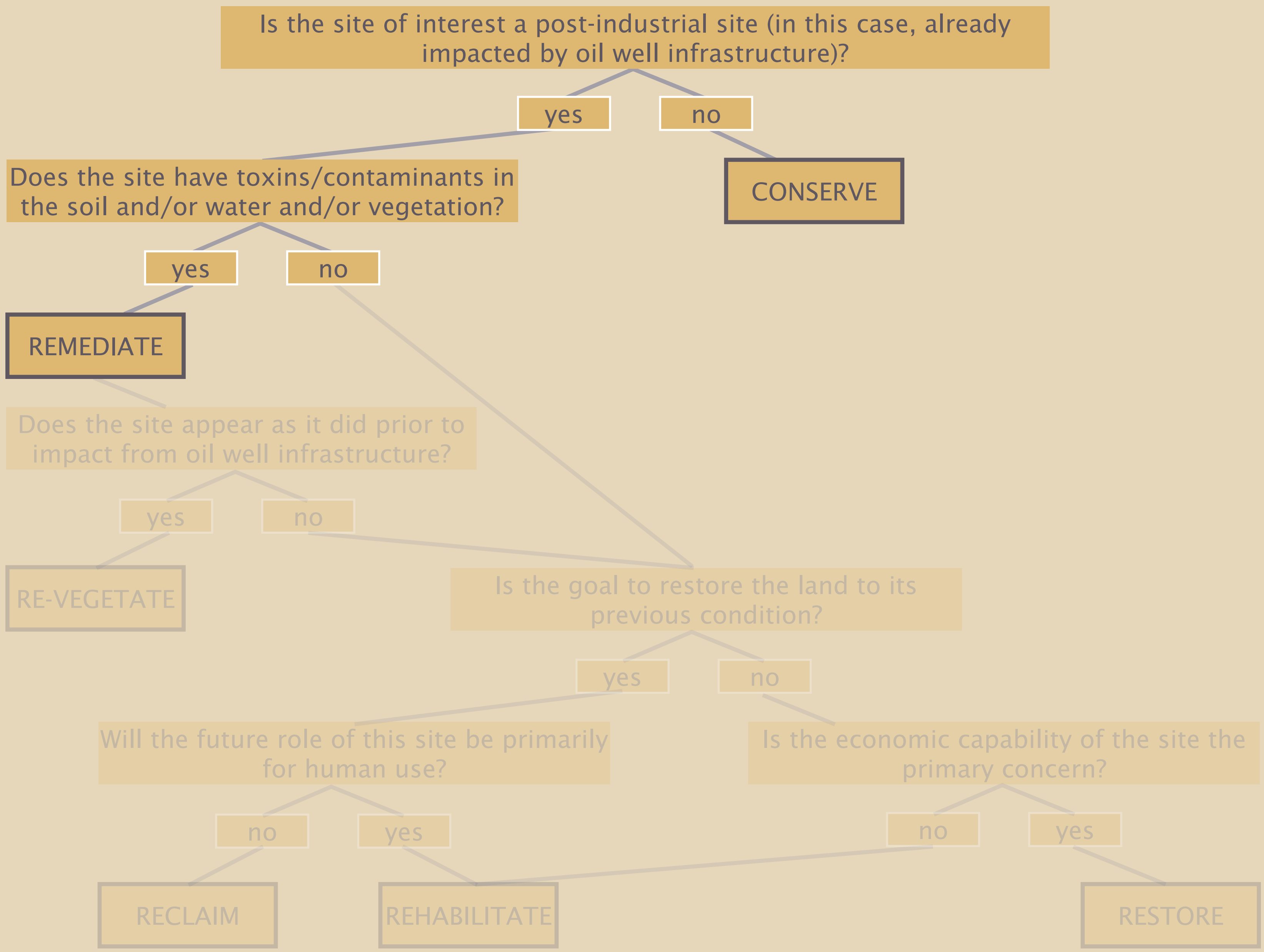


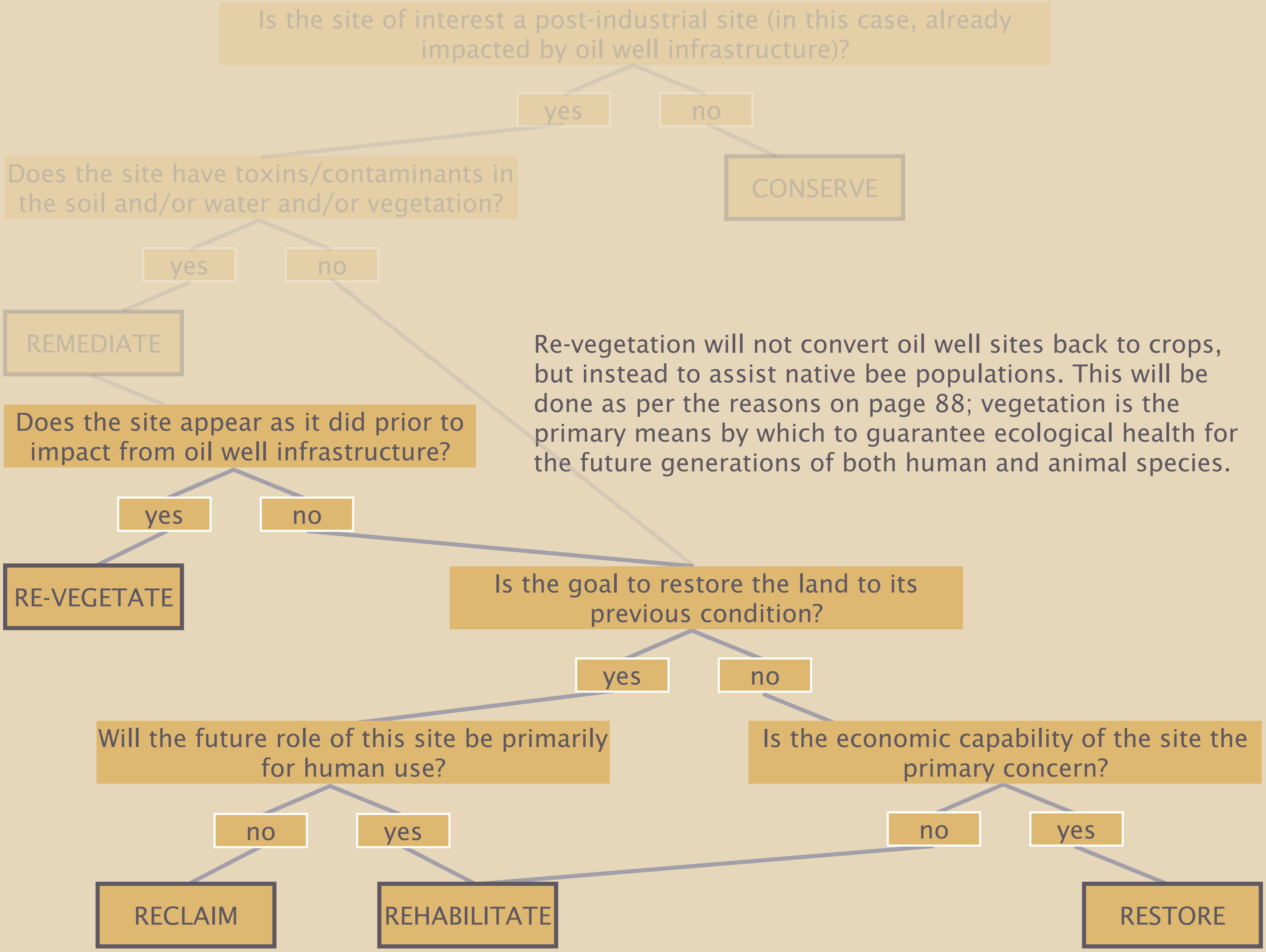
Figure 3.2.02: my interpretation of a chronological understanding of the language of post-industrial treatment – identifying the value of each step #1

The steps following remediation assume that the oil well companies have already accomplished the required environmental health standards.

These steps reference processes that may not promote a new land use strategy or any heritage and culture based response: they refer to altering back to the previous agricultural landscape and/or promoting human use and occupation. For the sake of environmental health and laws, remediation will be followed according to the regulations of The Oil and Gas Conservation Act, 2012 (Government of Saskatchewan, 2015c). The rest of the steps, however, will be interpreted to suit the needs of the overall ecology of the farming landscape, using a different lens to analyze their potentials.

For example, re-vegetation is a key means of changing the oil well sites from bits of barren gravel to a producing landscape. However, re-vegetation may be used in the context of re-vegetating to the surrounding landscape, i.e. agricultural crops. Perhaps suitable in some cases, this is a narrow-minded perspective of what re-vegetating could mean. When analyzing from a time-based perspective, for example, could re-vegetating not refer to pre-agriculture, re-vegetating to the pre-existing moist mixed grass prairie landscape? The appropriate timeline may be the historical timeline, and not the land use from the past 150 years but instead the past tens of thousands of years. This will be addressed in the applied design, considering the palimpsest of prairie land use.

Although human interaction on the oil well sites is an undesirable element to designing landscape in this region, highly modified (past and continually) anthropogenic landscapes must acknowledge the human aspect of land use, as per the objectives fo this practicum. For the oil well sites of southeast Saskatchewan, this means creating situations where treating the sites will not negatively impact the surrounding arable landscape. Reclamation, rehabilitation, and restoration all require human consideration, and careful design can use this to the ecological benefit as well. Using monetary and human appeal can provide one set of guidelines of oil well site reparation without promoting this as the singularly most important aspect. These requirements can be used as an appealing factor for oil well site treatment, but must be considered as only a part of the treatment. Therefore, reclamation, rehabilitation, and restoration will shift to acknowledge pollinator services. Economic capability and human use will shift to appreciate and respect the contributions of native bees for crop yield and economic return, as opposed to the direct financial gain from crop yields. These sites will still reference direct human use, but from a worldwide perspective of pollination and the greater productive capabilities of less land.



Re-vegetation will not convert oil well sites back to crops, but instead to assist native bee populations. This will be done as per the reasons on page 88; vegetation is the primary means by which to guarantee ecological health for the future generations of both human and animal species.

Reclamation will refer to the future oil well site conditions as reclaimed, suiting ecological processes, not crop land.

Rehabilitation will refer to the broader scope of humanity; the benefits to land use and users may not be immediately visible, but will affect the future state of the larger landscape.

Restoration must be addressed on the financial aspects of future land use; the oil well sites must reach equivalent land capability. However, the financial side can be addressed in other ways.

Figure 3.2.02: my interpretation of a chronological understanding of the language of post-industrial treatment – identifying the value of each step #2

standard oil well site treatment process

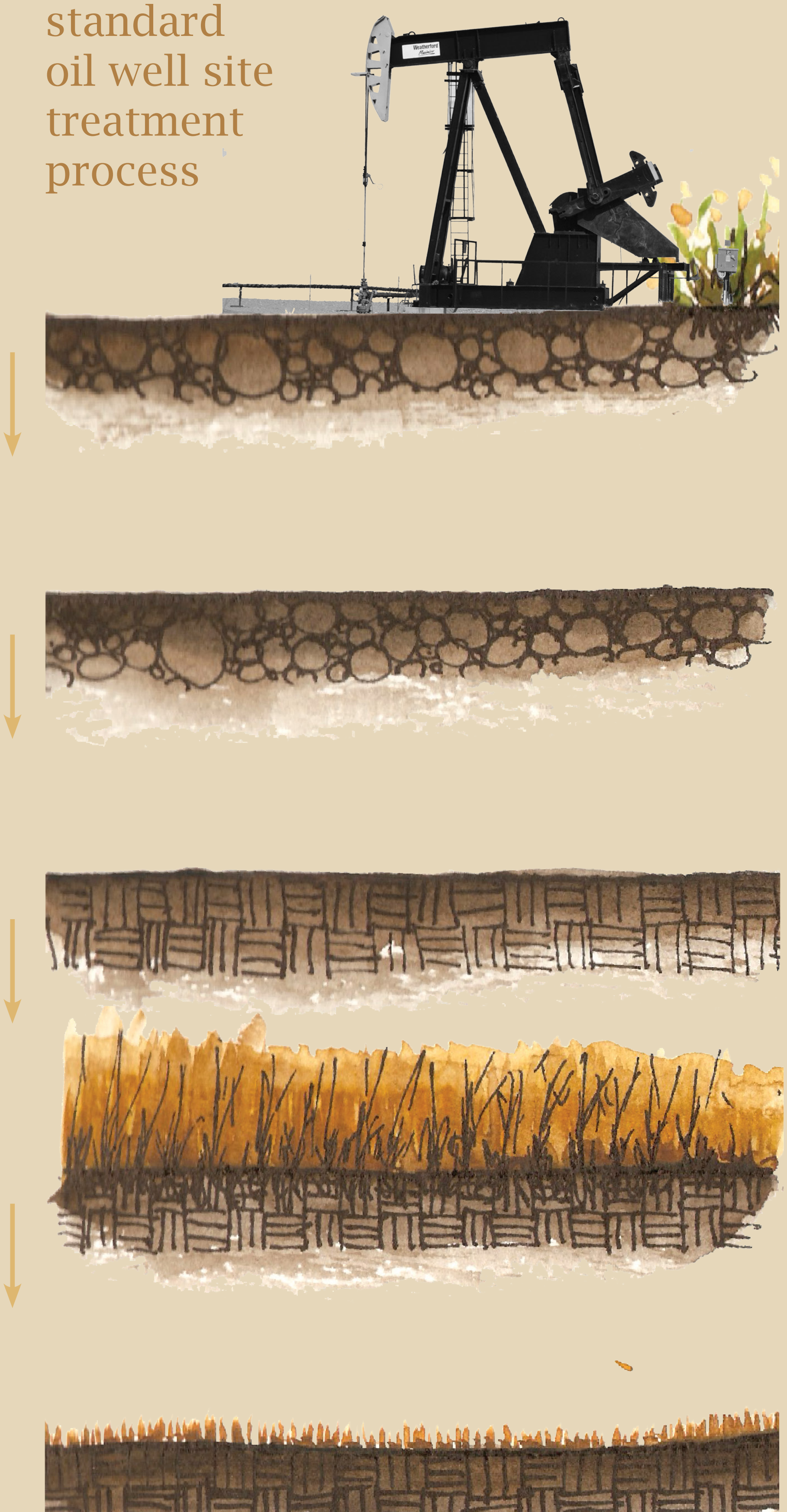


Figure 3.2.04: schematic diagram of current oil well site treatment

oil well site installation

The oil well site installation may recognize uncultivated areas, but as the site analysis (Chapter 1.4) indicates, there is no clear indication that uncultivated areas drive the location of oil well site installation; the regulations (pages 88-93) have more sway.

oil well abandonment

The abandonment process requires the removal of the oil infrastructure on site (see Chapter 2.1). There are no listed requirements for vegetation treatment, particularly removing established invasive species that often line the periphery of the site and access roads.

oil well site remediation

The remediation process requires treatment to ensure environmental health (see Chapter 2.1). It does not, however, refer to plant-based remediation -- such as phytoremediation -- or ensuring all invasive species are wholly removed.

oil well site re-vegetation

Re-vegetation does not refer to the specific vegetation that should be (re)instated, but instead that the ground is capable of having vegetation on site. For farmers, it would be most efficient to re-vegetate to the surrounding crops, even though that is not required.

oil well site future function

Converting the abandoned oil well site to crops is a reasonable expectation considering the surrounding land is, quite often, agricultural crops. This is an acceptable function, although it neither provides any new services nor addresses needed services.

recommended oil well site treatment

The installation and abandonment of oil well sites are regulated by the government and, for the sake of this practicum, acceptable in its processes and requirements. **The goal is not to require an overhaul government regulations but instead to work within those boundaries at the point that the necessary regulations end or can be adjusted**. This is particularly true for the potential planting plans.

With the surrounding land use dedicated to agriculture, planting is an exceptionally important consideration, whether it be the introduction, maintenance, or removal of species. This is why, as indicated in *Figure 3.2.03*, the language of post-industrial is accounted for, but with alterations to the definitions to suit the needs of an alternative land use strategy. Essentially, **re-vegetating should not be limited to a site-by-site basis, but instead capable of affecting the larger ecosystem**. These holes are part of a much larger landscape, not just physically but ecologically: ecological connections are not limited by anthropocentric boundaries and, as such, must be considered within this realm of thought.

oil well site remediation

The oil well site remediation is valued as it prescribes a regulated standard for how environmentally healthy a site must be upon abandonment. This **guarantee means that this practicum can safely propose alternative planting methods** for these sites.

oil well site revegetation

Re-vegetation can be considered alternatively from the surroundings: it is necessary to shift these oil well sites to a bee-friendly planting scheme, acknowledging the needs of native bees within the surrounding agricultural vegetation.

oil well site future function

The (re)installation of bee-friendly plant species will provide **invaluable habitat that varies from the monocultures of crops** for a variety of species, it will enhance biodiversity retention in the region, and yet it can still acknowledge the oil well sites.

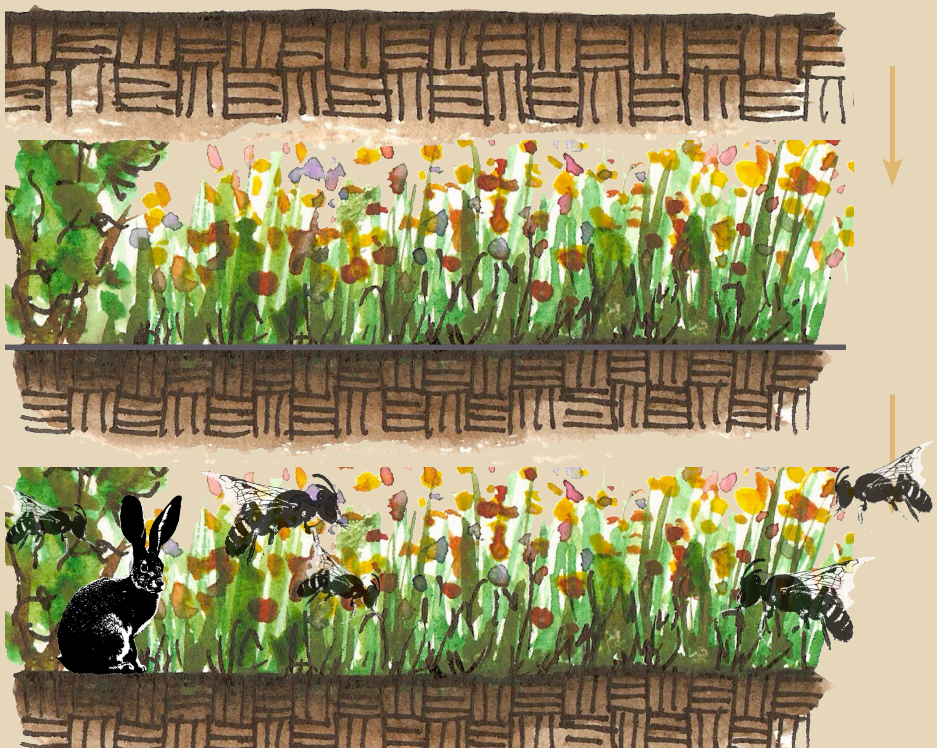


Figure 3.2.05: schematic diagram of repurposing oil well sites

RE-VEGETATION STRATEGY

from monoculture matrix to pollinator patches

The oil well sites are ideal for bees within the field, excepting the floral capacity. Repurposed, the well pads provide the patches needed within the agricultural matrix for bees to nest within. The access roads, as part of the oil well infrastructure, provide the much needed connections from patch to patch, but only when they are appropriately repurposed. If repurposed appropriately, the bees will be able to travel and live both within and around the field. Although the uncultivated areas exist, their changing conditions cannot be relied upon year after year (see Chapter 1.4). Bees are not static beings, but they still require a continual supply of uncultivated areas in which to nest and/or forage. By guaranteeing the repurposed oil well pads and access roads as spaces that cannot be cultivated, the bees will have continuous nesting and forage sites available to them. The repurposing strategy, must account for the bees greatest needs with nesting sites established: food.

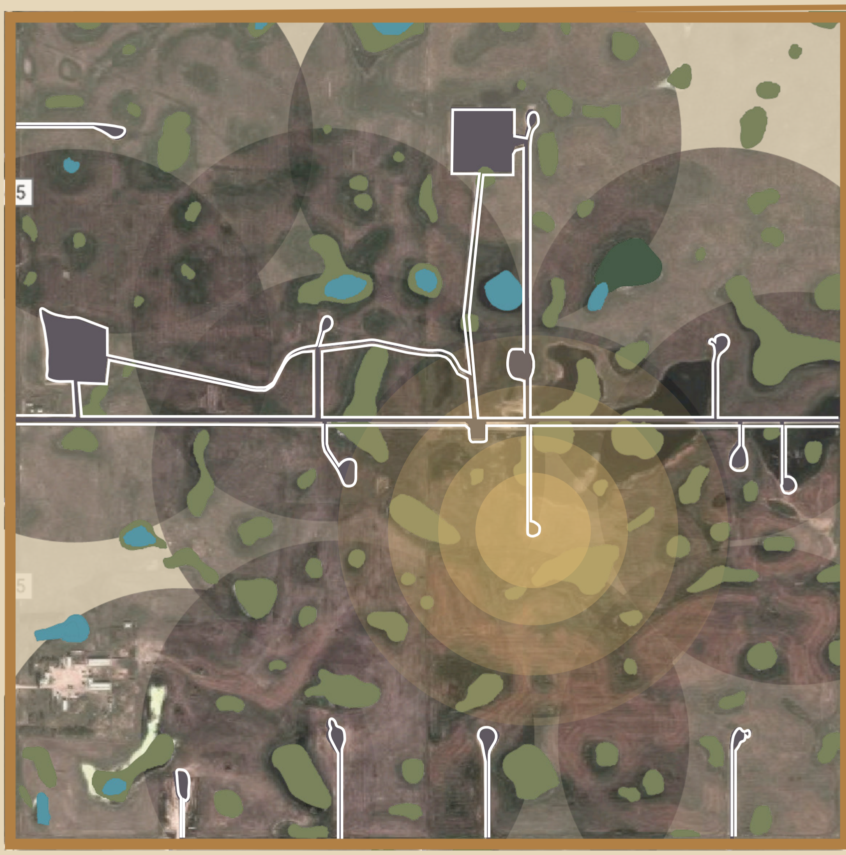
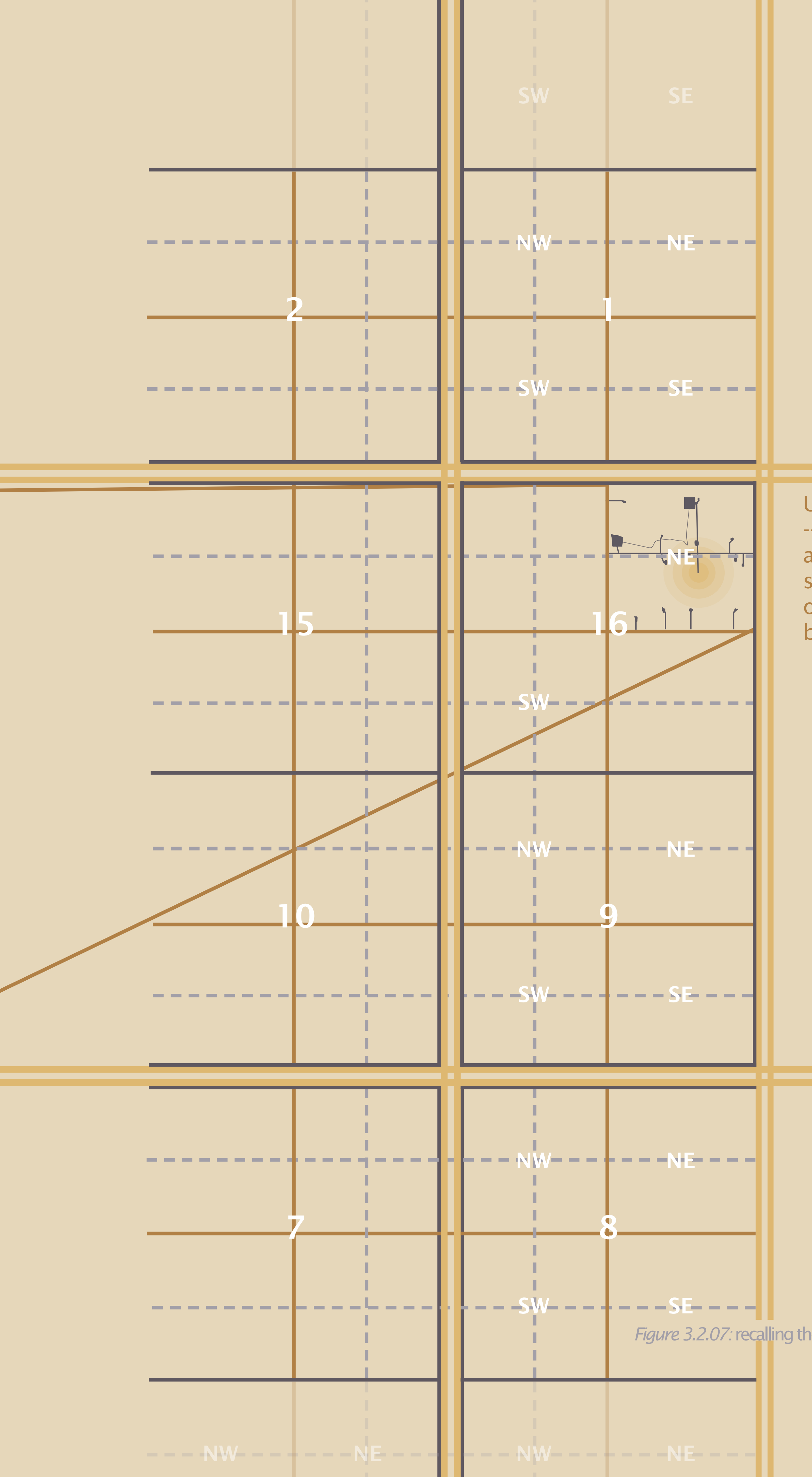


Figure 3.2.06: 400m flight distances from *Figure 3.1.08*

Oil Pump Jack Sites | Highways | Access Roads

Existing Well Pads and Access Roads | Shallow / Open Water | Swamp | Marsh

N 50m 100m 250m



Using the chosen site -- 16-004-06-W-2 -- the applied site distances showcase an example of flight distances within a section. It is visible that the repurposed oil well sites provide a much needed break amongst the field matrix.

Figure 3.2.07: recalling the surveyed structure of Saskatchewan *(Figure 1.1.13)*

1 eliminating invasive species

According to the Saskatchewan Guidelines For Use Of Native Plants In Roadside Revegetation Reference Manual (Neufeld, 2008), there are some steps that must be followed. First, the elimination of invasive species must be as intensive as possible. Invasive species "flourish in the disturbance-prone habitat they are adapted to" (Neufeld, 2008, p.16) and, with the anticipated disturbance of oil well sites, these sites will be susceptible to quick invasion by noxious species.

2 implementing native species

To counter invasive species, Neufeld (2008, p.16) recommends "by seeding native species as soon as possible after exposing bare soil, the chances for weed establishment are lessened. Most native grasses are quick to germinate and will readily establish in the first year. Although it may not be evident by looking at top growth, these seedlings are growing rapidly; most of their energy is being directed into producing extensive roots." Annual weed species can only dominate while their is no competition.

3 an established native species

Some "perennial weeds pose a larger and more long-term threat. Broad-leaf herbicide application during or after seeding native grasses may be required, along with other control measures." However, "once established, the native community should be able to deal with potential infestations ... as the dense ground cover provides little opportunity for weed seeds to germinate" (Neufeld, 2008, p.17). The native species will reduce erosion, runoff, sediment transportation, and chemical infiltration (Neufeld, 2008, p.15)

 Figure 3.2.08: steps 1, 2, 3 to removing invasive species, adapted from information by Neufeld, 2008

4 native species for bees

The Xerces Society (2003, p.79) states: "Native plants are usually the best choice to attract native pollinators not only because they evolved together, but also because the plants are well adapted to your local growing conditions, soils, and climate, and can thrive with minimum attention." Although some invasive species, such as purple loosestrife, are excellent sources of pollen, they negatively impact the larger landscape's biodiversity and, therefore, are not a suitable option (The Xerces Society, 2003, p.86).

5 colour blocking and visibility

The Xerces Society (2003, p.83) has further instructions for planting: "To form the larger clusters that attract many pollinators, plant flowers to form blocks of coloured blooms rather than scattered spots of colour. It is best to plant several individuals of the same species together." Furthermore, planting blocks of single species rather than multiple species of the same colour will be even more effective, "since the blooms of a particular native species will tend to vary little in colour" (The Xerces Society, 2003, p.84).

6 cyclical forage patterns

The Xerces Society (2003, p.49) insists that forage sites have "a diversity of native plants whose blooming times overlap to provide flowers for foraging throughout the seasons." This step is a crucial component of native plant species revegetation; although native species are beneficial overall, the bee species must be attracted to the specialized analysis of plant species and intentional application of certain species, particularly in the early stages of implementation.

Figure 3.2.09: steps 4, 5, 6 to implement native plant species, adapted from information by Xerces Society, 2003

RE-VEGETATION SCHEDULE

invasive weeds to native seeds to feeding bees

Using guidelines presented by Morgan, Collicutt, and Thompson in Restoring Canada's Native Prairies: A Practical Manual (1995), the oil well sites will be treated in such a way that restores a native prairie. Restoring a native prairie differs from the definition of restoration presented earlier in this document (see page 90). According to governmental regulations (SPIGEC, 2009, p.4), "restoration refers to the physical reclamation process involving recontouring, replacing topsoil, and re-vegetating to restore the surface of the land to its equivalent land capability." Ecological restoration, however, means "to re-establish on a site a native plant and animal community that once occurred there and is uniquely adapted to that area" (Morgan, Collicutt, et al., 1995, p.2).

As one objective in this practicum is to assist bee species in continual population growth, the oil well sites cannot be repurposed by planting without planning for the long-term. This includes the removal of invasive weed species. The Xerces Society (2003, p.86) recognizes that "a weed [is] any invasive non-native species, even if it is a good plant for pollinators, because it degrades the overall plant community by reducing the diversity of species." Although bee population growth is the leading reason for using native plant species, it also works with the practicum objective to respect surrounding land users; farmers cannot have invasive species introduced in their fields as it will overwhelm crops.

1 Site Selection

When proposing an alteration in planting schemes, the economic aspect will be a concern. To appease these concerns, Morgan, Collicutt, and Thompson (1995, p.5) state: "Planting prairie ... has significant positive economic advantages. Costs per acre for planting prairie are very competitive with traditional methods. Long term maintenance costs for prairie plantings are virtually nil. All that is required is an occasional mowing once every few years or a managed burn if feasible. Watering, mowing, and fertilizer applications are not required." These cost benefits can be further exploited for companies interested in appearances. "In today's era of declining budgets, native plantings are easier to justify to cost conscious clients and taxpayers. They also contribute to the image of environmental awareness and sensitivity that today's "green" marketplace and society demand" (Morgan, Collicutt, and Thompson, 1995, p.4).

Strategically, the manual outlines the many considerations necessary with the restoration of sites. Since the identification and reasoning to choose these sites are already covered by using oil well sites, the guidelines presented in the manual will be considered according to the parameters that the sites must benefit native bee species without negatively impacting the land user's farmed landscape.

2 Species Selection

The guidelines begin with the evaluation of the site; what is present in terms of topography, adjacent land use, weed populations, weed control options, long-term security, and public accessibility (Morgan, Collicutt, and Thompson, 1995, p.8). As this design strategy is limited to the oil well sites, there are repeating conditions that appear that have been identified earlier in this document: the well pads often exist at ground level while access roads may be raised, invasive species often exist on the peripheries of the access roads and oil well pads, spraying for weed removal is addressed by the individual land owner, the conservation of these sites is inherent to the design strategy, and the public is not welcome to access these private lands. Morgan, Collicutt, and Thompson (1995, p.11) note that one “can usually be flexible with the ultimate composition of your seed mixture. There are no hard rules on this, but try for a good cross-section of both grasses and wildflowers.” There are arguments surrounding “easy to grow pioneering species” while “others feel that a basic matrix of the dominant mature prairie species is best. In reality, no one knows if there is anyone best way, so both approaches are equally valid” (Morgan, Collicutt, and Thompson, 1995, p.11). In the end, it is not possible to predict what species will eventually establish and in what proportion, therefore “put as many species in as possible and let them sort out who grows where and when and in what amount” (Morgan, Collicutt, and Thompson, 1995, p.11).

3 Acquiring Seeds

“There are three ways to acquire seeds for a restoration project: purchase them from a commercial supplier, harvest them from existing prairies (wild harvest), or produce them from a nursery (nursery harvest)” (Morgan, Collicutt, and Thompson, 1995, p.25). Regardless of the means of seed supply, it is as important to know what is in the seed mix, as what is not: there is no excuse for a seed mix from any supplier to contain any invasive seed species (Morgan, Collicutt, and Thompson, 1995, p.26). Because this project focuses on oil well companies revegetating the site, it is unreasonable to expect the oil well companies to harvest seed from existing prairies. Instead, they will be required to ensure the seed mix is from a reliable native species supplier.

Figure 3.2.10: schematic illustration of invasive weed species

4 Site Preparation | year 1 + 2

The treatment of the existing sites depends on the conditions. For this site, the oil well companies are required to remediate and restore the site(s) so that they reach the Government of Saskatchewan's The Oil and Gas Conservation Regulations, 2012, (2015c, p.9) reclamation requirements: "re-contouring, landscaping, replacing or replenishing the topsoil and re-vegetating the surface of the soil so that it is compatible with its surroundings." Since the gravel will be removed, the appropriate site condition will be exposed subsoil or fill. Therefore, the guidelines recommend: "Newly exposed subsoil resulting from highway or other construction can provide a good, weed free medium for a prairie restoration. Prepare the site quickly, before weed seeds have a chance to blow in and take hold. In a raw clay subsoil, adding peat moss and sand will improve the structure and drainage of the soil. Do not add landscaping topsoil, manure or fertilizer. Prairie species do not need good soils or high levels of nutrients. Landscaping topsoil or manure invariably contains large amounts of weed seeds. If weed-free topsoil is available this can be used to amend poor soils" (Morgan, Collicutt, and Thompson, 1995, p.48).

Although the oil well companies will remove invasive species to the greatest extent possible under the current regulations, it is imperative that invasive species are thoroughly removed. "To begin, burn the site to remove the accumulated litter and surface seed bank. If a burn is not possible, mow and remove the clippings. Allow the vegetation to regrow to about 20 cm (8 in) in height. Then begin a series of herbicide applications with a qualified, licensed applicator. ... Several applications beginning in late summer, then the following spring, summer and fall are usually necessary. Back-pack sprayers may suffice for small sites. Larger areas need estate or field sprayers. Certain weeds, such as Canada thistle and leafy spurge, may not be controlled even by this regime of herbicides. Specific control of using more specialized herbicides with spot sprayers often is necessary" (Morgan, Collicutt, and Thompson, 1995, p.49). "Once a season of chemical control has been carried out, the remaining above ground vegetation must be removed either by fire or mowing and removal of the clippings. Cultivation should begin in the spring following herbicide treatments. Small sites can be dug by hand or with a rototiller. Larger sites will require a tractor with appropriate cultivators. Cultivate or rototill the site with a deep tiller down to about 10 cm (4 in). Cultivate a second time at right angles to the first. Harrowing (raking) the ground with diamond or spring toothed harrows will then smooth any surface irregularities or ruts" (Morgan, Collicutt, and Thompson, 1995, p.50).

 Figure 3.2.11: schematic illustration after the removal of invasive weed species

5 Seeding | year 2 + 3

Once the site has been properly cleared of invasive species and appropriately leveled, Morgan, Collicutt, and Thompson (1995, p.51) recommend seeding prior to rain, specifically the month(s) with highest precipitation. Based on the site analysis (page 72), this month will mean May in the moist mixed grassland. Two types of seeding exist: a specialized native seed drill, and broadcast seeding (Morgan, Collicutt, and Thompson, 1995, p.51). Because this project requires a specific planting plan -- similar species within specific areas -- the planting scheme will benefit most from seed broadcasting. "The chief advantages of broadcast seeding are that it can be accomplished without large, expensive machinery and the seed does not require as much processing. ... The main disadvantage is its inefficiency, relative to drilling, requiring twice as much seed per unit area. This is because seed is placed on the surface, rather than buried as with a drill, and the rate is less even" (Morgan, Collicutt, and Thompson, 1995, p.52). The seeding rate will be determined by professionals and/or the native seed suppliers. Because of the requirements for bee species, it may take multiple wildflower mixes to create the appropriate block planting mosaic. Each wildflower mix should be appropriately supplemented with specific seeds to enhance the required species as listed in the design plan. "Mosaic seeding may involve differential seeding rates, different seed mixtures, or multiple passages over portions of the site with different techniques to achieve highlights or greater patchiness in the restoration" (Morgan, Collicutt, and Thompson, 1995, p.54). Some simple recommendations to ensure establishment include "consider dividing your seed lot in half and covering the site twice. This ensures more even coverage. ... Incorporate the seed lightly into the soil by raking or using a chain drag and roller pack the site immediately" (Morgan, Collicutt, and Thompson, 1995, p.54).

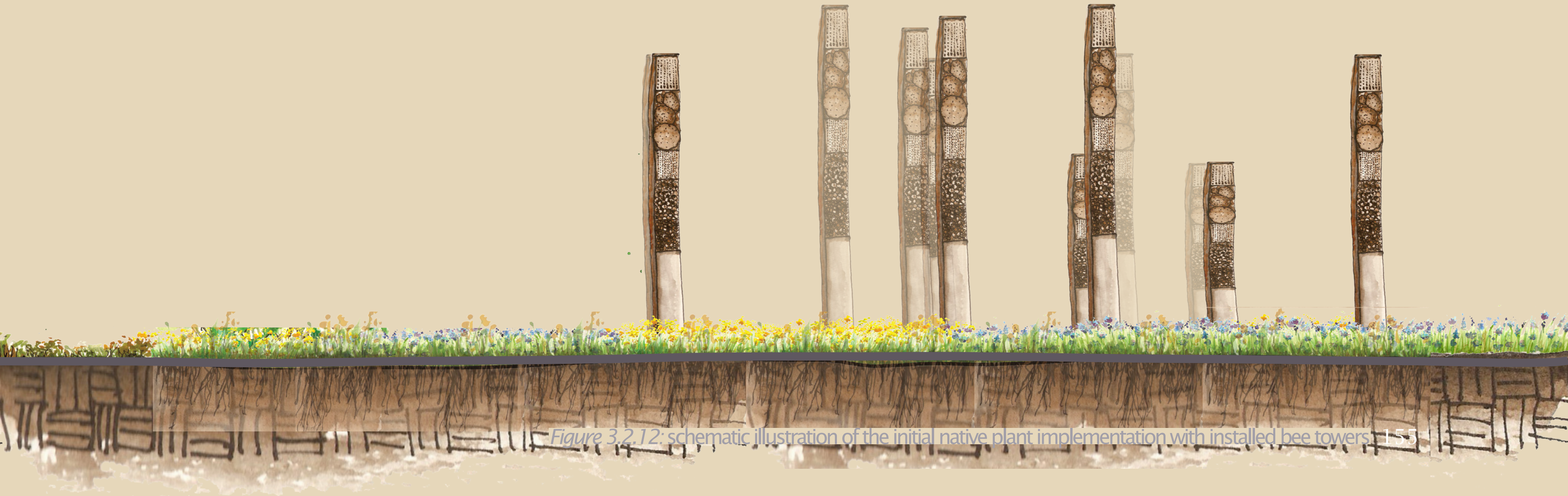


Figure 3.2.12: schematic illustration of the initial native plant implementation with installed bee towers

6 Cover Crops

Although it is not established if cover crops are a necessary element of native plant restoration, “a large body of practical farm experience suggests that whenever a perennial crop is planted, a faster growing annual crop planted as a companion is beneficial. By shading the soil it retains surface moisture, prevents sunscald of tender young perennial seedlings and out competes annual weeds. The cover crop provides quick soil holding capabilities on slopes or in light soils where wind erosion can be a problem” (Morgan, Collicutt, and Thompson, 1995, p.54). Because the oil well sites are within an agricultural field and will be disturbed for restoration practice, this practicum recommends using a cover crop to compete with weed species during the early years of perennial native plant establishment to counter non-beneficial invasive weed species. Morgan, Collicutt, and Thompson (1995, p.54) recommend Canada wild rye (Elymus canadensis): it is “native to the tall and mixed grass prairie, [and] can be used in restorations as a short-lived perennial cover crop. It establishes quickly, provides good soil cover and competes well with weeds. Canada wild rye usually does not persist beyond the first 5 to 8 years of the restoration planting, and allows other slower growing native species to fill in as it declines.”

7 Site Establishment and Monitoring

To evaluate the success of planting, Morgan, Collicutt, and Thompson (1995, p.56) state: “The density (number of individuals per unit area) of prairie plant seedlings achieved during the first growing season is the only indicator available for evaluating planting success” and will determine if remedial elements -- such as reseeding -- will be necessary based on the germination rate. For this practicum, it is necessary to establish block planting of specific wildflower species. Therefore, the restoration of the site will be evaluated based on the amount of germinating wildflower species based on the planting plan. “Wildflower densities of at least 5 per m^2 (I per ff) appear to be required. If by early in your second year after planting, native plant densities have not reached these levels, reseeding should be undertaken” (Morgan, Collicutt, and Thompson, 1995, p.57). Reseeding can be done by broadcasting or planting started seedlings at “10 to 15 per m^2” and irrigated (Morgan, Collicutt, and Thompson, 1995, p.58).

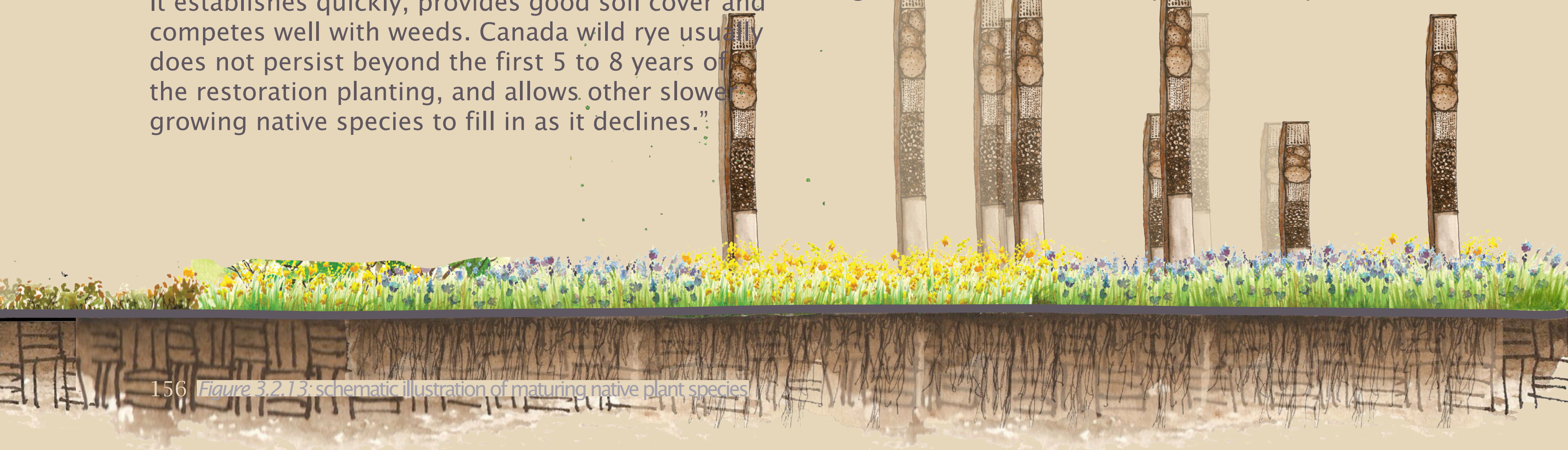


 Figure 3.2.13: schematic illustration of maturing native plant species

to reduce herbicide and pesticide impact on existing bee populations:

If it is necessary to apply ---cides (herbicides, pesticides, insecticides) to remove invasive weed species, certain steps can be taken to reduce negative impact on existing bee populations.

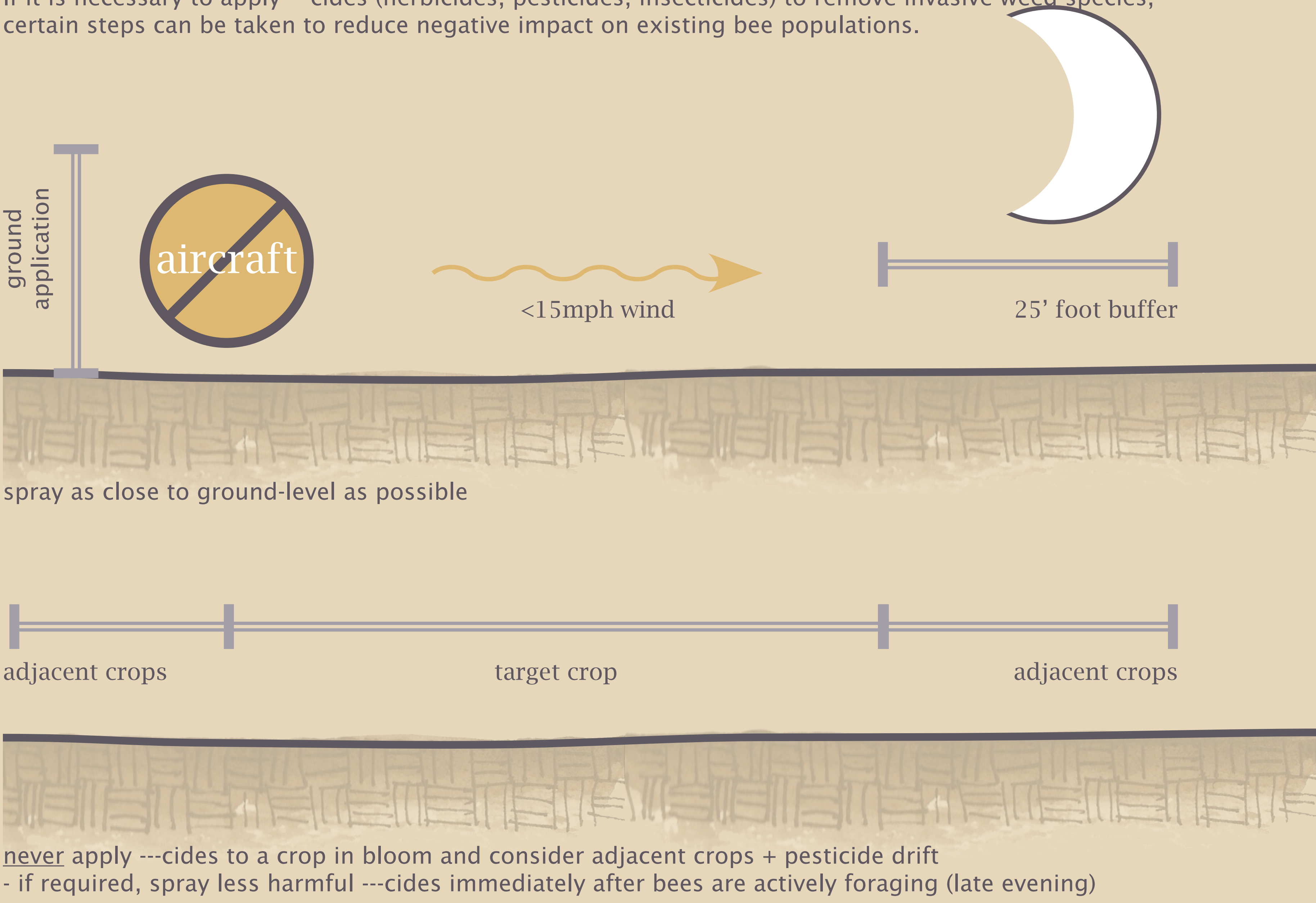


Figure 3.2.14 schematic illustration to apply —cides in the least harmful manner for existing bees, adapted from information by Vaughan et al., 2007, pp.32-35

RE-VEGETATION SPECIES

methods and species for pollinator meadows

The oil well sites and their accompanying access roads can be re-vegetated outside of the Government of Saskatchewan (2015a, p.18) definition: “at the time of reclamation the salvaged soil should be replaced as evenly as possible across the site and the use of native species is encouraged to re-vegetate native grassland.” The first portion of that statement regarding recontouring is up for debate. Depending on the desired function of the site, contouring may vary. The second part, however, forms the basis of the re-vegetation strategy. Although it is desirable to recontour the site to the surroundings, the combination of vegetation and recontouring can be used to greater effect for both pollinator species and the possible semiotic interpretation of the design.

Figure 3.2.15 describes possible planting schemes for the oil well sites and access roads. These diagrammatic sections are derived from bee habitat requirements and the site analysis in chapter 3.1. As has been stated throughout this chapter, bees require nesting and forage sites. The Xerces Society lists some such requirements:

1 “Woodland margins that are too shady to be home to forage flowers may contain beetle-riddled snags and logs in which bees can nest” (The Xerces Society, 2003, p.58).

2 “Wetlands may not suit ground-nesting bees, but may well contain flowers for foraging and probably twigs or reed stems that offer nesting sites for wood-nesting bees” (The Xerces Society, 2003, p.58).

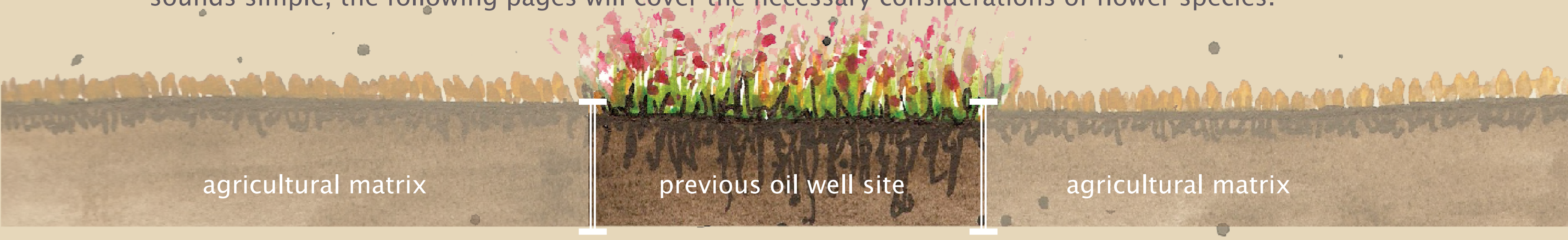
3 “Trees have both advantages and disadvantages: alive, they act as windbreaks to help warm a site and they can be a source of abundant nectar and pollen, though they may create too much shade. Dead, they provide nesting sites for solitary bees” (The Xerces Society, 2003, p.59).

4 “Habitat patches that are bigger, rounder, and closer to other patches will generally be better than those that are smaller, of uneven shapes, and more isolated from one another” (The Xerces Society, 2003, p.60).

5 “Ground-nesting bees seldom nest in rich soils, so the poorest soils will provide fine sites. These bee areas do not have to be large; planting hedgerows of shrubs and perennials, for example, can produce excellent bee habitat and will help to provide corridors across agricultural landscape” (The Xerces Society, 2003, p.71).

Based on the analysis surrounding pollinator flight distances, it is clear that this is not a 'one intervention fits all' strategy. However, not every site will require a brand new approach to planting to promote bee populations, but instead a few key elements can be followed. *Figure 3.2.15* diagrams some possibilities.

Where there are shallow/open water polygons near the oil well sites, the primary purpose of the oil well sites and/or access roads will be to host foraging elements, i.e. native perennial flowers. Although this sounds simple, the following pages will cover the necessary considerations of flower species.



Where the (abandoned) oil well sites are lacking in uncultivated areas that host shallow/open water polygons according to Ducks Unlimited Canada (2017c), trees must be included as part of the oil well site revegetation, along with native species.

Where the oil well sites are of an abnormally large size compared to the other well pads on the section (site 1 hosts one and site 2 hosts two such sites), the planting strategy could change: these sites have the potential to become wetlands based on the Ducks Unlimited Canada (n.d.) information on page 71.

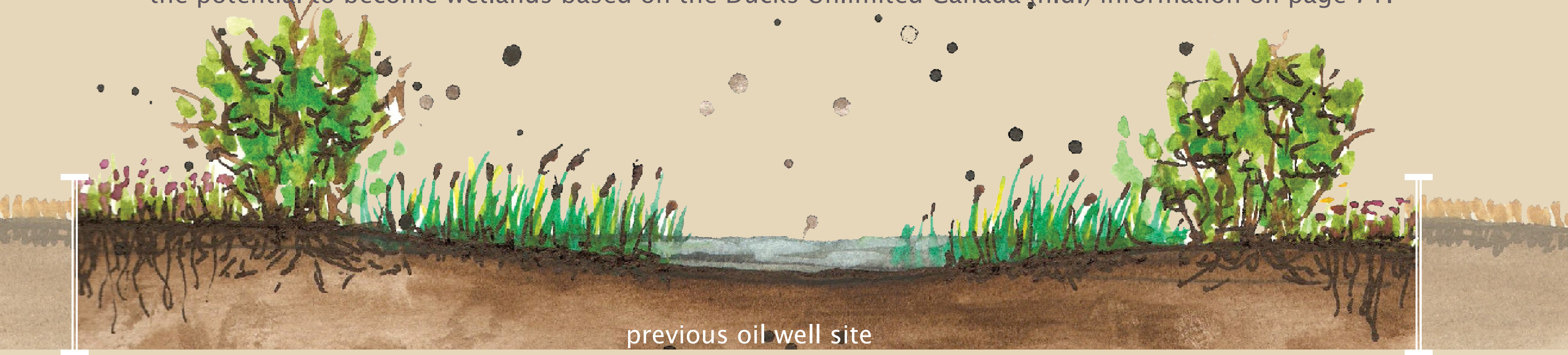


Figure 3.2.15: schematic illustration of possible repurposed oil well pad treatments

grasses and trees | a meadow is more than wildflowers

The options illustrated in *Figure 3.2.15* are only concepts, for now. To create a meaningful pollinator meadow, more considerations will take place. For example, post-industrial sites may reference the layers of time created by the oil well sites and their access roads, agriculture, and the original native prairie. This means that a unique opportunity exists for Repairing the Prairie Apiary: **planting can be used as a dynamic aspect of memory to make time visible**. The shifting and semi-ephemeral nature of planting can be used to mark spaces through colour, texture, height, particularly in contrast to surrounding areas.

For the oil well sites replanting, it is well established that it is desirable to re-vegetate with native species but this can go further. Native species replanting can be carefully constructed to contrast the surrounding landscape, while still providing the necessary species for successful pollinator forage. It can showcase a landscape by contrasting the surrounding land use, by presenting a new aesthetic, by referencing a historic landscape. It can host a variety of species that host a variety of ecological services, creating an alternative land use strategy the promotes ecological productivity on a seemingly productive landscape. The re-establishment of native prairie species must host specific benefits to bee populations but an alternative land use strategy can be both beneficial to bee species and still reference the historical landscape. These layers of requirements will create a productive landscape that is legible to the inhabitants and travelers of the region, both human and animal species.

The concern, however, is that the aesthetic factor cannot overwhelm the practical factor. As much as the wildflower species may be striking and provide recognition for the past infrastructure, it will not function without the appropriate vegetation species. A wildflower meadow in a native grassland must have grass species for establishment and maintenance purposes. The agricultural and native landscape is also populated by aspen trees in the depression areas. In turn, trees can be added elsewhere as they, a natural element of the pothole prairie, may provide other, relevant eco-services for existing, native species.

refer to *Figure 1.3.15* for more details

grass species

A native meadow cannot exist without grass species. Based on Morgan, Collicutt, and Thompson's restoration manual (1995, p.17), certain native grass species are both desirous to re-restablish, well-suited for it, and proven as effective:

Western Wheatgrass	*Agropyron smithii*
Slender Wheatgrass	*Agropyron trachycaulum*
Blue Grama	*Bouteloua gracilis*
Canada Wild Rye	*Elymus canadensis*
Northern Wheatgrass	*Elymus lanceolatus*
Plains Rough Fescue	*Festuca altaica*
Rough Fescue	*Festuca hallii*
Western Porcupine Grass	*Hesperostipa curtiseta*
June Grass	*Koeleria gracilis*
June Grass	*Koeleria macrantha*
Mat Muhly	*Muhlenbergia richardsonis*
Western Wheatgrass	*Pascopyrum smithii*
Sandberg's Bluegrass	*Poa secunda asp secunda*
Needle and Thread Grass	*Stipa comata*
Western Porcupine Grass	*Stipa curtiseta*
Green Needle Grass	*Stipa viridula*

These grass species will be planted with the wildflowers species, covered in the next pages.

protective vegetation

As the existing landscape features various patches of aspen, particularly surrounding water bodies, it is worth considering the additions of more aspen where the repurposed oil well sites are lacking nearby treed areas. "Nearly 70 percent of the solitary bee species -- as well as all of the social sweat bees -- nest in the ground" but "of the remaining 30 percent, most nest in beetle holes in dead trees or limbs. A few, such as the carpenter bees, use their powerful mandibles to chew tunnels into stems or wood that are relatively soft" (The Xerces Society, 2003, p.89). The source of a windbreak to both warm and protect a site make trees a valuable asset, so long as they do not provide too much shade on the site(s).

Figure 3.2.16: schematic illustrations of species to be established beyond wildflowers

wildflowers

The distinct planting scheme will reflect the needs of the bees first and foremost.

The Xerces Society (2003) has developed easy-to-follow guidelines for providing foraging habitat:

1 “It should incorporate a succession of flowers in order to provide blooms throughout the entire growing season” (The Xerces Society, 2003, p.75).

2 “It should have several different species in bloom at any one time” (The Xerces Society, 2003, p.75).

3 Colour is important: “Bees ... visit many colours, but are strongly attracted to blues and purples and are blind to red” (The Xerces Society, 2003, p.77).

4 Planting patterns can be more effective: “plant flowers to form blocks of coloured blooms ... of the same species together” (The Xerces Society, 2003, p.83).

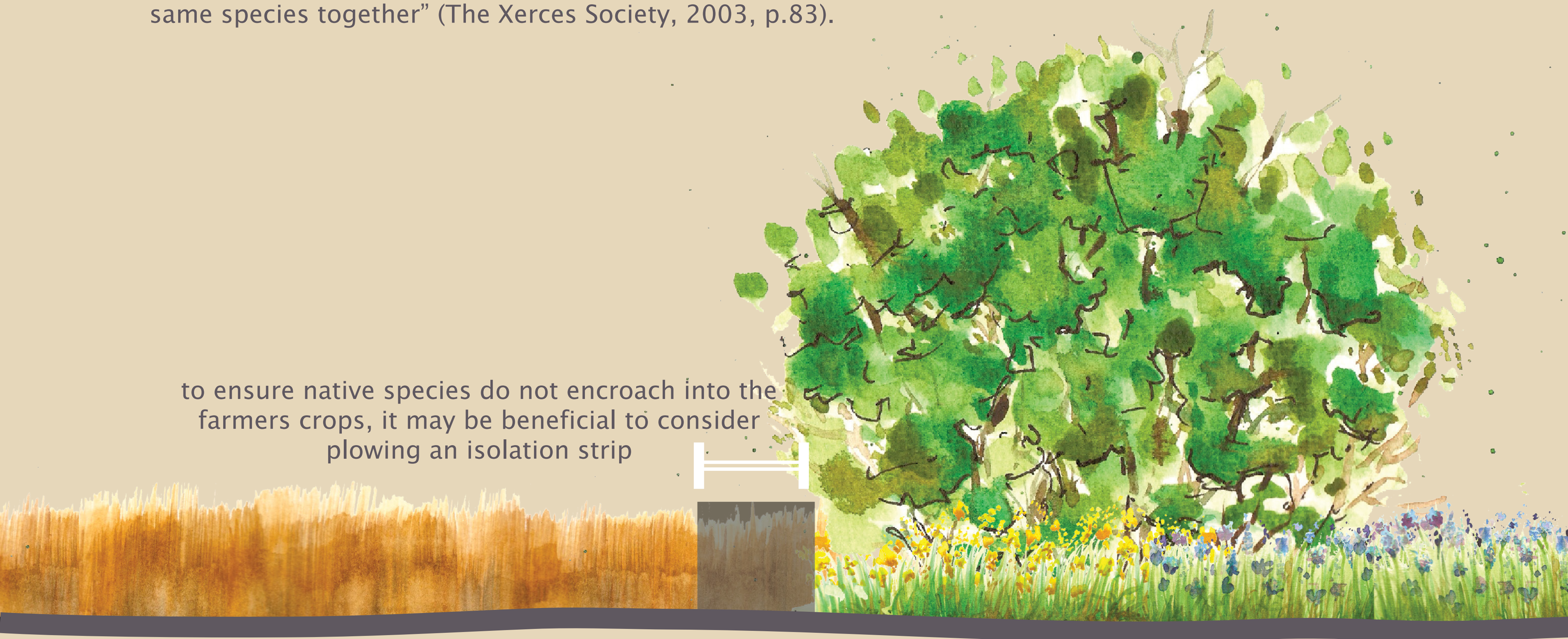


Figure 3.2.17 illustrates the wildflower plantings on repurposed oil well pads while they still have the block planting visible, but already well-established.

The native wildflowers that will build up the block planting as indicated in *Figure 3.2.17* are laid out in *Figure 3.2.18* on the following page. This chart is a wildflower blooming schedule that also acknowledges the particular benefit from each proposed species for the re-vegetation scheme. The species are derived from four lists to appeal to the greatest range of foraging types and ensure long-term establishment:

1 the native wildflower species have been chosen for their restoration abilities (both quick to establish and those that dominate upon maturity);

2 wildflower species native to moist mixed grasslands;

3 native wildflower species that ensure continual blooming during the active season; and

4 native wildflower species that appeal to bees.

With a variety of species and families, even if one fails within a genus, the others may still survive and thrive, creating a comprehensive, ever-blooming mosaic of flowers.

The wildflowers, planted in groupings originally, will appear as blocks of colour in the early years. They will be sown to have families of plants grown together at approximately 3 metre by 3 metre blocks, appealing to polylectic and oligolectic bees alike. This planting scheme will reference the mosaic of agriculture on the landscape initially, creating mini-mosaics within the larger mosaic.

Figure 3.2.17: schematic illustration of a maturing prairie after *Figure 3.2.13*

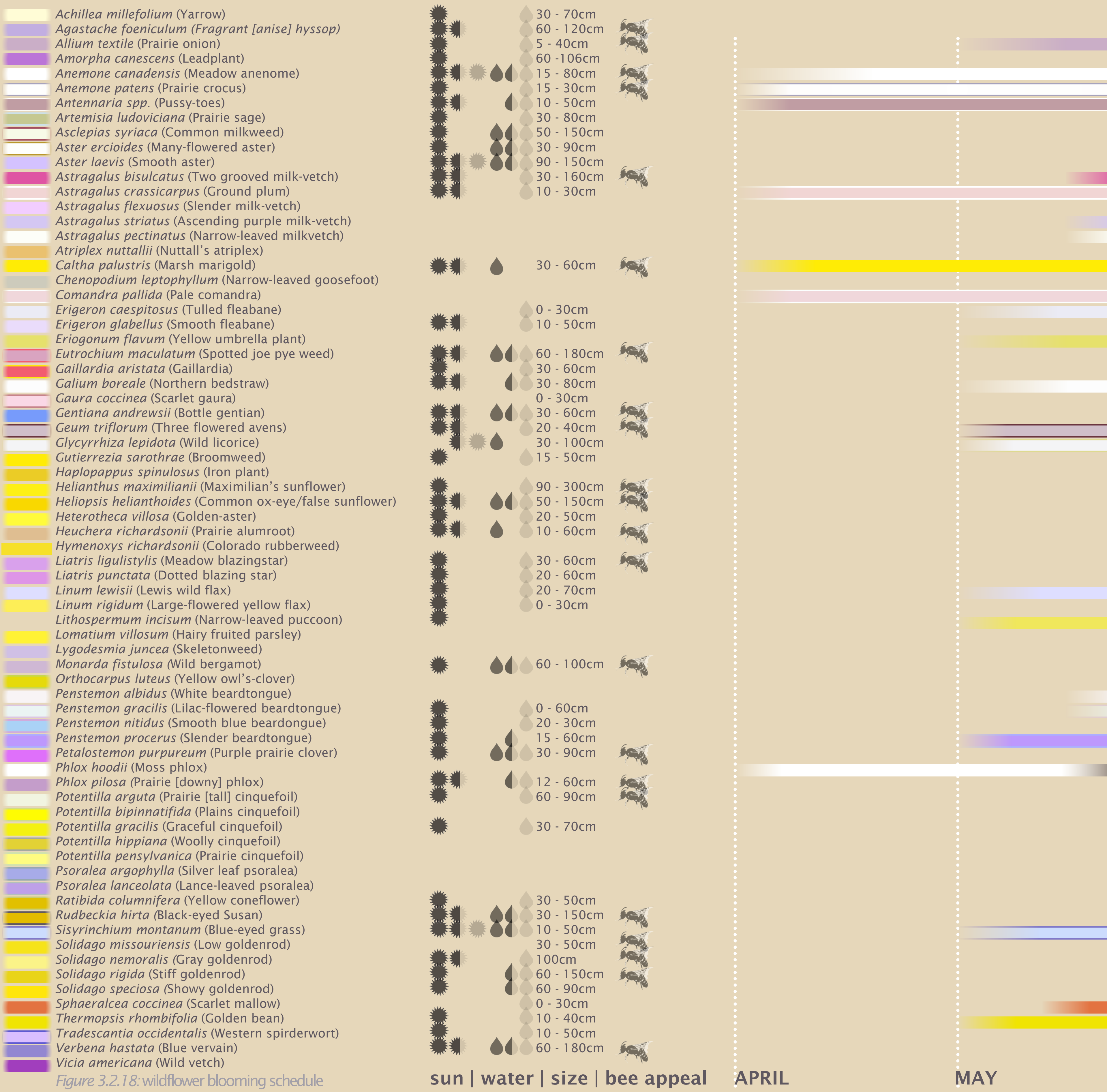


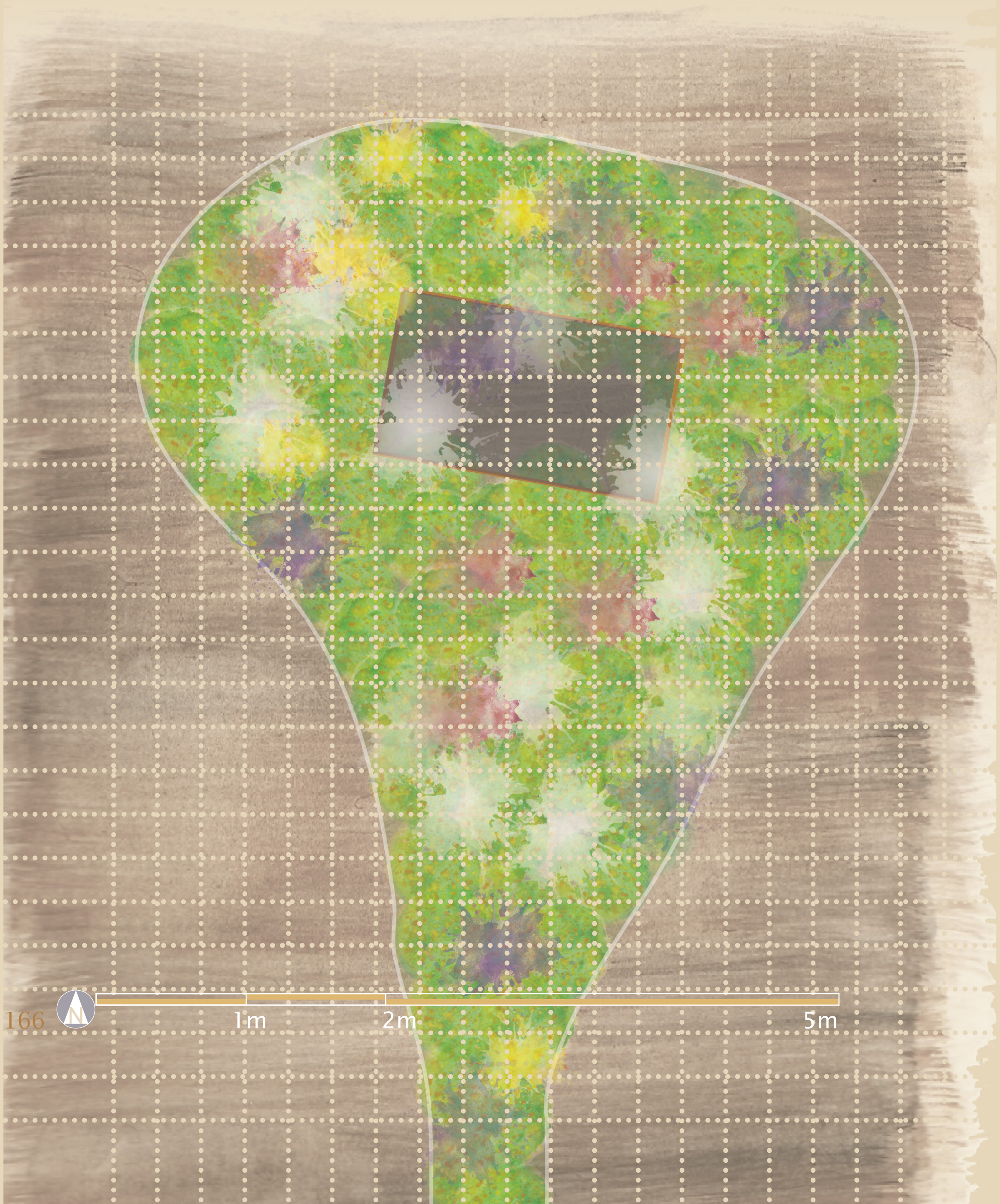
Figure 3.2.18: wildflower blooming schedule


JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER

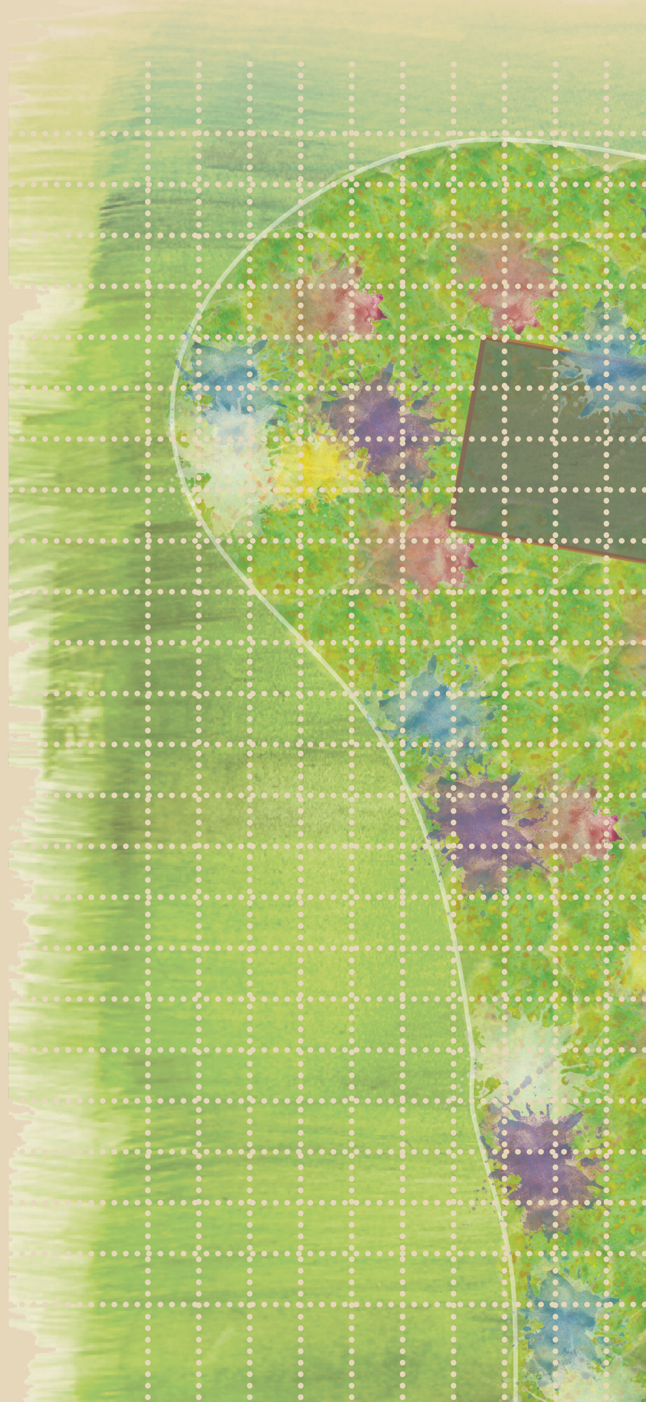
schematic block planting of wildflower species

Vaughan et al. (2007, p.22) lays out some recommendation for plant species. Although it has been established that native species are preferred, bees will respond differently to colour: because bees visual spectrum differs from ours, they will see black in place of red. “In practical terms, this means that good flower colours for bees are blue, purple, violet, white, and yellow. Some red flowers, such as blanket flower and poppies, have a UV colour component and are therefore also attractive to bees” (Vaughan

April - May



June - July



et al., 2007, p.22). To use this theory, the wildflowers will be planted by groups of colour and, in some cases, by family. For example, a yellow patch could contain seeds from *Potentilla spp.*, *Heliopsis* spp., and *Helianthus* spp. These plantings will mature in clumps to ensure yellow blooms will sufficiently establish; even if one species is unable to survive in that microhabitat, the others might and create the needed foraging flowers.

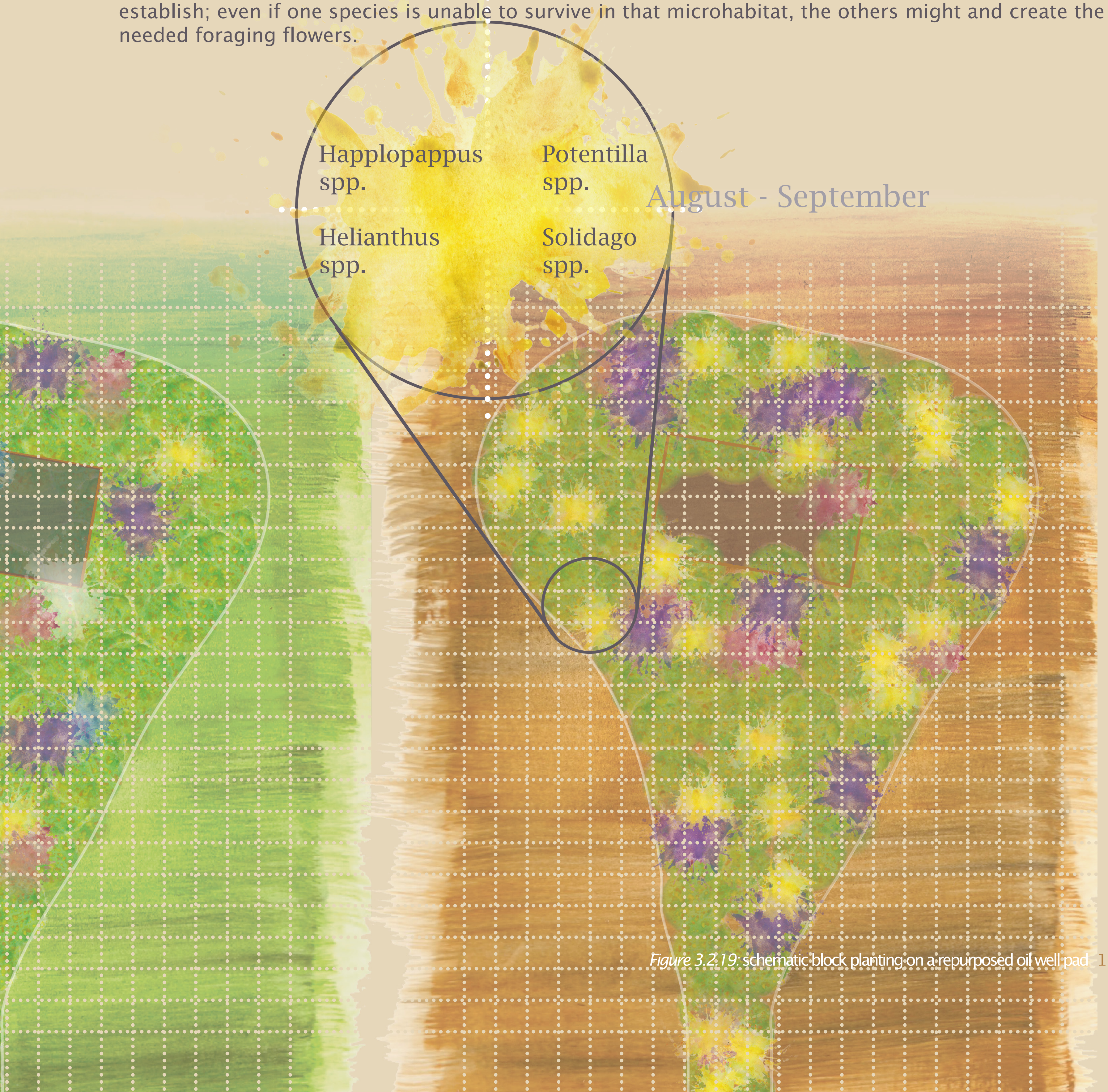


Figure 3.2.19: schematic block planting on a repurposed oil well pad

The wildflowers will eventually mix, reducing the initial block planting. This is acceptable; natural succession and health of the overall site is of far greater importance than the visual aesthetics of block planting. It is not necessary to ensure a specific percentage of wildflower species and, quite frankly, an unnecessarily impossible expectation of the oil company responsible for revegetating the site.

The oil companies are responsible for re-vegetating the sites and so they must also take some responsibility for ensuring the sites are appropriately established, but only for a specific time or percentage of plant success. As alluded to in section 2.2, conservation organizations could provide the necessary knowledge to ensure re-vegetation success.

diagrammatic plan

diagrammatic section

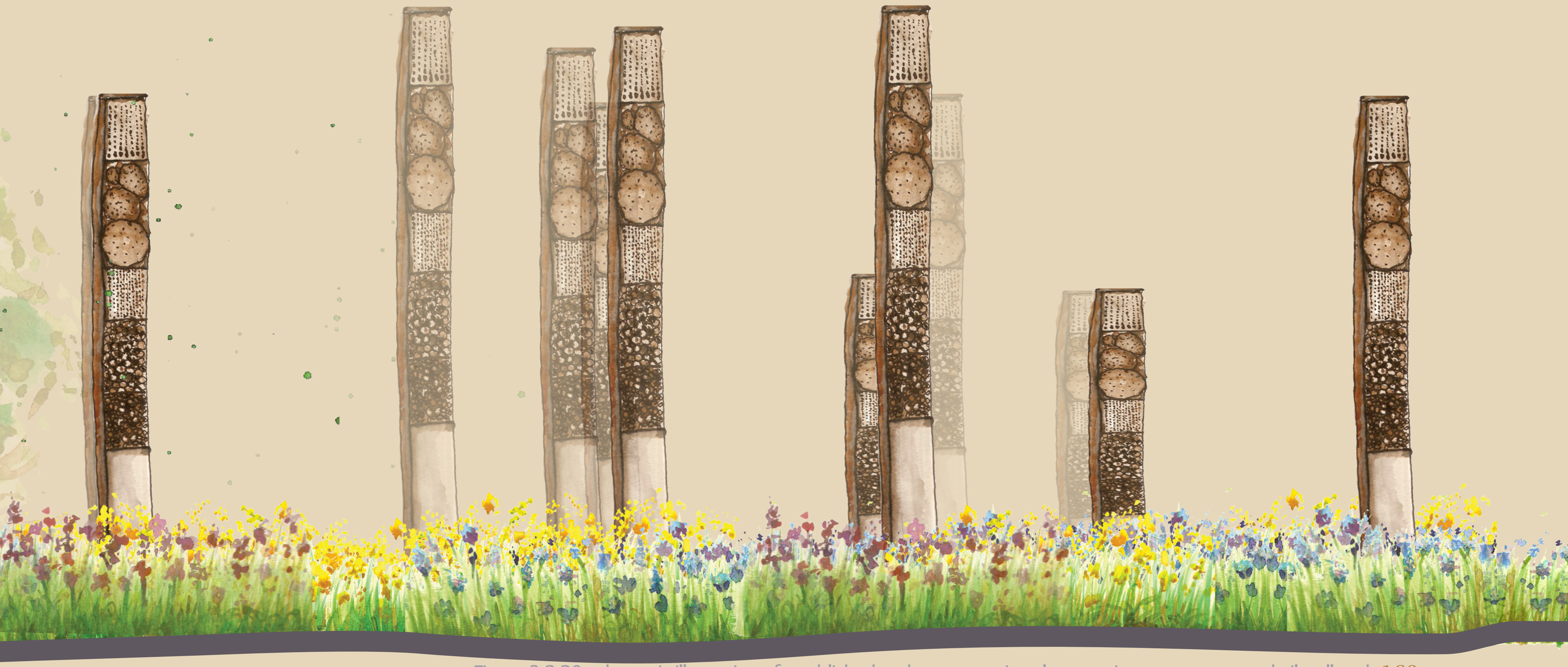


Figure 3.2.20: schematic illustration of established and mature native plant species on a repurposed oil well pad

ground-nesting

Figure 3.2.21: schematic illustration of the pump jack footprint pre-treatment

The Xerces Society (2003, p.97) states: "While it's fun to fashion bee blocks for wood-nesting bees, most of our native bees nest in the ground in areas that are sunny, well drained, and either bare or partly vegetated. There are many ground-nesting bee species, and different conditions -- from flat ground to vertical banks, packed earth to loose soil -- will attract different species." Although soil conditions will vary per species, "many bees prefer to nest in sand or a mixture of sand and loam that is soft enough to dig in and stable enough that it won't collapse, and that drains easily so the nest won't flood" (The Xerces Society, 2003, p.97). Oil well sites, prior to being repurposed, already host many of these conditions and, as such, offer prime real estate for ground-nesting bees. The repurposing strategy will, therefore, use and enhance the existing conditions to provide appropriate ground for native, ground-nesting bees.

Following site treatment between remediation and re-vegetation these sites are also, however, susceptible to invasive weed species due to their newly disturbed nature. To counteract invasive species while also encouraging ground-nesting conditions, the footprint of the pump jack will be treated differently than the remainder of the well pad. The well pads and access roads are to be re-vegetated with the previous listed strategy, focusing on wildflower and grasses establishment and natural succession. The footprints of the pump jacks, however, will instead require a specific monoculture plant: Canada wild rye (*Elymus canadensis*). As an annual cover crop -- see page 56 for more -- the Canada wild rye will prevent invasive weeds from establishing in the early phases of native perennial species establishment on the surrounding portion of the site. In time, however, Canada wild rye will give way to open soil and/or native meadow establishment; either way, this is a desirable succession. Planning for ground-nesting bee species is a battle between leaving open space -- which is susceptible to invasive weed invasion -- or planting native species to discourage invasive weed species.

diagrammatic plan

diagrammatic section

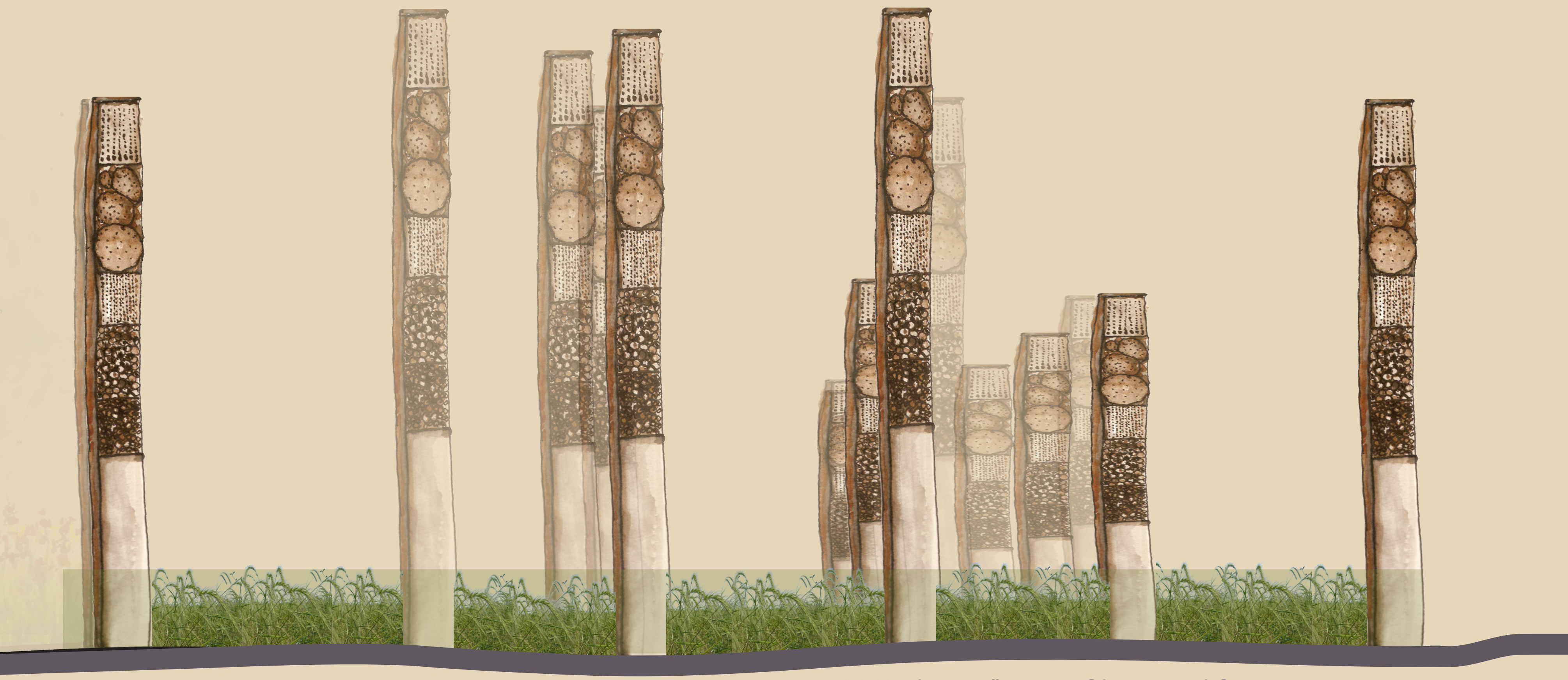


Figure 3.2.22: schematic illustration of the pump jack footprint treatment

 Figure 3.3.01: an oil well pad within wetland, nearby an uncultivated area near 16-004-06-W-2 in southeast Saskatchewan

3.3 MANAGEMENT

conservation for land owner compensation

APPLYING THE PRAIRIE APIARY

land use | the site of study

To repair the prairie apiary, this design has, so far, focused on strategic application methods for oil companies legally responsible for treating their installed oil well sites post-industrially. These strategies are to be adopted and introduced into current treatment practice to focus on native bee-based population rehabilitation or, at least, sustaining the remaining populations. This section delves into the applied strategy on the site of study, solving the practical considerations for a typical site.

Figure 3.3.02 is the site of study, overlaid with Ducks Unlimited (DUCs, 2017c) data, and minimized to the oil well sites and their immediate, surrounding uncultivated areas. This overlay demonstrates some key features: the oil well sites are often located alongside or within uncultivated areas, these uncultivated areas are not strictly aligned with Ducks Unlimited (DUCs, 2017c) data, and the majority of the oil well pads are similar sizes (excepting two distinctly large sites). These conditions will carry through to the application of the re-vegetation strategy and bee towers, acknowledging what is there and, in turn, what needs to be there.

Figure 3.3.02 visually represents the existing conditions of 16-004-06-W-2. The cultivated areas are the golds of ripe and dessicated crops ready for harvest, best highlighting the difference from uncultivated areas. Although the colours of the cultivated areas shift based on the plantings and time of year (see *Figure 1.1.16*), it is irrelevant for bee species; regardless of the crop, the brief blooming period does not account for the matrix conditions for the majority of the season. In *Figure 3.3.02*, the uncultivated areas retain their colours visible from satellite views, the greens and browns of open water spaces and accompanying vegetation true to on-the-ground study, a truthful representation of ecologically important areas.

Access Roads
Oil Pump Jack Sites
Highways
Existing Well Pads and Access Roads
Quarter Section
Legal Subdivision
Private Farmyard
Uncultivated Area
Cultivated Area
Marsh
Swamp
Shallow / Open Water

50m 100 250m

5,750 linear kilometres of access road

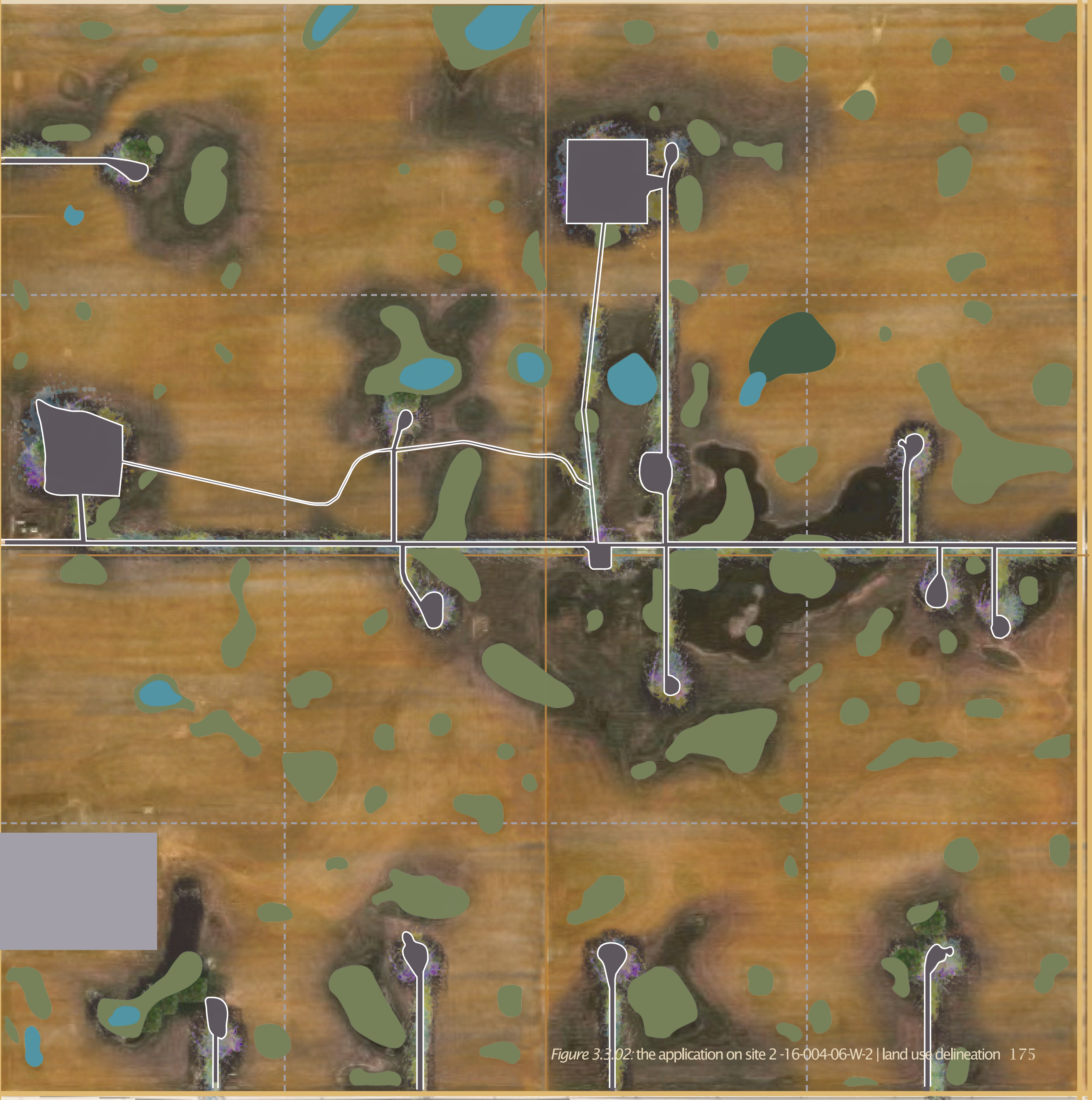


Figure 3.3.02: the application on site 2 -16-004-06-W-2 | land use delineation

land use | proposed

The applied design focuses on integrating the re-vegetation strategy into existing uncultivated areas. The use of evaluated and established re-vegetation species will create a new texture and colour scheme across the landscape, creating rows of colour across the agricultural landscape.

These strips of colour will provide valuable connective corridors for bees. The patches of oil well pads and uncultivated areas will provide the much-needed forage-scape in the monoculture fields. Their presence will encourage movement and diversity of bee species from patch to patch, reducing competition and isolation in these small areas.

Beyond this, however, the aerial perspective reveals the landscape that once existed. The access roads, distinctly re-vegetated, will stand as separate from the surrounding ecological conditions. The landscape of oil and its invasiveness cannot be erased when it is visually recognizable as a new form within the fields and uncultivated areas, distinctly different and ecologically functioning by comparison.

This visual impact will change perspectives as people move through the region. The rows of re-vegetation may not always be visible, appearing in and amongst the uncultivated areas depending on the perspective of the viewer. It is not necessary that all of the access roads and well pads be visible at any given point; the impact of their visual difference will be strengthened, in part, from the seemingly random arrangement. As repurposed access roads appear on the horizon, disappearing in the rear view mirror, another will appear, branching perpendicular to the roads, a new swath and a seemingly new grid to complement existing geometries, but a grid based on historical land application nonetheless.

Applied Re-vegetation

Private Farmyard

Quarter Section

Uncultivated Area

Highways

Legal Subdivision

Cultivated Area

N

50m 100 250m

Figure 3.3.03: the application on site 2 -16-004-06-W-2 | the alternative land use strategy, applied

the conservation strategy

When I first told my dad about the rough concept of this project, his immediate question was "Oh? And who's going to pay for that?" This question hosts more than a concern over payment. It represents the implied burden placed on land owners to host publicly beneficial projects at the cost of their time, money, and resources. For every space that cannot be cultivated, a land user must work around the dips and curves accompanied by such placement. This is visible in *Figures 1.2.18* to *1.2.22*. These required dips and curves alter the efficient farming pattern of straight, clean rows where there is minimal overlap in seeding, spraying, and harvest. I observe that curving rows host the potential for overlap of materials (seed and spray), going over the same area twice (time and money), and the general frustration of inconvenient patterns taking place on the landscape.

To mitigate this issue, this practicum seeks to make it worth the while of the land users -- specifically farmers -- to allocate uncultivated areas of land to the alternative land use strategy. The dedication of these spaces will make areas worthless in terms of crop production worth something again. As the pothole landscape already hosts marshes and shallow / open water spaces (DUCs, 2017c), the oil well sites can be considered in a similar manner.

To promote the greatest amount of uncultivated areas, studying satellite images will be particularly useful. Across the region, precipitation affects the amount of yearly non-arable land. By studying satellite imagery of years with high precipitation (*Figures 1.4.12* to *1.4.14)*, the non-arable depressions become more visible. To offer the greatest appeal to the land owner, these larger, more saturated areas should be dedicated as conservation lands. In doing this, land users will be guaranteed a payment for sites that are not always going to be cultivated; in some years, they could be farmed, but in saturated years they cannot.

Applied Re-vegetation

Private Farmyard

Uncultivated Area

Cultivated Area

Areas to be Conserved

Quarter Section

Legal Subdivision

Highways

N

50m 100 250m

Figure 3.3.04: the application on site 2 -16-004-06-W-2 | the alternative land use strategy, conservation and management

flight distances and conservation spaces

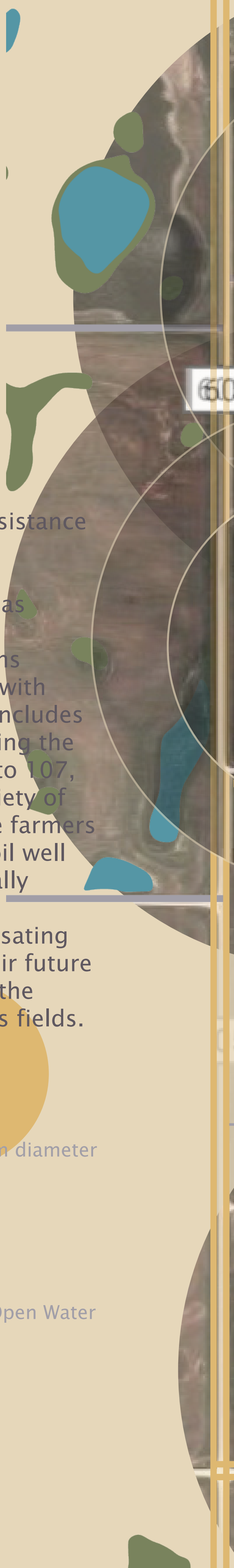
The site of study hosts a unique pattern for the oil well sites; with two distinct east-west bands and a multitude of large depressions, east-west connectivity is easily managed even by short-mid range flight distances. The central east-west corridor, varying in width and containing a third of the oil wells on site, contains prime bee habitat surroundings upon being repurposed. The southern corridor, although not directly attached, contains short enough distances between each patch that pollinators with >200m flight distances can comfortably make the trek between repurposed sites. The north-south corridors are sorely lacking in this section, but ditches will flank either side of the fields, providing the missing uncultivated proposed conservation areas. With the largest area available, the two largest sites can be repurposed to host the most bee habitat for the shortest flight ranges in a singular space, addressing the bees that need the most assistance in the agricultural habitat.

To promote conservation, ensure these areas remain uncultivated, and promote positive relations with land owners, certain programs can be adopted by farmer's in partnership with conservation organizations. This not only includes lessening the financial burden, but increasing the financial desire. As indicated on pages 98 to 107, there are multiple organizations with a variety of programming options that can compensate farmers for maintaining conservation areas. Once oil well sites have been remediated to an ecologically healthy state, they can become a part of conservation initiatives. Moreover, compensating land owners for larger sites guarantees their future condition as an uncultivated area, limiting the whole scale monoculturistic planting across fields.

100m diameter
200m diameter
300m diameter
400m diameter

Access Roads
Oil Pump Jack Sites
Highways
Areas to be Conserved
Quarter Section
Legal Subdivision
Private Farmyard
Uncultivated Area
Flight Distance Outline
Marsh
Swamp
Shallow / Open Water

N
50m
100
250m



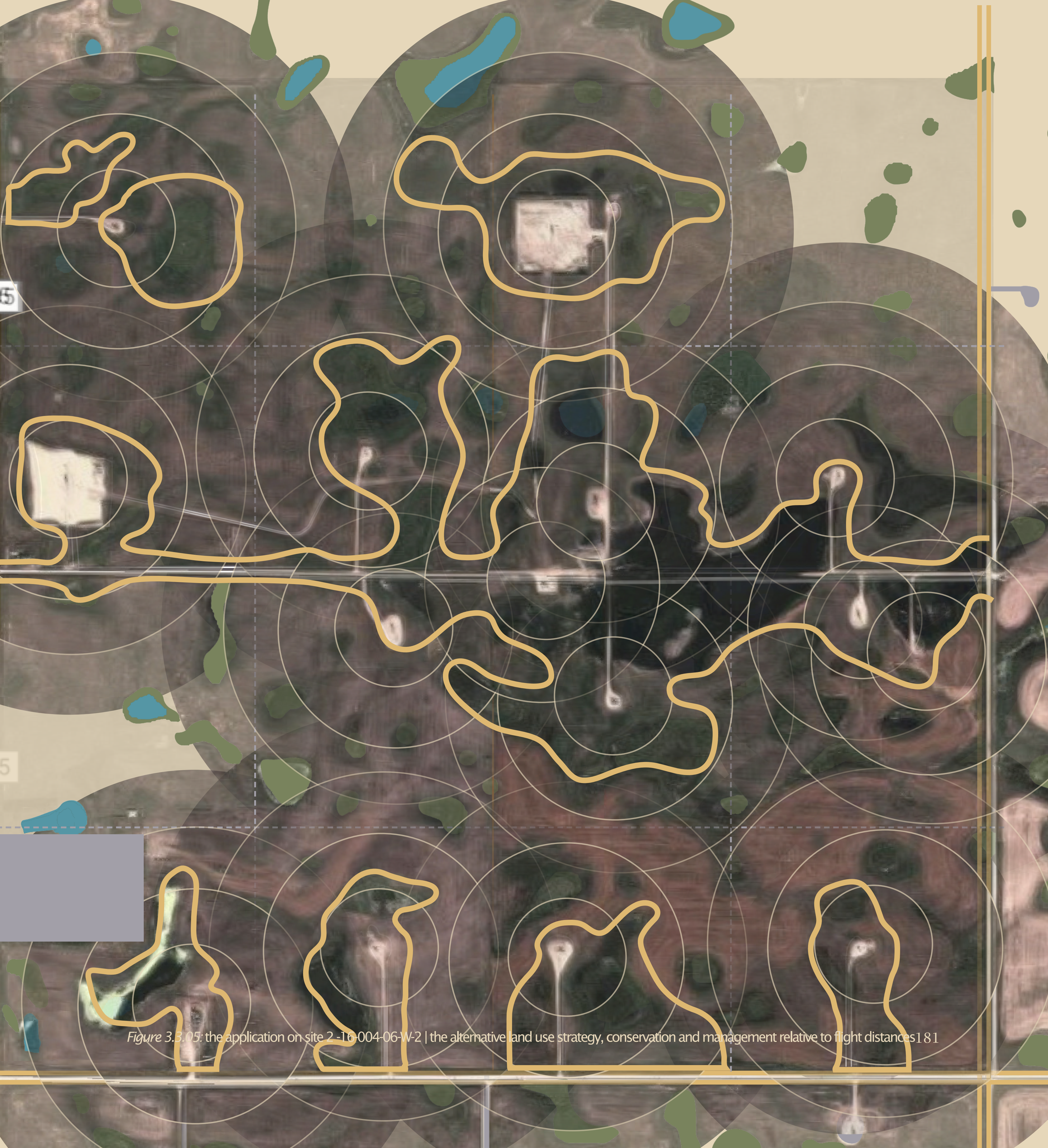


Figure 3.3.05: the application on site 2-16-004-06-W-2 | the alternative land use strategy, conservation and management relative to flight distances

APPLYING CONSERVATION

possible programs for repurposed oil well sites

The re-vegetation strategy is defined, promoting native bee species populations through continual blooming of appealing, native wildflower species. The oil companies, responsible for the original disruption of the oil well sites on the landscape, are also responsible for the treatment of the sites (see section 2.1). However, after the native plant species are established, the oil companies are not responsible for the long-term management and care of these spaces; their responsibilities must end at acceptable establishment conditions, as described in section 3.2.

The programs already exist and, in many ways, simply need to be made available to the farmer's as viable options. With the combination of uncultivated areas and oil well sites, connected as re-vegetated sites of productivi-bee, these section-wide areas are large enough to warrant conservation programming. Not every oil well site and uncultivated area will be appropriate for every organization, but many of them could be viable development sites.

Ideally, multiple organizations would band together to both reduce the financial strain for any one organization, but also to promote the application of the alternative land use strategy. These programs can be promoted as individual options for farmers, or in conjunction with one another, creating the greatest opportunity for the advertised success.

Ducks Unlimited Canada (DUCs, 2017b)

The FlexFarm program, conservation easements, and wetland restoration will be of most interest to the proposed design strategy. These programs all compensate farmers for their contribution to the health of the greater landscape, acknowledging the benefits of uncultivated areas within the agricultural landscape, making all of the spaces of a field financially and ecologically productive.

Alternative Land Use Systems
(ALUS, 2017a; 2017b)

Conservation easements are a suitable solution for farmers. By preserving one acre at a time, those that support ALUS can choose which initiative is preferred to support. As native pollinators are the focus of this practicum and the design strategy is in place, the support of ALUS will be well understood and well visualized on the landscape from the outset.

Nature Conservancy of Canada (NCC, 2017)

The Natural Areas Conservation Program is ideal for the application of this design. By promoting connectivity both on small scale and across the landscape with the application of a larger strategy combined with the on-the-ground abilities of NCC, the land owners will be compensated for the uncultivated areas and have available resources.

Saskatchewan Wildlife Federation (SWF, 2017a; 2017b)

Focused on habitat preservation for wildlife, the established revegetation of the repurposed oil well sites will become a part of the areas requiring conservation. SWF does not promote the development of these spaces but, instead, the natural succession; as the oil companies have already remediated and revegetated the site, this step is accomplished.

Nature Saskatchewan (Nature Saskatchewan, 2017a; 2017b)

As research grows in this field, there may be sufficient cause to include bees in the Stewards of Saskatchewan program. There is also an opportunity to include PlantWatch in conjunction with this; as revegetation is key to promoting bee populations, the establishment and study of native species in conservation easements can be monitored by Nature Saskatchewan.

Saskatchewan Prairie Conservation Action Plan (SK-PCAP, 2017a; 2017b)

The combination of these programs can be part of the education program for the whole landscape strategy. The productive effectiveness of the landscape will be visible by the infilling of the holes in the bee towers; with permission, students could possibly access the towers to study these changes. They could also be a part of the building and installation of bee homes process.

In summary, all of these programs have merit in relation to the design strategy. The overlapping programs of conservation easements, stewardship, and compensation are a continual theme that can be divided up by section, area measurement, or function. For example, DUCs may only be interested in repurposed oil well sites attached to existing wetlands, while NCC may be interested conserving the connections between sites. By using the available programs creatively and together, the more uncultivated areas can be conserved and land owners compensated for their contributions.

DETAILED DESIGN

a typical section

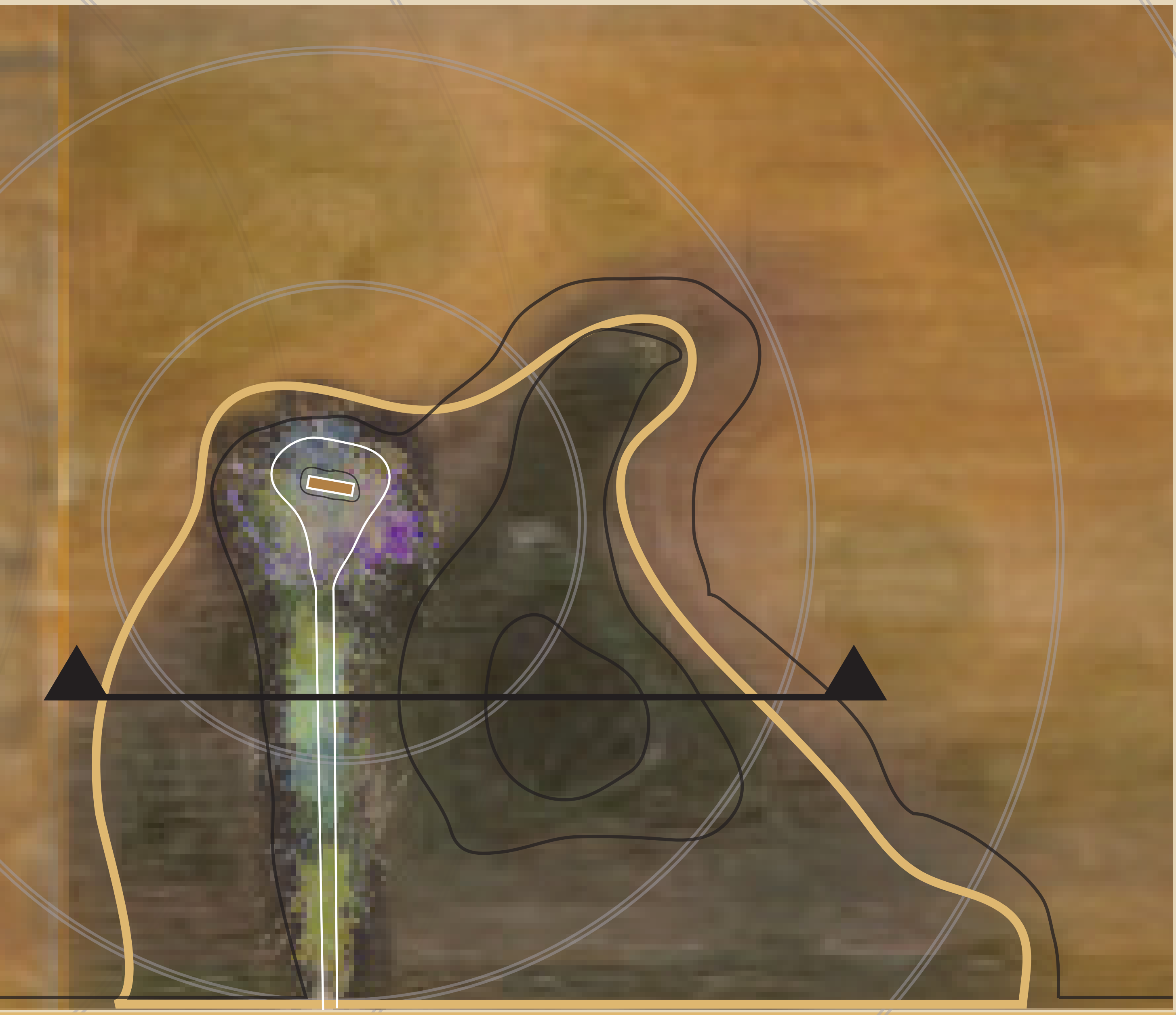
Former Pump Jack Location

Previous Oil Well Site

Section Line

Uncultivated Areas Outline

Schematic Contour Lines



As is typical of the region, the oil well sites often share similarities. A typical site is considered a well pad that is between 25 meters - 40 meters diameters, with an attached access road of any length. Oftentimes, these access roads are located along the periphery and/or within uncultivated areas. Although these uncultivated areas change year-by-year based on precipitation amounts, the darkest areas (as per the satellite imagery) will, most likely, not be cultivated year after year. These areas are often too deep and/or too permanent to cultivate, many with trees and wetland vegetation (as per page 71). The exterior of these dark spaces may be cultivated in a dry year, reducing the amount of available uncultivated space.

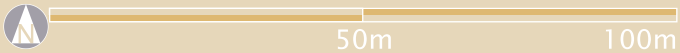
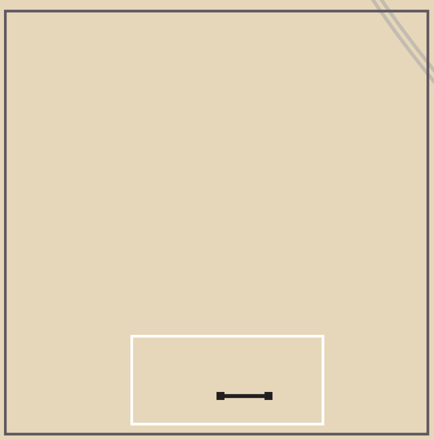


Figure 3.3.06: the application on site 2-16-004-06-W-2 | the alternative land use strategy, applied to a typical oil well pad and access road

Although the re-vegetated corridors will originally appear as distinct from the uncultivated areas, it is acceptable -- if not desirable -- that the native species mix into the uncultivated areas. The uncultivated areas can be altered according to the needs of the conservation organizations focus. If, for example, Nature Saskatchewan (2017b) wanted to initiate these sites as part of a PlantWatch program, the uncultivated areas can be altered to suit these requirements as necessary.



Previous Oil Well Site

Section Line

Uncultivated Areas Delineation

Flight Distances

Any existing wetland areas should not be disturbed. These spaces will already be functional wetlands and not benefit from human interference.

The only exception for this would be an invested interest by an organization such as Ducks Unlimited Canada. If the wetland requires alterations to be more productive without negatively impacting native bee species, then alterations are not only allowed, but encouraged.

The agricultural areas will be out of the scope of the proposed strategy. This strategy will not affect land users and, as such, these spaces are not to be impacted.

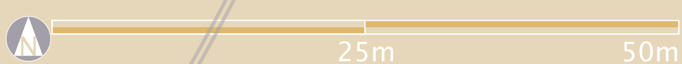
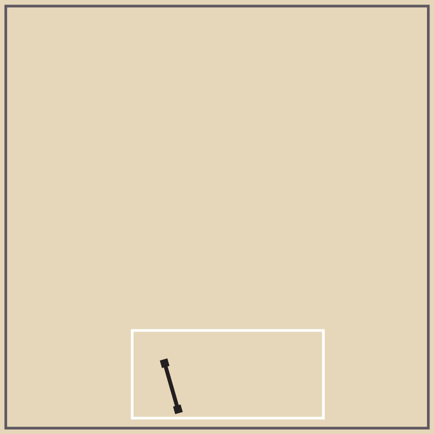


Figure 3.3.07: the application on site 2 -16-004-06-W-2 | the alternative land use strategy, applied to a typical oil well pad - section

In the absence of trees in the existing uncultivated spaces, it is necessary to consider the addition of aspen trees along the peripheries of the oil well sites to provide wind breaks and nesting materials for bees.

The repurposed well pads will resemble the access roads but larger, the initial block planting visible if close to the edge of the fields, near the gravel roads.

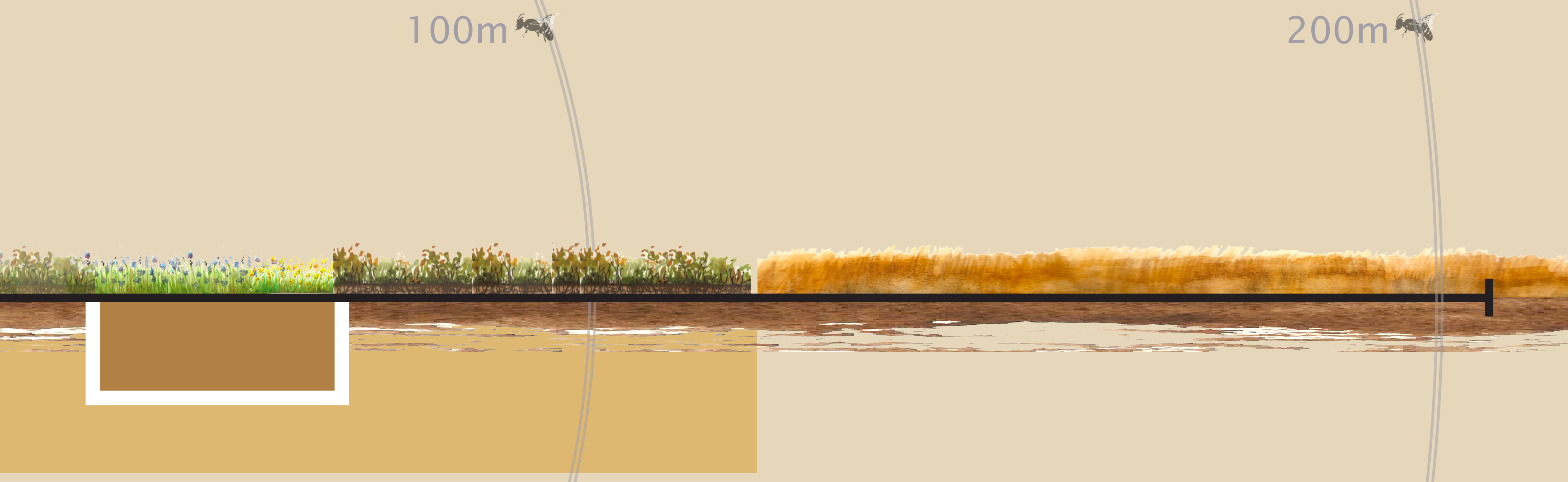


Previous Oil Well Site

Section Line

Uncultivated Areas Delineation

Flight Distances



The access roads will, in the initial stages of establishment, stand out as visually distinct. This effect is desirable so long as the vegetation establishes and supplies bees with the needed forage and connections.

If desirable by the land user, isolation strips (at approximately 8 meters) can be cultivated along the edges of the uncultivated areas, preventing the spread of invasive species into the farmed area. This is a desirable method, particularly compared to the use of pesticides to accomplish the same task.

Figure 3.3.08: the application on site 2 -16-004-06-W-2 | the alternative land use strategy, applied to a typical oil well pad and access road - section, again

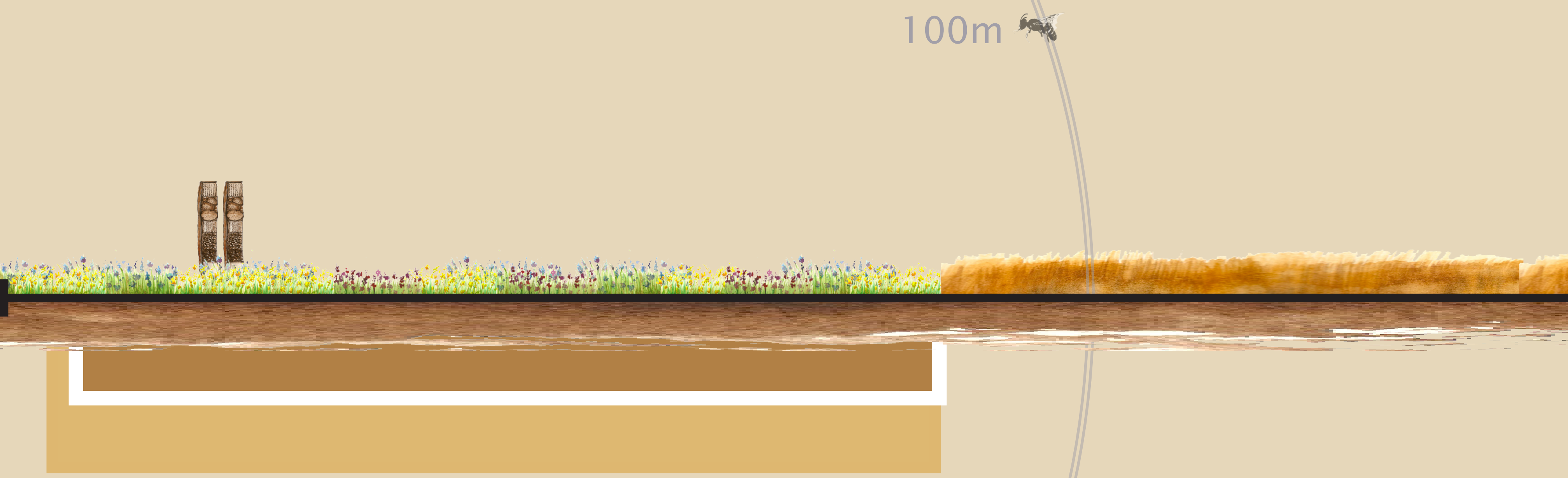
atypical section

Some sections will host oil well sites that are larger than the average 25 - 40 meter diameters. These sites have capabilities beyond the proposed revegetation strategy. The immediate benefit is for short-range flight bees; at 100 meters by 100 meters, the bees can use the full extent of the site without relying on the narrow corridors supplied by the repurposed access roads to access other repurposed oil well sites for nesting homes and materials.

Although the large oil well pad occupies a large enough space to accommodate short-range flight species, it does not discount the surrounding, uncultivated conditions. Farmers still cannot farm these areas and, as agriculturally-wasted space, payment for these spaces is still desirable. Essentially, the scale of the repurposed well pad in relation to its surroundings does not discount its placement within the land use designation of the field.

Former Pump Jack Location
Previous Oil Well Site
Section Line
Uncultivated Areas Outline
Schematic Contour Lines

Figure 3.3.09: the application on site 2-16-004-06-W-2 | the alternative land use strategy, applied to an atypical oil well pad and access road



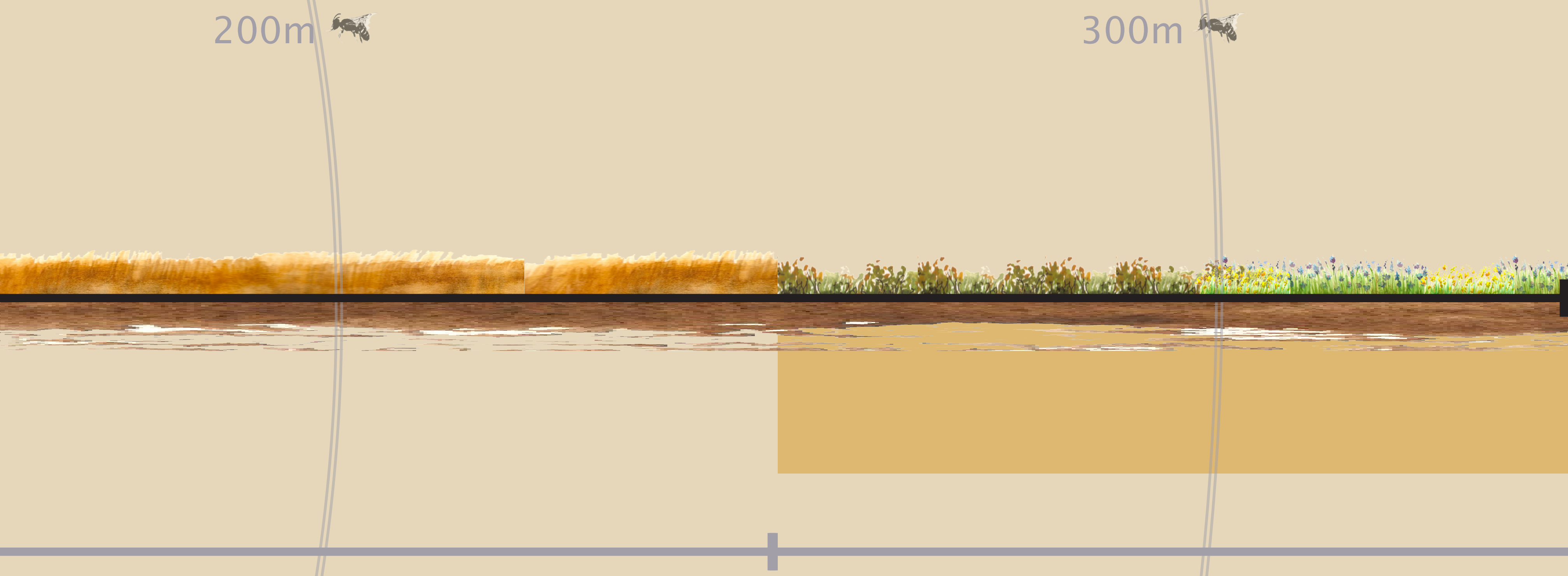
In some cases, the access roads are not suitable to repurpose as bee forage. These situations must be evaluated individually but if the access roads cause unjust disruptions to the land users, then they must be reconsidered as maintained sites.

Previous Oil Well Site

Section Line

Uncultivated Areas Delineation

Flight Distances



In this section, bees with flight ranges of >200 meters are capable of accessing the next-nearest uncultivated patch. As such, this access road can be reclaimed by the land user and revegetated to crop land. This cannot be the case for all access roads, particularly those where the flight range analysis indicates that the majority of native bee species could not reach the next nearest uncultivated patch(es).

This uncultivated patch will provide the necessary bee forage and nesting materials despite the absence of a connective corridor. As many bees can still access this patch, the conservation of this area is crucial if the access roads are not to be repurposed.

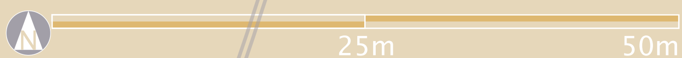


Figure 3.3.10: the application on site 2 -16-004-06-W-2 | the alternative land use strategy, applied to an atypical access road - section

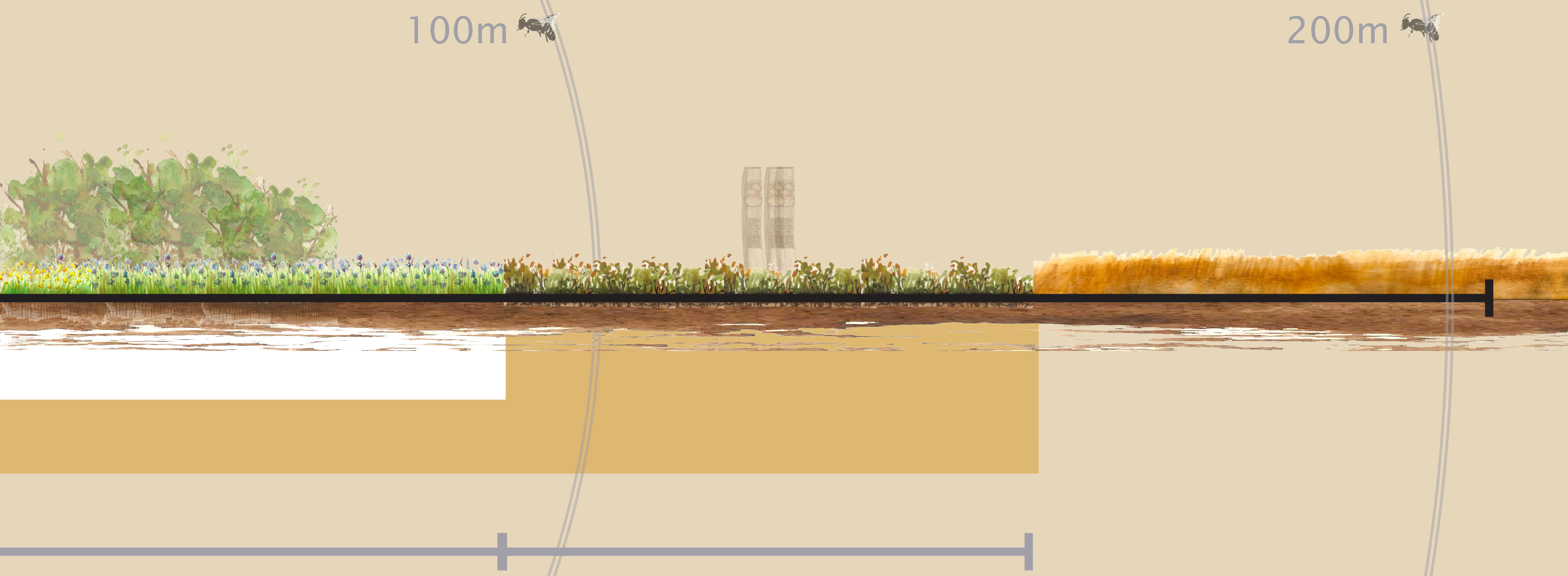
If these sites are repurposed to the revegetation strategy, they will host ample space for short-range flight distance bees to access all the site has to offer. The addition of trees and forage (wildflowers) plus the bee towers can host all the required materials for successful bee population (re)establishment.

Previous Oil Well Site

Section Line

Uncultivated Areas Delineation

Flight Distances



If this site is converted to constructed wetlands by invested conservation organizations (such as Ducks Unlimited Canada). The oil companies must remediate the site to acceptable environmental health standards, but then (for example) Ducks Unlimited Canada could take over the next steps of the process.

Surrounding uncultivated areas can be merged into the conservation organizations scheme, or held separate. This section showcases ample area for more than one organization to consider compensating the land owner; Ducks Unlimited Canada may reconstruct a wetland, while the Nature Conservancy of Canada is evaluating the remainder of the site as part of a larger, connective section. The Saskatchewan Wildlife Federation may consider this land as ideal for certain rare or endangered species, supplying resources and/or volunteers to assist in managing and maintaining the site.

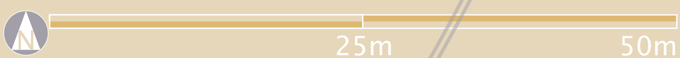


Figure 3.3.11: the application on site 2 -16-004-06-W-2 | the alternative land use strategy, applied to an atypical oil well pad - section, again

If an organization chooses to adopt or manage a larger-than-average repurposed oil well site, it will take place after the remediation process. Remediation guarantees uncontaminated soil that reaches a level of health for both human and wild species. With a toxin-free environment, the conservation organizations are not responsible for the expensive remediation process but they also have a clean slate on which to work.

As an example, a constructed wetland built on an existing oil well pad promotes a use outside of the revegetation strategy but one that will not dissuade bees from occupying the space. **It is important that conservation organizations are given flexibility in their management of repurposed oil well infrastructure; not only are they the experts, but it will encourage continual, appropriate maintenance that will not place a burden on the land owner(s).**

As a constructed wetland will differ from the strategy listed thus far, it need only be aware of the guidelines and, although altered, meet the recommendations. Although the strategy aims to support and promote bee populations, it can also assist other, necessary ecoservices.

re-vegetate

If an organization opts to install a new re-vegetation scheme, it is allowable so long as the guidelines in *Figures 3.2.08* and *3.2.09* are followed. The species are not limited to *Figure 3.2.18*; a wetland will not support many of those species -- as many of them are native to grasslands -- but an organization may install other relevant, non-invasive vegetation. In a constructed wetland, water-loving species will thrive and can be edged with the species of *Figure 3.2.18*.

reclaim

The definition "landscaping, replacing or replenishing the topsoil and re-vegetating the surface of the soil so that it is compatible with its surroundings" will shift (Government of Saskatchewan, 2015a, p.9). The "surroundings" will not pertain to agriculture but, instead, the larger landscape, the pothole prairie.

restore

The definition is similar to reclaim but focusing on "equivalent land capability" (SPIGEC, 2009, p.4). In a constructed wetland, however, the equivalent land capability will refer to the land directly surrounding the repurposed oil well pad: the uncultivated area(s).

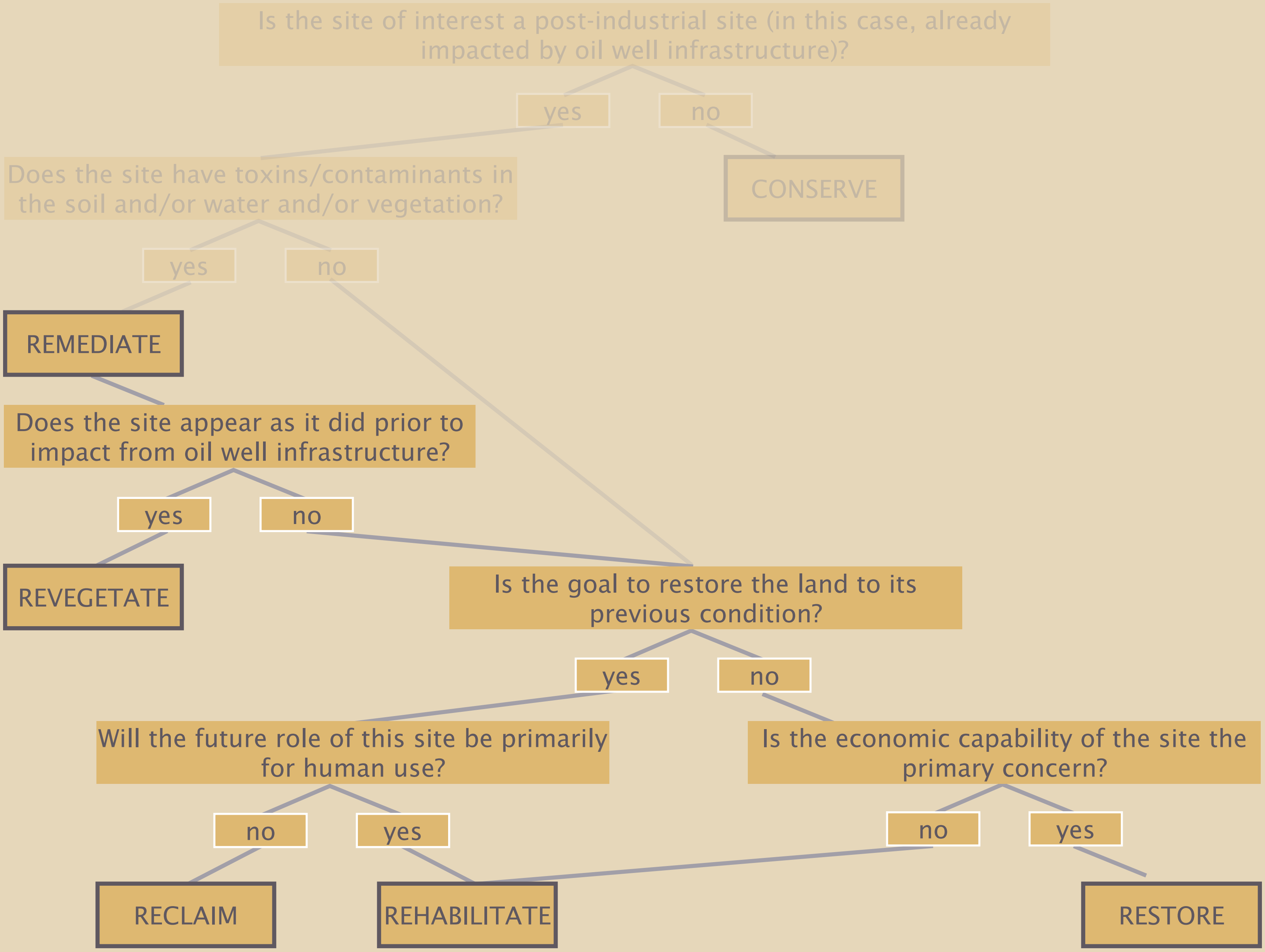


Figure 3.3.12: based on *Figure 3.2.03*, the regulatory requirements are, once again, reconsidered for atypical sites

 Figure 3.4.01: an oil well pad near a farm, nearby an uncultivated area near 16-004-06-W-2 in southeast Saskatchewan

3.4 AN ALTERNATIVE STRATEGY

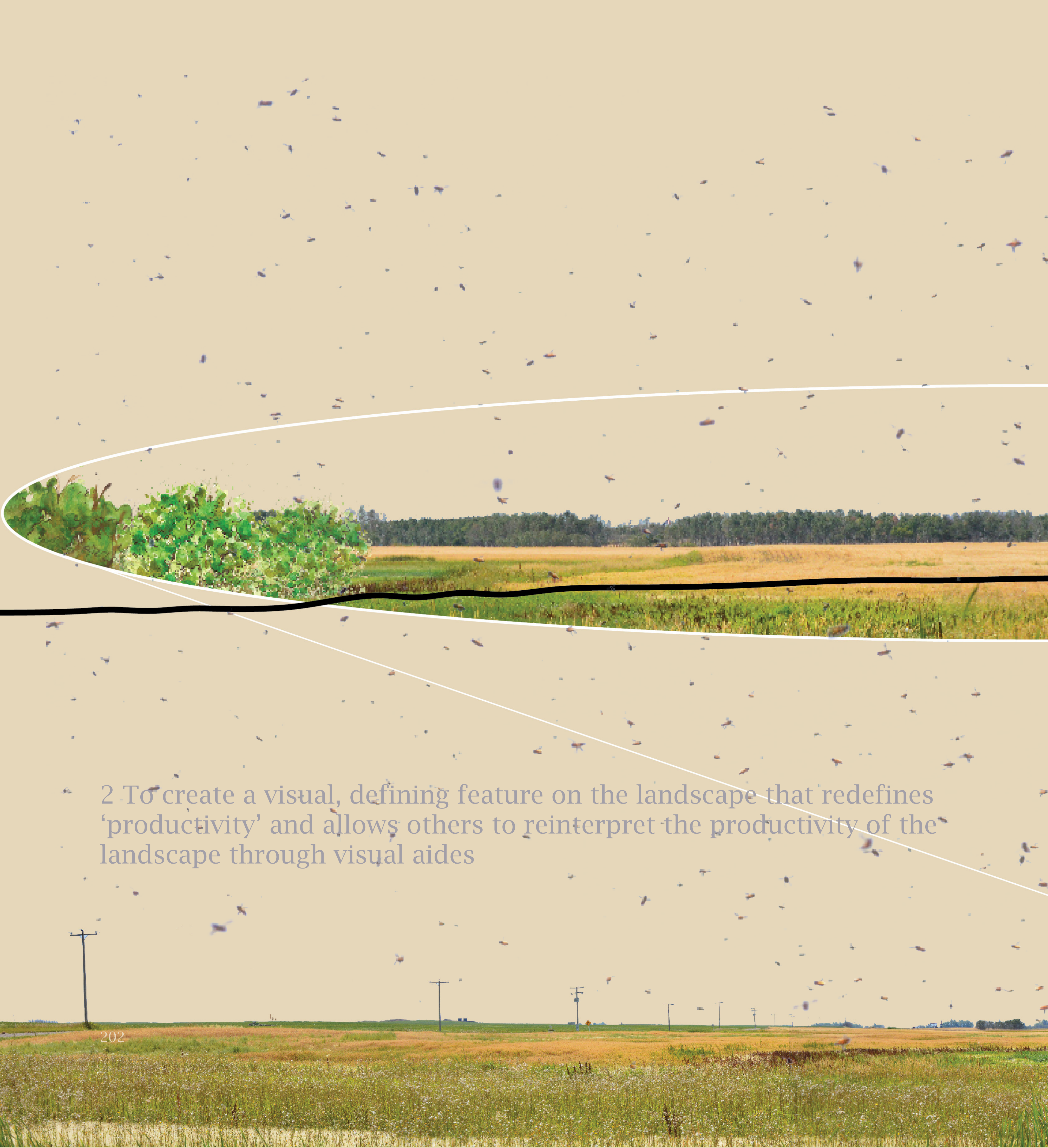
concluding land use and conservation

1 To reflect the history of the oil well sites post-decommissioning

As the first bee towers are introduced, they will create a new shape on the horizon, one that mirrors the repetitive elements of power poles and pump jacks and rows of seeded crops, but also stands alone as a new form. Visually, these towers must be interpreted, what are they doing there? reminiscent of the oil infrastructure that once existed in place but has since, in the future, been removed.

The form of the bee towers combined with the distinct re-vegetation strategy will visually document the effect that oil once had on the landscape. The wildflowers, streaking through fields, will create corridors of colour and texture that differ from the visually monochromatic crops. As towers are installed, conservation organizations and land users must visit the existing delineations, creating the least intrusive and most productive areas for bee species and land users alike.

Figure 3.4.02: the first bee towers are applied to the landscape



2 To create a visual, defining feature on the landscape that redefines 'productivity' and allows others to reinterpret the productivity of the landscape through visual aides

When this strategy is applied to the greater landscape, there will be a new landscape to read and interpret. The design strategy is split between providing habitat for bees, recognizing the requirements of land ownership and usage, and creating large enough patches to be worthwhile for conservation organizations to invest in to create a functional, new productivity.

These installations are time-based, intending to be continually developed and allowed to grow successively. As the bee towers and access roads are continually witnessed, repeating over and over, the viewer is reminded of how many pump jacks once existed and just how far a new productivity can extend.

Figure 3.4.03: more bee towers are applied to the landscape


3 To repurpose abandoned and decommissioned oil well sites

The uncultivated areas gain a new life, compensating farmers for a land use strategy that acknowledges their needs and contributions to the health of the greater landscape, without placing the financial burden on them. The oil companies continue to treat well sites, but with a new end purpose. The bees are given living conditions that will promote population maintenance, if not growth, supplying pollination services to crops and making their productive worth known. The impact of oil is not erased, but repurposed, acknowledging our history while providing for our future.

Figure 3.4.04: more bee towers are applied to the landscape, appearing on the horizon

4 To implement the necessities for native bee populations to survive

Figure 3.4.05: a native prairie is established along a repurposed access road and oil well pad, representing a repurposed alternative land use strategy.

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