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The Dakota Access and Keystone Pipelines

Environmental Impacts, Health Outcomes, and Facility and Representative Access

Cover Images from
https://www.pbs.org/newshour/politics/federal-officials-leave-future-of-dakota-access-pipelines-river-crossing-unclear-in-draft-review
https://abcnews.go.com/US/cause-found-keystone-pipelines-massive-oil-leak/story?id=97011583

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EXECUTIVE SUMMARY

The Dakota Access Pipeline (DAPL), constructed in 2017, has been the source of much controversy over the environmental and physical health impacts of its operation, in addition to the catastrophic impacts of a potential spill. The Standing Rock Sioux Tribe, under whose main source of water the pipeline was built, has been especially instrumental in alerting the world to the devastating consequences of pipeline construction and failures, including the dismal track record of the company responsible for pipeline operation and maintenance. There were 5 spills in the first six months of pipeline operation alone, highlighting how probable these events are, despite the assurances made by the construction company to the contrary. The goal of this project is to compare the impacts of the Dakota Access and Keystone pipelines, looking specifically at the geospatial impacts of the pipeline on indigenous communities and reservations and how this impact compares to that of the wider states populations, to determine how these communities are disproportionately affected. It also aims to examine health and environmental outcomes and impacts, determining how and if these have changed since DAPLs construction as compared with state-wide averages and county-level data around Keystone as well. It examines the access to healthcare facilities which are present and available to those impacted by such events and to determine if there is adequate healthcare coverage, both for those directly around the project site as well as in areas serviced by impacted waterways. Finally, this project will look at access to elected officials, as potential sources for effect remediation and accountability. The data for this project has come from the North Dakota and South Dakota geoportals, data.gov, and a variety of other state-level sources.

INTRODUCTION

The Keystone Pipeline

source: https://www.popsci.com/story/environment/keystone-xl-pipeline-goes-green/

The Keystone and Dakota Access (DAPL) Pipelines, operating since 2010[1] and 2017[2], respectively, are major transporters of oil throughout the country. The Keystone Pipeline stretches almost 3,000 miles and transmits up to 500,000 barrels of oil per day,[3] running from Canadian oil fields to Texas refineries. It crosses the border into the United States into the eastern edge of the Dakotas before continuing on into Nebraska. A proposed extension of the project, called the Keystone XL, was introduced in 2008 to expand the capacity of the pipeline to nearly double the amount of oil being transported; this proposal went through a variety of political upheavals, due in large part to presidential administrative changes, before finally being denied in 2021.[4] While this expansion was canceled, the original pipeline continues to operate, despite having leaked 22 times since it began operating,[5] including a notable spill in 2019 of more than 378,000 gallons in North Dakota.[6] The Keystone Pipeline carries tar sands oil, which is notoriously difficult to clean due to its consistency; rather than floating, like traditional oil, it sinks to the bottoms of wetlands, making it far more difficult to remove before it spreads into soil.[7]

The newer DAPL, which begins in the Bakkan oil fields of North Dakota before running south, can transmit up to 750,000 barrels of oil per day[8] and was constructed in 2017 amid mass protests around the environmental justice, ecological, and health impacts of the project. Central to these protests are the Standing Rock Sioux Tribe, whose land and water systems could be contaminated in the event of a spill. The pipeline also crosses under Lake Oahe, which serves as a major water source for both the Standing Rock and Cheyenne River Reservations,[9] while also intersecting with a huge number of rivers and streams which could be poisoned and carry toxic oil to other communities. Energy Transfer, the company behind DAPL, has a dismal safety track record, and has faced many lawsuits including 48 criminal charges connected to leaks in a Pennsylvania pipeline last year;[10] indeed, the DAPL spilled 5 times in the first year of operation.[11] Despite this, the pipeline continues to operate illegally, given that no environmental impact statement has been approved.[12]

Protesters at the Dakota Access Pipeline

source: https://bigfirelaw.com/big-fire-statement-on-dapl/

Oil and oil spills are immensely detrimental, both directly and indirectly, for human and planetary health. The health impacts of oil spills impact nearly every system of the body through direct exposure or exposure through air, water, or soil contamination.[13] Studies have found evidence of harmful respiratory, dermatological, and neurological impacts such as headaches, dizziness, and decreased cognitive functioning immediately following exposure[14]. Longer-term exposure has also been linked to increased risk of cancer, liver damage, more severe neurological symptoms, and mercury poisoning[15], in addition to adverse respiratory and mental health impacts such as increased depression and stress.[16] Indirectly, oil spills can affect health through degrading soil and destroying subsistence farming practices,[17] creating food insecurity which is linked to worse health outcomes from diseases like chronic obstructive pulmonary disease (COPD)[18] and cardiovascular disease.[19] Additionally, indigenous communities nationally have higher national prevalence of mental health disorders,[20] COPD,[21] and cardiovascular disease,[22] due to the impact of years of systemic discrimination, violence, and displacement.[23] Finally, research has demonstrated that living within close proximity to oil pollution is connected to increased mental and emotional distress.[24] This suggests the need to not only consider the health impacts of environmental disasters such as oil spills, but also the ways in which the presence and operation of a pipeline exacerbates existing health disparities, even in lieu of a spill occuring.

Research Questions

Despite these risks, the health impacts of oil spills, particularly the long-term outcomes, remain relatively understudied.[25] Given the large amount of oil currently being transported through the United States in close proximity to rural marginalized communities[26], there is huge risk for disproportionate and dramatic health impacts on communities which already bear the bulk of this impact. My research questions, therefore, were four-fold.

01 How would an oil spill impact land and water, particularly in tribal lands and waters?

02 How did the construction and operation of the DAPL impact the health of those in its path, particularly tribal communities, and how does this compare with the longer-term health impacts of the Keystone pipeline?

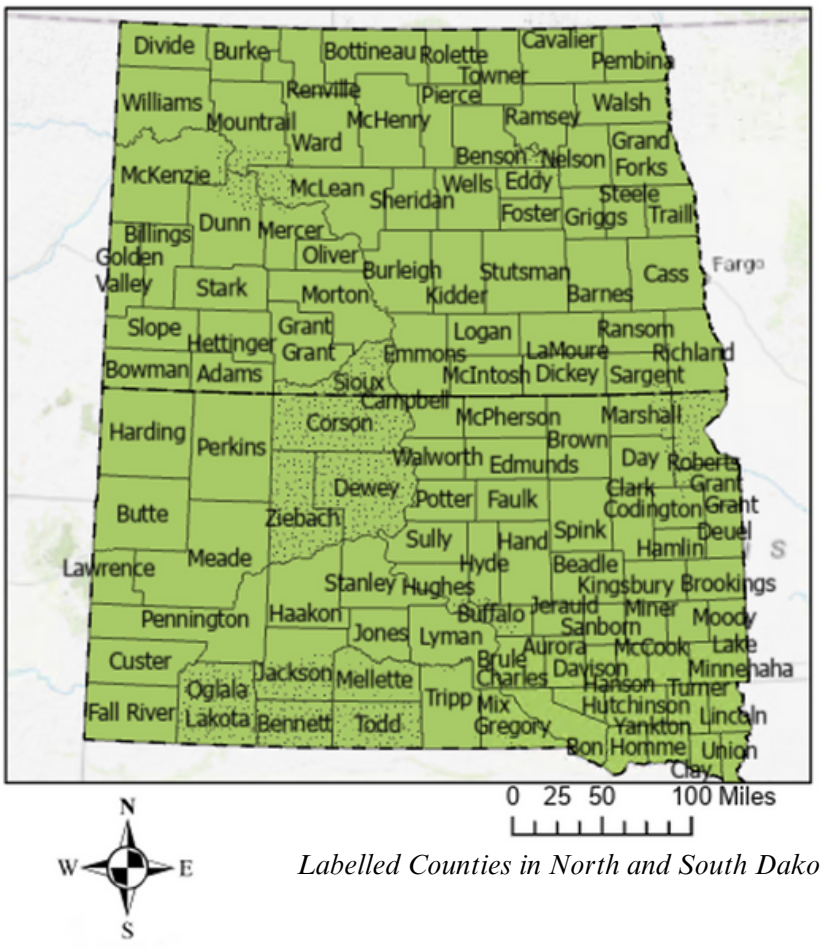
03 How are the areas through which the pipeline passes equipped to deal with a potential oil spill?

04 And finally, what is the access and proximity of those living in areas most affected by the pipeline construction to remedies for accountability and change?

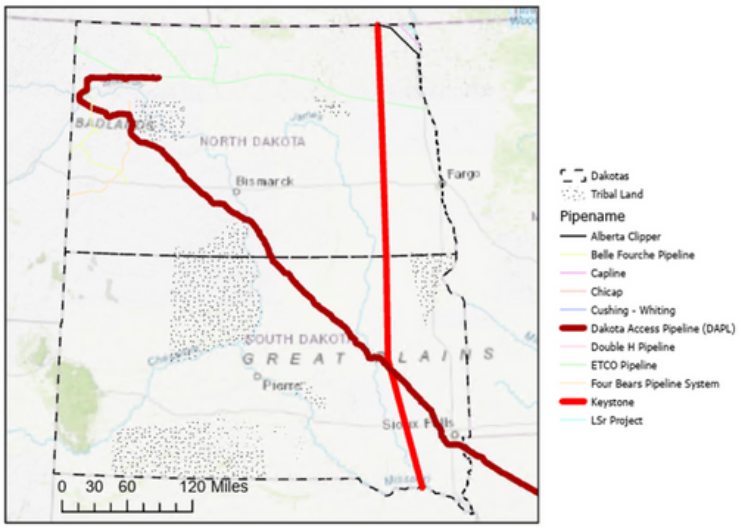
DATA AND METHODOLOGY

Study Area Definition

The initial goal of this project was to study many crude oil pipelines globally and examine similarities in health outcome trends; however, it soon became obvious this would be a far too ambitious undertaking in both scope and ability. The study area was subsequently narrowed to just the DAPL in both North and South Dakota, as well as tribal lands, to be able to adequately consider a variety of impacts and outcomes. While doing so, however, it became apparent that analysis would benefit from the inclusion of an older pipeline; additionally, when comparing to the rest of the state, it was important to note other areas in which oil was being transported and had been spilled. The Keystone pipeline was thus added to consider two pipelines, providing a more complete description of the landscape as well as a useful comparison for older pipeline outcomes.



Labelled Counties in North and South Dakota



The Dakota Access, Keystone, and other oil pipelines in the Dakotas

When selecting for health outcomes, I chose COPD, average days of mental distress per month, and cancer rates, all of which have been linked to pipeline proximity and/or oil spills as noted above. I also considered one additional measure of specific environmental exposure, PM 2.5, which has been linked to negative health impacts in addition to oil pipelines and spills.[27] Despite not knowing exactly where spills occurred, I wanted to see whether or not any pure environmental and air metrics were higher as a result of the pipeline construction, in addition to potentially related health outcomes.

Data Sources and Collection

Data was sourced from the following websites and downloaded into a centralized project folder. Further resources were consulted, but the following were ultimately determined to be the most complete and reliable, albeit with the limitations noted below.

- CDC[28]: COPD Prevalence
- County Health Rankings[29]: North and South Dakota County-Level Health Outcomes; data used was sourced specifically from:
    - Behavioral Risk Factor Surveillance System[30] (CDC)
    - Census Population Estimates[31] (US Census Bureau)
    - National Environmental Public Health Tracking Network[32] (CDC)
    - American Community Survey[33]
- Data.gov: TIGER Road Data
- Indian Health Services[34]: List of Health Centers in Tribal Territories
- North Dakota Geoportal[35]: County and State-Level Outlines, Streams and Rivers, Tribal Water Supply Shapefile
- Plural Policy[36]: Elected Official Address Data
- South Dakota Geoportal[37]: County and State-Level Outlines, Streams and Rivers
- State Cancer Profiles[38]: County Cancer Rates and Trends
- US Energy Atlas[39]: Crude Oil Pipeline Shapefiles
- US Department of Homeland Security[40]: Hospital Data

These data were suitable and applicable to my research question; however, I did have difficulty finding some data which would have provided far greater insight into my analysis. Notably, I was unable to locate reliable oil spill location data, which would have been very useful for examining health impacts more specifically.

Data Transformations

All data was loaded into ARCGIS Pro into a project with a basemap using the 'NAD 1983 (2011) StatePlane South Dakota N FIPS 4001 (Meters)' coordinate system. The state and county boundaries and pipeline Shapefiles were loaded before the switch to this coordinate system; therefore, they were projected using the 'Project' Analysis tool into this coordinate plane. The county boundary Shapefile was then joined to the health data from given CSV files on the County column, enabling them to be displayed using various symbologies. However, several data transformations were needed to enable this process, as detailed below.

In order to easily select the necessary data, the two state outlines were joined using the 'Merge' tool, as were the river and roads data. Data points such as hospitals and elected officials were added through the XY Table to Point (hospitals) and geocoding addresses (elected officials). All subsequent files which contained data outside the project study area (i.e. pipeline routes, hospital locations) was then clipped using the outline of both states to focus on only relevant data points, using the 'Clip' tool. Given that the elected official data had to be geocoded from both North and South Dakota individually, the 'Merge' tool was used to combine the two datasets and generate the analysis presented below. The 'Merge' tool was also used to combine Indian Health Center locations with general hospital sites, given their exclusion for the overall hospital dataset.

The cancer data at the County level included an extra parenthesis, which made it difficult to complete the join. The following code was used to compute a new field, which then enabled the join to occur successfully:

```
def calcCounty(org_county):
   county = ""
    for character in org_county:
if character == "(":
return county
        else:
             county += character
    return county
```

Several data values in the County Health Rankings file were in 'character' format, despite being numeric. The data transformation was attempted using a native function, but was unsuccessful due to differences in "n/a" data delineation throwing errors. Specific examples include PM2.5 prevalence and county-level cancer trends. The following code was used to capture errors thrown while converting the major of the data to numeric format, which was then assigned to a new value field:

```
def convertNums(value):
    try:
        float(value)
        return value
    except ValueError:
        return 0
```

Finally, once the data was cleaned, the 'Merge' tool was used to combine the most relevant county-level health metrics from both North and South Dakota from both the 2016 and 2021 datasets into one layer.

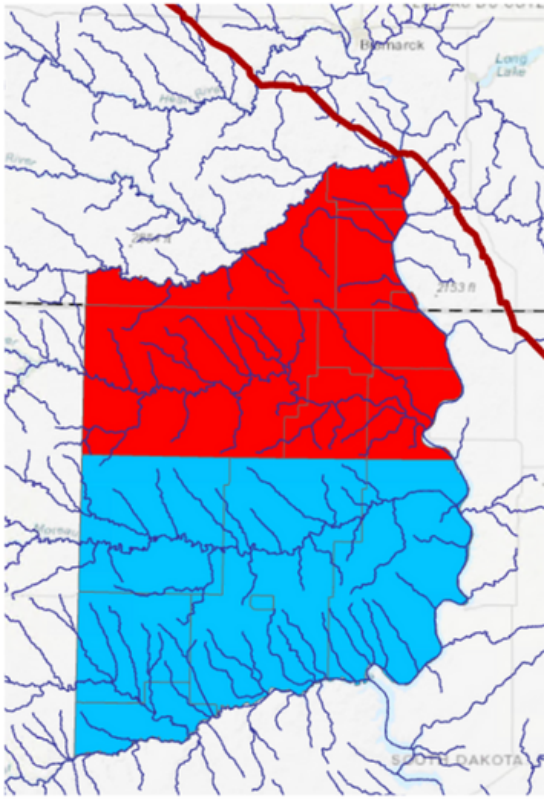
Data Limitations

There are several limitations to this dataset, particularly given its emphasis and consideration of indigenous populations. As noted above, I was not able to identify exact spill locations, which makes it difficult to determine specific health outcomes related to direct oil exposure vs the pipeline more broadly. Errors in the data collection process can lead to undercounting of indigenous health outcomes, including cancer rates[41], and cancer data was unavailable to be broken down by race/ethnicity in North Dakota[42], which severely limited equity analysis ability. Additionally, in counties where there were only small numbers of disease incidence, mortality, or people surveyed for a given question in the cancer survey, this data and outcomes were suppressed to protect confidentiality.[43] This count was likely small, given the criteria for suppression, but could have possibly influenced the outcome. Further, given the complexity in defining race and ethnicity across the different data sources used by the County Health Ratings, there may be inaccuracies in their breakdown of different health outcomes by race; therefore, analysis focused on spatial variation and considered counties within tribal reservations rather than looking at overall racial and ethnic disparities. While avoiding potential misclassification, this level of analysis may miss disparate outcomes among indigenous folks who do not live within these counties, despite their similar exposures to environmental hazards due to systemic racism. Finally, COVID-19 may have impacted health outcomes and data collection during and after 2020, which may result in discrepancies between any data points from before and after this time period.

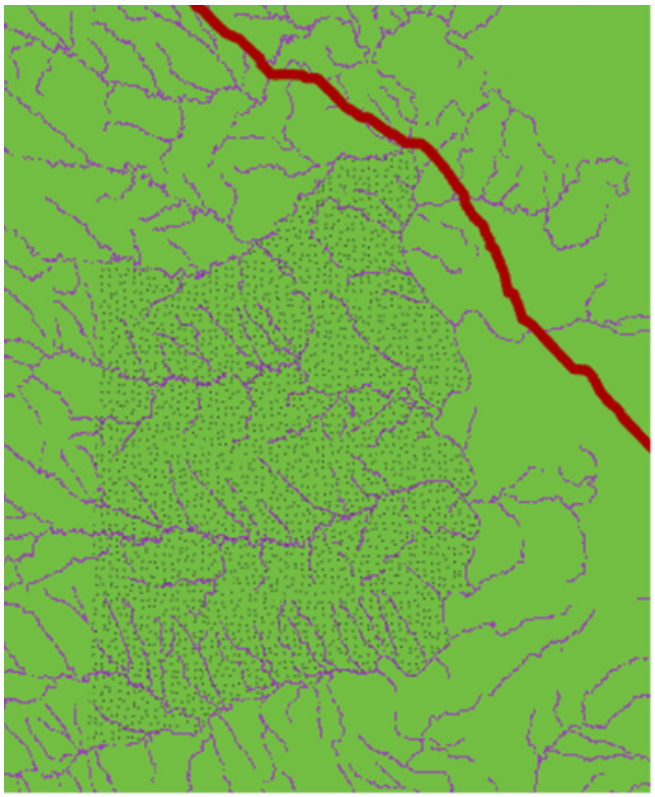
DATA ANALYSIS

Pipeline Proximity to Tribal Land and Water

When calculating the impact of oil on tribal lands and waters, I added the map of rivers, tribal lands, and DAPL to understand the interconnection of the rivers which would further contaminate tribal land should a spill occur. I used the Shapefiles of rivers in North and South Dakota and converted them to rasters using the 'Feature to Raster' tool. I wanted to provide an accurate picture of the relative difficulty of oil moving through water and soil, so tried to use NOAA's GNOME software to estimate how fast oil would move through the water, loading the Detroit River pre-set location as it seemed the most similar to this situation. However, this only resulted in a series of dramatic internal service areas without much success. I finally decided to use a value of '1' for the raster reclassification in the 'Reclassify' tool, and a value of '50' for land; given that oil does move through soil, I wanted to represent this without making it too high, despite not being able to estimate exactly how much harder it was.



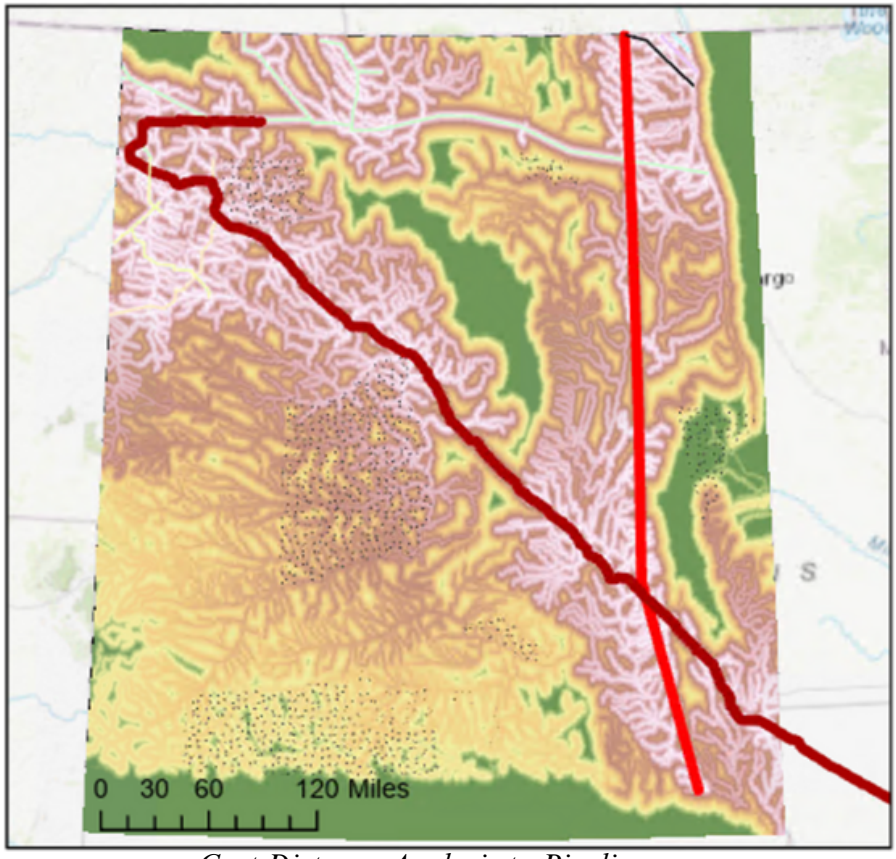
DAPL, rivers, and tribal reservations (Standing Rock, red, and Cheyenne River, blue)



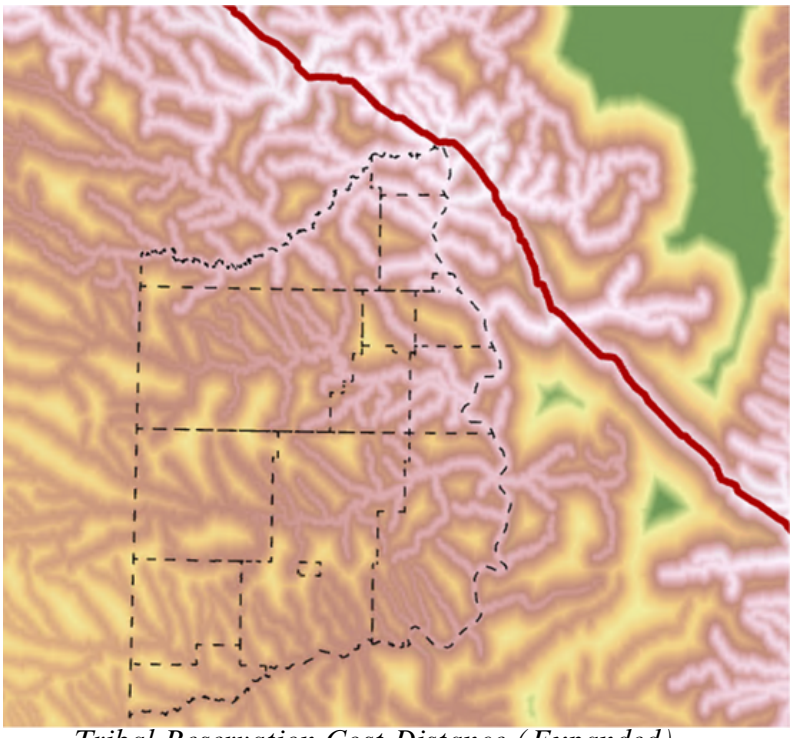
River Friction Raster after Reclassifciation

Pipeline Proximity to Tribal Land and Water

A notable limitation is the fact that I cannot identify in which direction the river flows, so had to model this equally despite the fact there are likely some areas with which it would have considerably more difficulty traveling upstream. I then combined this into a 'Cost Distance' from the pipeline to produce the ease at which a pipeline spill would impact waterways, and used 'Clip' to select the area around the Dakotas. This created a map of where the oil would more easily impact land and water, which, as demonstrated in the white and red below, is quite prevalent throughout the Standing Rock and Cheyenne River Reservations.



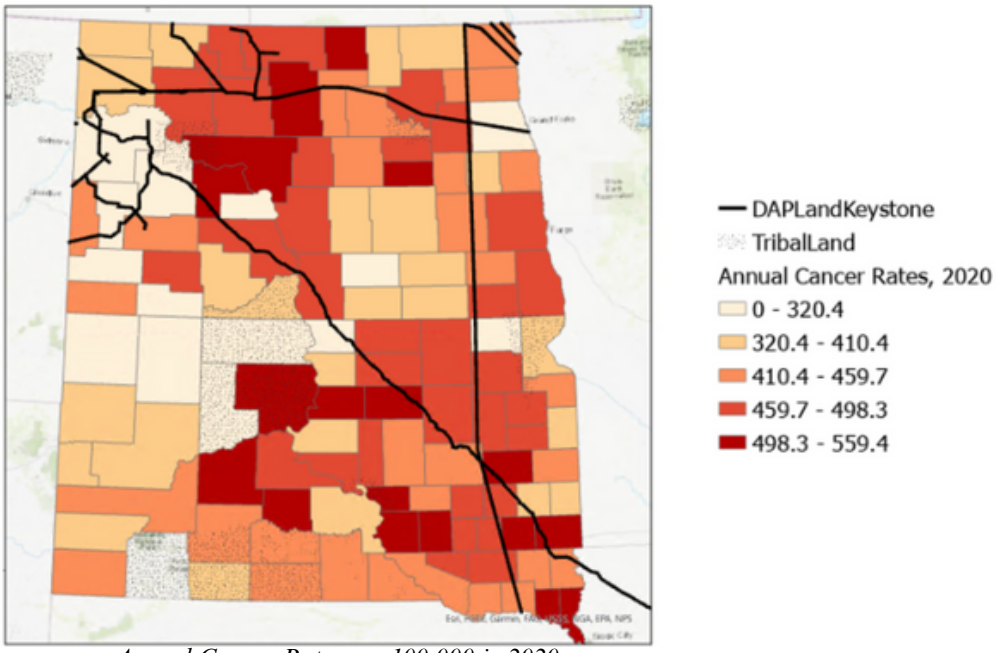
Cost Distance Analysis to Pipelines



Tribal Reservation Cost Distance (Expanded)

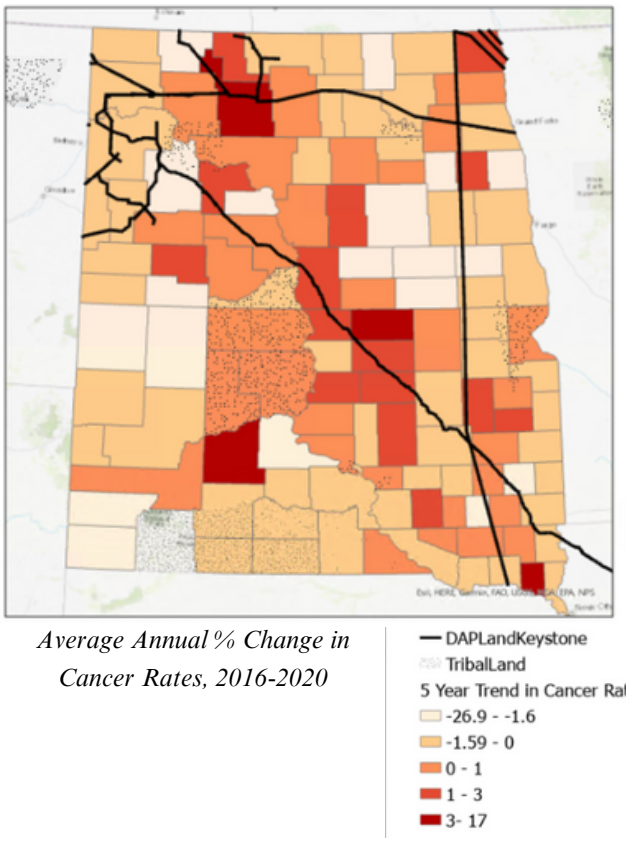
The vast impact a spill in one of these waterways would have on tribal lands and waters is evident, especially as compared to the impact it would have on the state capital of Bismarck, which is located upstream from the pipeline and away from which the pipeline was routed for fear of water contamination.[46] This is a dramatic illustration of the potential for contamination of tribal waters and lands, in addition to a clear example of environmental racism which prioritizes the health and well-being of those in Bismarck over those living on the reservations.

Cancer Rates and Trends



Annual Cancer Rates per 100,000 in 2020

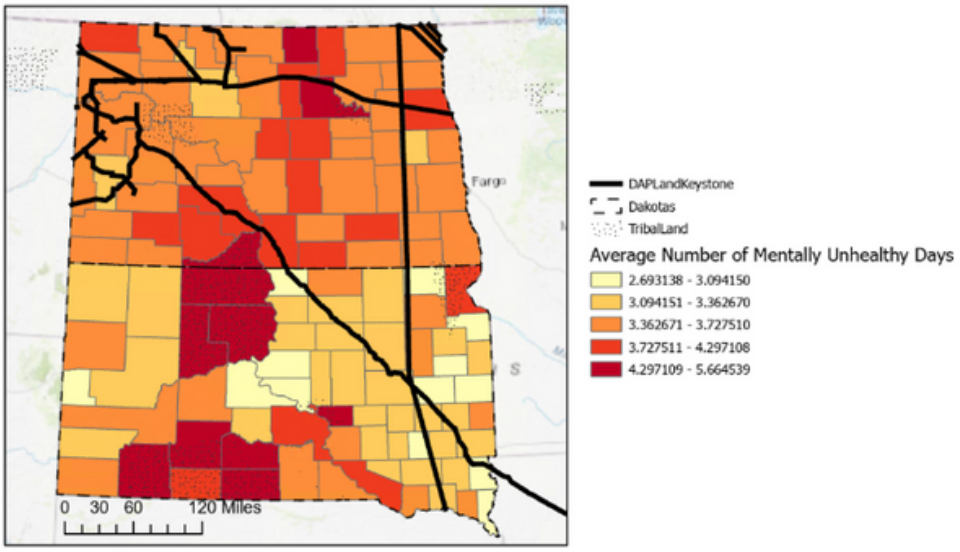
This map shows the annual cancer rates per 100,000 people in 2020 by county, which were downloaded as a .csv file and joined to the county shapefile to produce this vector map. Although there appears to be some trend around the pipelines, it is difficult to tell, especially given the relative newness of the pipeline. However, this will be an essential area to monitor in upcoming years. Similarly, the increase in cancers from 2016 to 2020 (right), from just before DAPL was constructed and began operating, show a similar pattern of potential clustering around the new pipeline. There are outlying counties and could be other reasons for this increase, but counties such as McPherson, Ward, and Mercer demonstrate a concerning trend of high, and increasing, cancer rates.



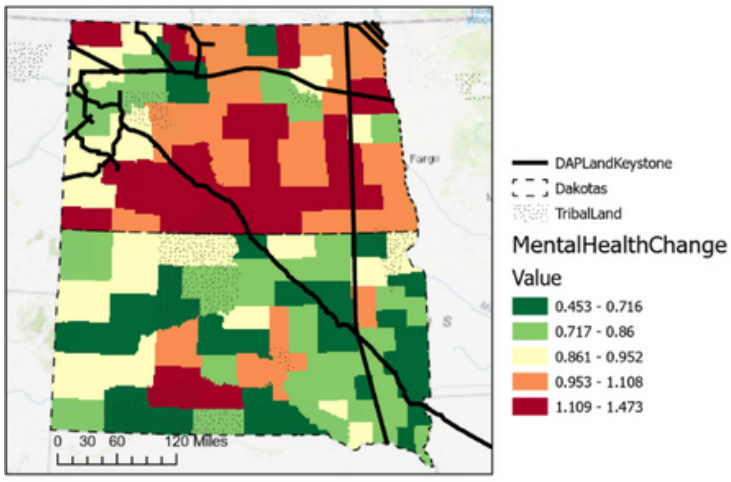
Average Annual % Change in Cancer Rates, 2016-2020

Mental Health

These maps examine mental health through the average number of self-reported poor mental health days per month, as well as the change in this value from 2014-2018. This encompasses the construction and first few months of the DAPL, in addition to the protests around its construction. This data was downloaded as a csv, then added to the county level shapefile. Both 2018 and 2014 data was then converted into a raster, using the 'Feature to Raster' tool. The 2014 raster was then subtracted from the 2018 levels using the 'Raster Calculator' tool to get the change in number of days. Unsurprisingly, there is a high level of mentally unhealthy days in all tribal counties throughout the two states.



Number of Mentally Unhealthy Days, 2014-2018

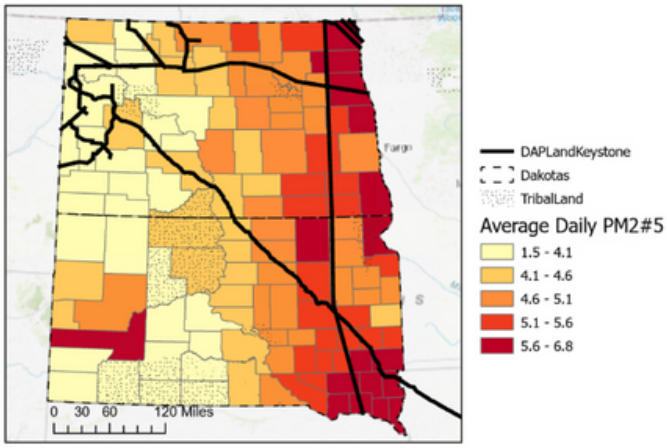


Change in Number of Mentally Unhealthy Days, 2014-2018

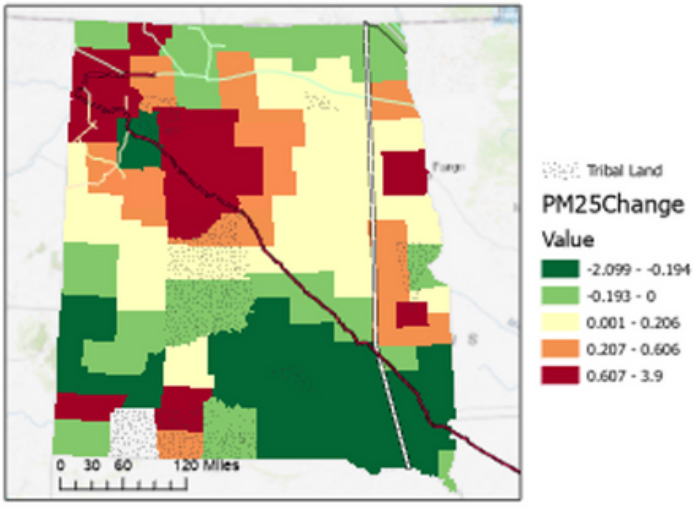
There appears to be some clustering of mental distress around the pipeline, but this pattern is not consistent. North Dakota seems to have experienced a much larger increase in the number of mentally unhealthy days; however, it is worth noting that mental health decreased everywhere to a greater or lesser degree. It is also worth considering how much some of these communities could increase, given how bad the outcomes are in the initial comparison.

PM 2.5

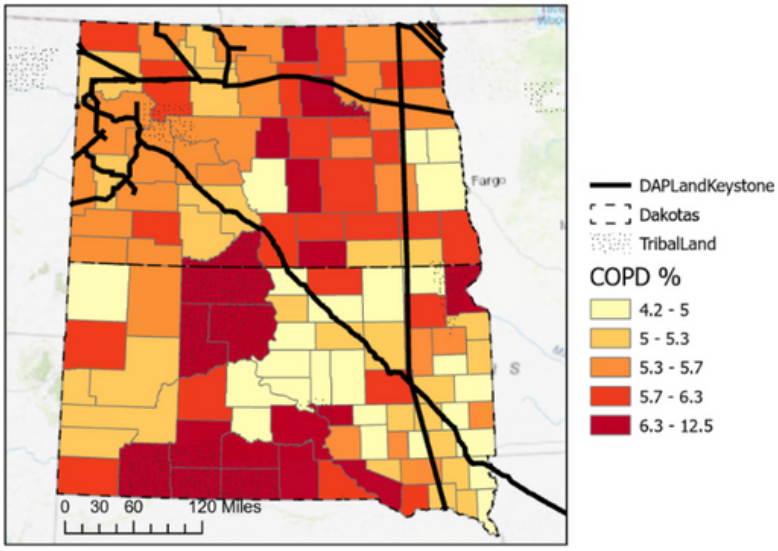
This map looks at the average daily PM 2.5 by county in 2016, just before pipeline construction and operation began. As described above, there was some amount of data cleaning required to produce useable values, which were downloaded in .csv format, attached to the county shapefile, and transformed into rasters to be compared as described for other data points above. There is clear clustering in the eastern part of the state around the Keystone and other, smaller, oil pipelines. When considering the change in average exposure from 2016-2019, after the DAPL began operating, there is clearly an increase around the Bakken fields , the area where the pipeline originates and where the oil is being produced. There is also a hotspot in the center of the map, just above the Standing Rock Reservation, which could be indicative of increased construction activity, potential leaks, or due to other confounding factors. Regardless, given the myriad of health impacts associated with increased PM 2.5 exposure, this hazard is important to monitor over the coming years to ensure this trend and potential clustering is addressed.



Average Daily PM2.5, 2016



Change in Average PM 2.5 Exposure, 2016-2019



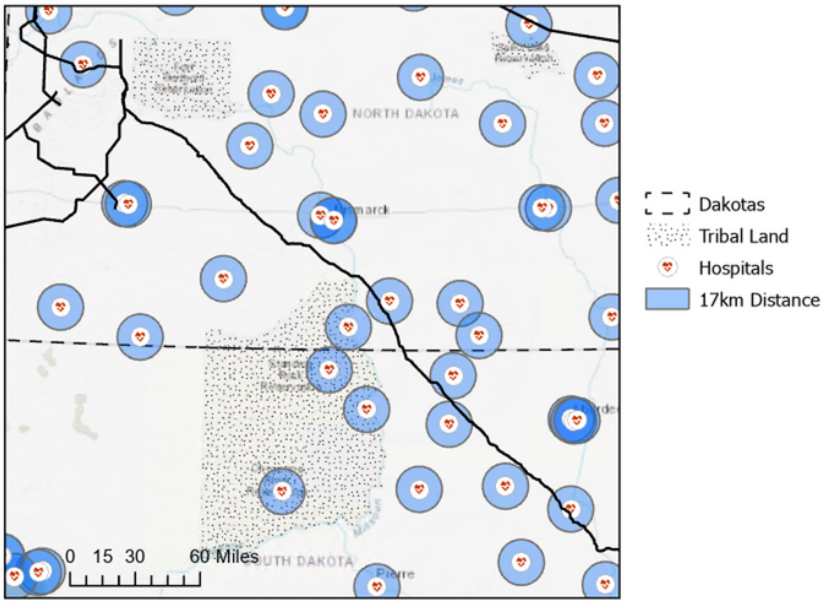
% of Population with COPD, 2021

COPD

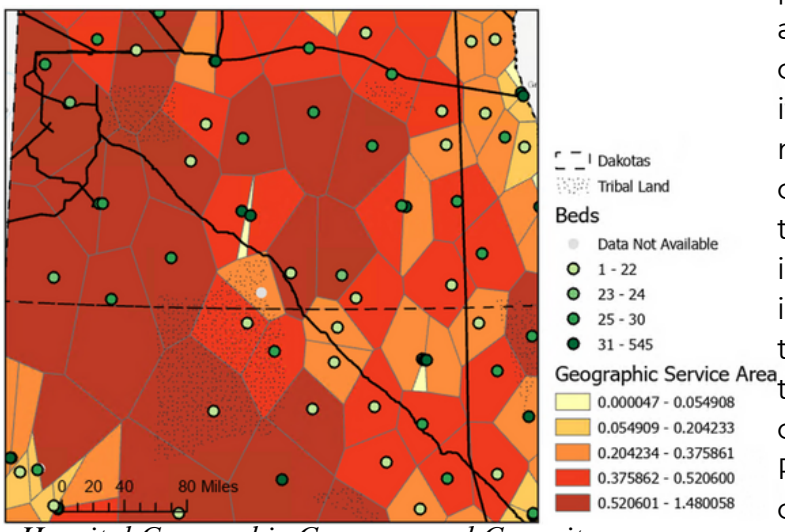
This map examines the prevalence, by percentage, of COPD per county. This data was downloaded as a .csv file from the CDC before being attached to the county Shapefile. While there are no clear trends of pipeline clustering, there are clear disparities which exist on tribal lands and reservations. Given the potential for pipeline spills to make this disease and symptoms associated with it worse, the lack of consideration of underlying health disparities in areas placed at risk by this project is incredibly irresponsible and is a clear example of a decision which will lead to increased health inequities through environmental racism.

Distance to and Capacity of Health Facilities

In addition to potentially experiencing adverse health outcomes as a result of pipeline construction and operation, I wanted to examine the availability of and access to care in the Dakotas, both on tribal reservations as well as other remote areas crossed by the pipeline. I began by using the 'Buffer' tool to calculate a 17km buffer around each hospital, which is the average distance for rural Americans to the nearest hospital. There appears to be relatively good coverage for many areas around the pipeline, even within tribal reservation areas; however, when I filtered for only 'Hospitals', which was listed as facility type for Tribal Health Centers data and for which I used the 'Calculate Field' tool to input directly for the Hospital data, that coverage decreased significantly.



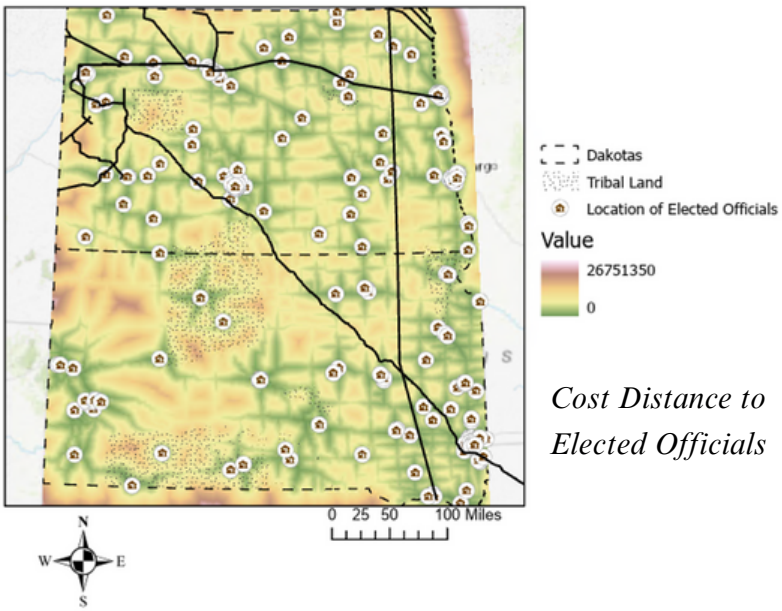
Hospitals with a 17 km buffer



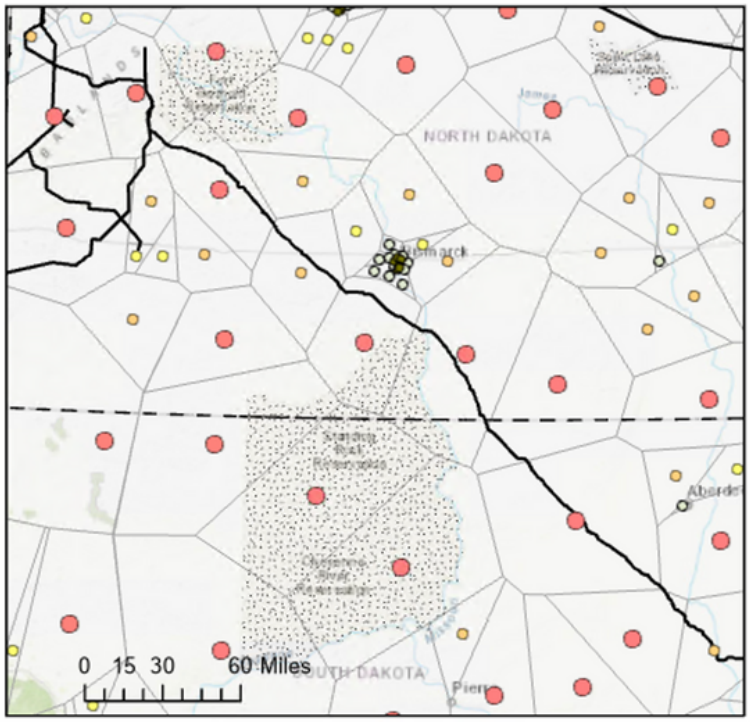
Hospital Geographic Coverage and Capacity

In order to measure the area serviced by each hospital, I created Theissen polygons which showed the amount of area each hospital has to provide coverage for geographically. This makes it easier to see which areas could be more easily overwhelmed in the event of a disaster like an oil spill. The color of the dots represents the beds available in each hospital; values of -999, which indicated no data, were replaced. Again, there is relatively good coverage around the pipeline itself; however, a notable coverage gap exists in the Fort Berthold Reservation in the North-West map corner, as well as in other areas which could be impacted by oil in their water sources. Despite hospitals existing on tribal lands, many have lesser capacity and larger services areas than those in other parts of the state.

Distance to Elected Officials



Cost Distance to Elected Officials



Theissen Polygons of Elected Official Access

Dakotas
Tribal Land
Area Covered
440000 - 10000000
11000000 - 150000000
160000000 - 1100000000
1200000000 - 3300000000
3400000000 - 14000000000

Finally, I wanted to examine the access to elected officials as a measure of proximity to those who hold power to change or determine the pipeline's future. There have been numerous examples of disenfranchisement of the Standing Rock Sioux Tribe throughout the DAPL construction and operation process, most recently during a public comment period was held far from the reservation in Bismarck, reducing accessibility to comment by tribe members. I downloaded the addresses of the offices of elected officials in North and South Dakota and used geocoding to map them to the points on the left. A Cost Distance analysis was created with the TIGER road Shapefile, converting it to a raster and reclassifying to used as the friction raster. I also created Theissen polygons through both states to examine which elected officials have to represent more areas by geographical coverage; given that elected officials represent a set politically designated area, this is likely not as representative of the actual coverage area, but does serve to represent those areas which have less access to political centers, represented by the red dots in the map to the left. This clearly demonstrates a geographic difficulty in accessing elected officials from tribal and rural areas, which will persist in lieu of conscious efforts to address this outcome of past and ongoing tribal disenfranchisement, erasure and discrimination.

DISCUSSION

As demonstrated by the maps above, it may be too early to see any direct health outcomes from the Dakota Access or Keystone pipelines, as well as determine direct causality. However, there are clearly large health disparities between tribal and non-tribal counties, reflective of national and international trends and due to repeated discrimination and exposure to environmental racism by placing hazards such as pipelines through these areas. There is also potential for disproportionate impact on these communities in the event of an oil spill, a lack of adequate large-scale hospital coverage, and disenfranchisement from political processes which may provide some opportunities to shut down the pipeline or promote company and state accountability.

Future monitoring should look closely at these outcomes, especially in the event of any oil leaks or spills, and especially around any increasing PM 2.5 exposure and subsequent health impacts. It would also be good to investigate any state-wide trends, such as the entirety of North Dakota having higher mental distress than South Dakota, and ensure continuity of data for the purpose of accurate comparisons.

CONCLUSION

In considering the above analyses, I provide three conclusions which may be helpful for future projects, as well as the monitoring of these pipelines and their impacts:

Equity must be centered in project planning	The examination of land and water impacts, health disparities, and healthcare access in the event of an emergency should be central to all evaluations, and projects should aim to actively reduce these disparities through projected and potential impact
Constant examination of health is crucial	Evaluation of physical and mental health impacts for those living around environmental hazards such as pipelines is necessary, given the likelihood of disasters; this data must be reliable, consistent, and comprehensive
Efforts must be actively undertaken to combat existing systemic discrimination	Years of discrimination and erasure of tribal communities have lead to inequitable access to health services and political power centers, as has a lack of consideration for rural communities. If not directly addressed, these structural and geographic inequities will contribute to the persistance of health disparities

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