Assessing Oversight of Acidizing in Oil and Gas Development in Florida

Environmental Science Practicum 2020-2021

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Foreword

This report was created by nine environmental science students in the Institute of the Environment and Sustainability (IoES) at the University of California, Los Angeles. The work was produced at the request of the Natural Resources Defense Council (NRDC).

We recognize that the University of California, Los Angeles resides on the land of the Gabrielino/Tongva peoples, the traditional land caretakers of Tovaangar. We pay our respects to Honuukvetam (Ancestors), elders, and ‘Eyoohiinkem (our relatives/relations) past, present and emerging.

We thank all of those who have made this project possible, including, but not limited to: our advisor, Noah Garrison; our client, Alison Kelly of NRDC; those who provided feedback on our final report, Felicia Federico and William Boyd; and Noam Rosenthal, Tom Gillespie, and Travis Longcore for GIS advising.

Disclaimer: The views and positions expressed in this report are those of the authors, and do not necessarily reflect those of the NRDC or any of the other parties identified here.

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INTRODUCTION

Between 2017 and 2018, the Burnett Oil Company conducted seismic surveying in the Florida Everglades' Big Cypress National Preserve in its hunt for oil. In the process, they cut and knocked down cypress trees, disturbed and destroyed ground cover vegetation, compacted fragile soils, and altered the hydrology of the Preserve's freshwater swamps, which feed the Everglades' world-renowned marl prairies and serve as critical habitat for endangered wildlife themselves (Quest Ecology, 2018; 2019). All this before even a drop of oil is pumped from the ground by Burnett Oil. The next steps, extraction and production, are only likely to further industrialize the natural landscape and degrade remarkable ecosystems. Substantial machinery is typically needed to construct well pads, which can cover several acres, and to build new roads to reach these sites. Heavy trucks are used to transport chemicals and other fluids to and from wells. The alterations from development activities often lead to habitat loss and fragmentation for native plants and animals, such as the endangered Florida panther, increasing their vulnerability to invasive species and ecosystem collapse (Meng, 2016).

New oil and gas drilling in Big Cypress National Preserve also threatens to harm cultural resources, values, and lands of the Miccosukee Tribe of Indians of Florida and Seminole Tribe of Florida, some members of which have voiced concerns over the potential environmental harms as well. Currently, the Burnett Oil Company has proposed two new well drilling sites in Big Cypress National Preserve (Schneider, 2021). In response, members of both Tribes organized a prayer walk to one of the proposed new drilling sites in April 2021 in opposition to the proposed drilling operations (Schneider, 2021).

In Florida, producers may use acid during production in a process known as acidizing. Acidizing uses acid and other chemicals to clean the wellbore or dissolve surrounding rock and strata to stimulate the well and improve oil and gas production. However, the extent to which acid is used, and the threat it poses to the environment, are not well documented. Specifically, acidizing poses a threat to the quality and quantity of water supplies, which is a particular concern for public health in Florida, where 93 percent of the population relies on groundwater for their drinking water (Kelly & Mordick, 2019).

As Florida moves towards potentially more drilling, we have conducted research to assess the extent of acidizing practices in Florida and to highlight many of the potential environmental impacts of oil and gas development in the southern part of the state. Based on available state records, a majority of producing wells in the state were acidized at one point during the well's lifetime. Acidizing, however, can refer to the use of acid for both well cleaning practices (where acid is used for regular maintenance), and to well stimulation (where the acid is injected into the surrounding rock, potentially releasing the acid and associated fluids more broadly into the environment) (Friends of the Earth, 2018). It was not immediately feasible from publicly

available records from the Florida Department of Environmental Protection (DEP) to distinguish whether acid was used for maintenance as opposed to production for any individual well. Nor was it clear that the available records were complete. For example, a state report stated that DEP - the state agency responsible for oversight of oil and gas production in Florida - received 41 well workover notifications – forms filed with the state to report the completion of operations to repair, maintain, or improve well function, including the use of well stimulation practices - involving the use of acid between 2016 and 2019 (Committee on Environment and Natural Resources, 2020). But our review of DEP's available records found references to acid use for only eight wells for the same period. Further, representatives for DEP stated in personal communications that acid has only been used for production, as opposed to cleaning, in two incidences. But we were unable to obtain state records to support these claims.

Generally, our analysis was hindered by the poor organization and availability of records maintained by DEP; our review required manually sifting through thousands of oil and gas records to locate any information on use of acidizing or other well stimulation techniques. The state's oil and gas management system should be reorganized and expanded to allow members of the public to easily search for and filter information, including different types of well stimulation operations, taking place near their communities. Moreover, given the apparently wide-spread use of acidizing, more research and better oversight is needed to assess the potential water quality and ecosystem impacts from potential spills, leaks, and contamination.

BACKGROUND

History of Oil and Gas Production in Florida

Oil was first found in Florida in 1943, in what is now referred to as the Sunniland Trend, a formation deep below South Florida that spans from Miami to Fort Myers, beneath the Greater Everglades, and offshore into the Gulf of Mexico (Widener, 2018). Florida oil production peaked in 1978 at 47 million barrels per year and then rapidly declined, producing just under 1.4 million barrels in 2020 (U.S. Energy Information Administration [U.S. EIA], 2021b). Florida produces little natural gas; gas production peaked in the 1970s at 51,595 million cubic feet (MCF) of gas withdrawn (U.S. EIA, 2021a), and most of the gas produced today is re-injected into oil fields to stimulate additional oil production. Currently, the majority of oil and virtually all gas in the state is produced in the Florida Panhandle, and little is produced in the Sunniland Trend (Ackerman, 2018). Figure 1 shows the location of permitted and currently active wells in Florida.

Onshore, the Sunniland Trend underlies the Alligator Alley Reservation section of the Miccosukee Tribe of Indians of Florida Reservation and the Seminole Tribe of Florida's Big Cypress and Immokalee Reservations, as well as sensitive wetland ecosystems including the Big Cypress National Preserve, Florida Panther National Wildlife Refuge, and Ten Thousand Islands

National Wildlife Refuge. Originally established in 1974 to protect the region from development as a planned jetport to serve the growing population of South Florida, Big Cypress National Preserve's designation as America's first national preserve allows for activities generally prohibited in national parks, such as the adjacent Everglades National Park, including extraction of oil and gas, as well as traditional use by Native American Tribes (National Park Service, 2018). Because the majority of the oil beneath the Preserve is privately-owned, some oil production still takes place there.

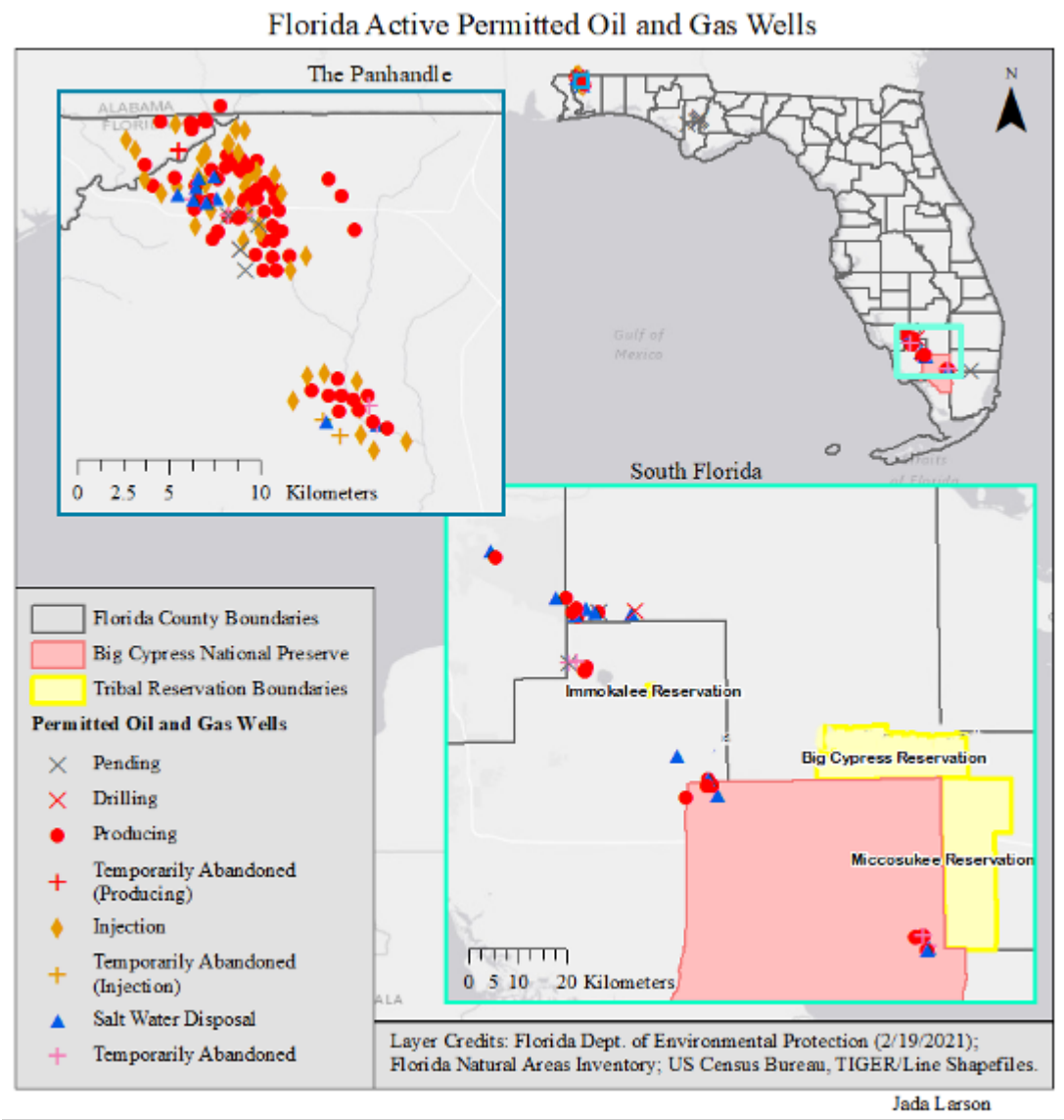

Figure 1: The location and types of active oil and gas wells permitted by the Florida Department of Environmental Protection as of February 19, 2021. In the Panhandle, wells are concentrated at the northeastern corner of Escambia county and northwestern Santa Rosa county. In South Florida, the Sunniland Trend crosses beneath Big Cypress National Preserve and Tribal reservation land, including the Alligator Alley Reservation section of the Miccosukee Tribe of Indians of Florida Reservation and the Seminole Tribe of Florida's Big Cypress and Immokalee Reservations.

The Science of Oil and Gas Drilling

Oil and natural gas production can be categorized as either conventional or unconventional. In conventional operations, wells are drilled into a rock formation where the oil and natural gas in the reservoir easily flows to the wellbore (U.S. EIA, n.d.). Usually, conventional wells are drilled vertically into highly permeable formations, where the fluids are contained in a geological trap, or rock formation that allows the oil and gas to accumulate in an underground reservoir (see Figure 2). The primary stage of production relies on the reservoir's natural pressure to extract oil and gas, but once production declines, particularly for oil production, additional production techniques such as flushing oil from the reservoir with water or injecting steam or carbon dioxide are commonly used (Scanlon et al., 2014).

Unconventional oil and gas production techniques are somewhat loosely defined, and the exact technologies that fall under this umbrella term vary and fluctuate over time (U.S. EIA, n.d.). Generally, in unconventional operations, oil and gas is extracted from tight geologic formations that have low permeability, such as shale deposits found in New Mexico's Permian Basin. To access more of the deposit, wells are commonly drilled vertically until they near the target layer and are then curved and horizontally, or directionally, drilled as much as thousands of feet further (FracTracker Alliance, 2020). Most unconventional production then requires well stimulation to open new pathways for oil and gas to flow through before it can become commercially viable. Hydraulic fracturing, acid fracturing, and matrix acidizing are three common types of well stimulation techniques, each of which improve the flow of oil and gas from the reservoir by increasing the permeability of the formation (Shafiq & Mahmud, 2017).

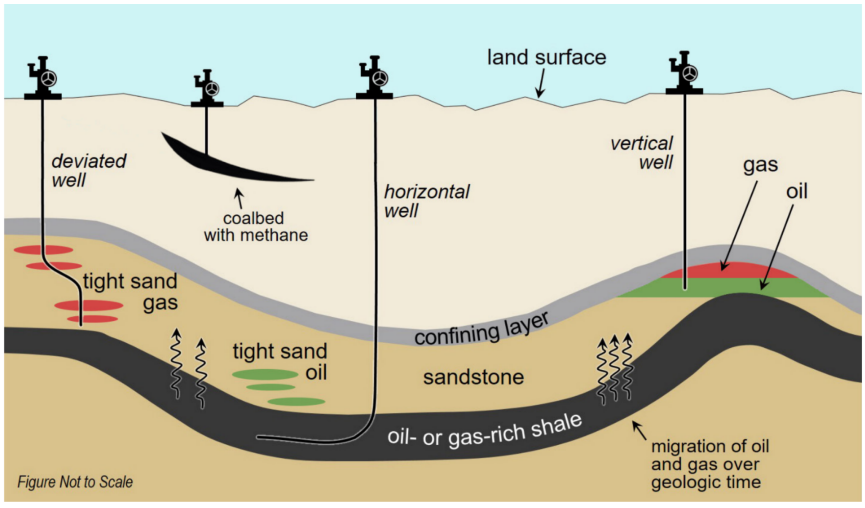

Figure 2: Oil and gas from conventional reservoirs flow relatively easily to the wellbore. Unconventional production is required when oil and gas are trapped in tight geologic formations, such as shale (pictured here), or in the case of south Florida, limestone. Image source: EPA, 2016

Hydraulic fracturing, or "fracking," involves injecting fluids and solid proppants at a high pressure into a rock formation to create and prop open fractures, which allow oil and gas to flow into the wellbore (U.S. EIA, n.d.). Fracking of even a single well can require up to millions of gallons of water, a variety of chemicals, including hazardous or toxic fluids, and proppants such as sand or ceramics (Environmental Protection Agency [EPA], 2016). The exact chemical mixture of fracking fluid can vary greatly and is often considered to be a trade secret – information that is not disclosed to the public. Biocides, scale inhibitors, solvents, friction reducers, additives, corrosion inhibitors, non-ionic surfactants, and other chemicals provide lubrication and prevent corrosion, clogs, or bacterial growth. The chemical mixture comprises around 1% of the total fluid injected; approximately 50,000 gallons of chemicals are required per well (American Chemical Society, 2020).

Once the fluid and proppant mixture is prepared, it is injected through perforations in the well at a high enough pressure to cause the desired rock layer to fracture (FracTracker Alliance, 2020). Oil, gas, and hydraulic fracturing fluid then flow through the newly created fractures, which are held open by the proppant. Once it reaches the surface, the recovered flowback fluid is treated, recycled, or disposed of, commonly by re-injecting it underground in deep injection wells, though in some cases requiring tanker trucks for removal offsite. However, over 90% of the fluid used for fracking generally remains underground (Hansen et al., 2013).

Although considered unconventional, hydraulically fractured horizontal wells are the most common type of wells drilled since 2014, and in 2016, they accounted for 69% of all wells drilled in the U.S. (U.S. EIA, 2018).

Florida's unique geology, with much of the state sitting over layers of highly permeable and porous limestone aquifers known as "karst" is generally thought to be a poor fit for fracking (DEP, 2020b). As a result, the most common form of well stimulation used in Florida involves acid treatment, or acidizing. In contrast to the use of sand, water, and other chemicals to physically break rock formations apart in fracking operations, acidizing instead involves shooting acids and other fluids into a well, also sometimes under pressure, to dissolve the surrounding highly soluble karst, opening pathways for oil and gas to move through the rock (Earthworks, n.d., para. 1; see Figure 3). Acidizing is usually used in a well in its final stages of production to clear blockages that formed over time or to encourage marginal oil reserves to flow towards the wellbore, but it can also be used to complete a new well to boost its initial performance (American Petroleum Institute [API], 2014, pg. 1). Acid washing, matrix acidizing, and fracture acidizing are the three primary types of acidizing. Acid washing, also called acid maintenance, is used to clean deposits on well surfaces and is not a type of well stimulation treatment, unlike matrix and fracture acidizing, which are used to dissolve the productive rock formation (Friends of the Earth, 2018).

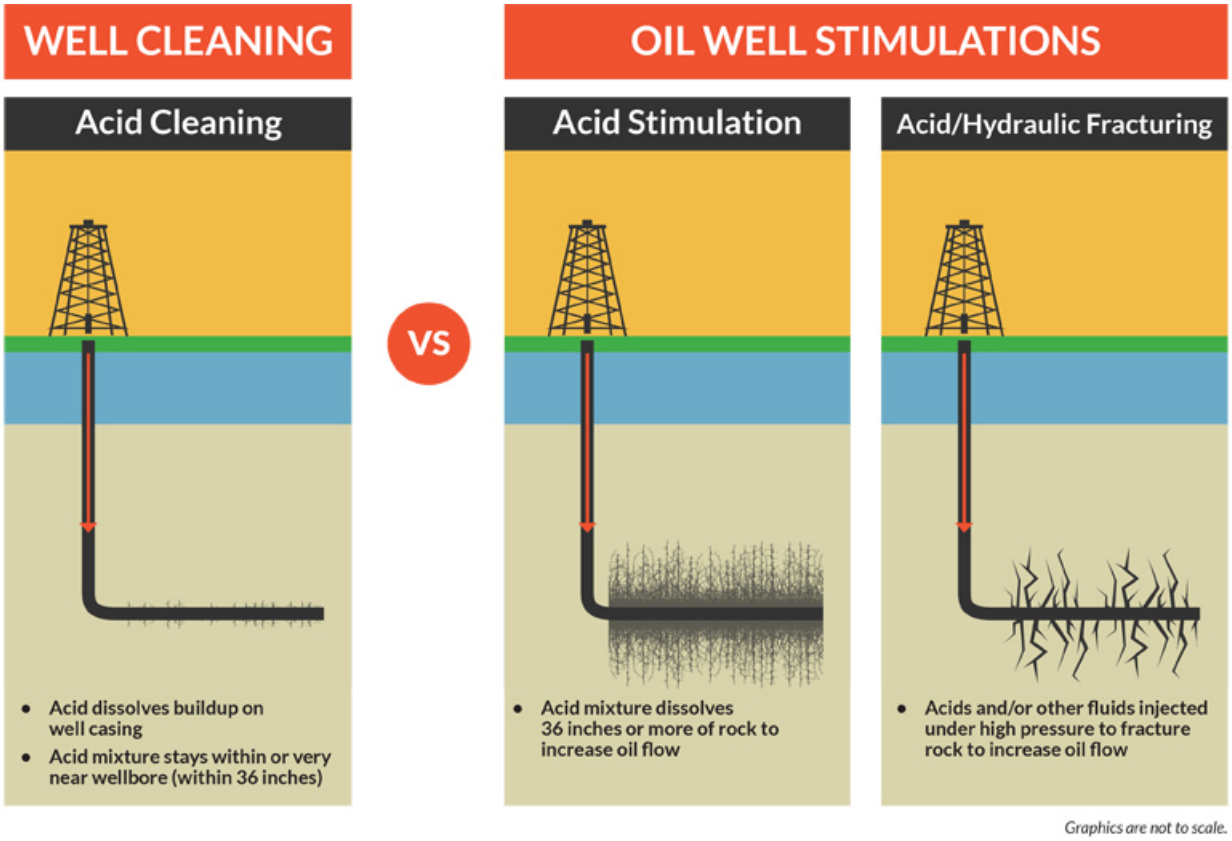

Figure 3: Acid cleaning differs from the oil well stimulation techniques of matrix acidizing, also called acid stimulation, and acid fracturing because the acid remains near the wellbore. Image Source: Conservancy of Southwest Florida

While there is the potential for harm resulting from acid cleaning, our focus is on oil well stimulation. For oil well stimulation, the type of acid used and the pressure used to inject it depend on the type of rock formation that the oil is extracted from and how porous it is. Carbonate formations, such as Florida's limestone bedrock, are usually acidized with hydrochloric acid (HCl) (API, 2014). However, most acid treatments require a mix of HCl and hydrofluoric acid (HF) due to heterogeneity of geological formations, and in some special cases, organic acids are used instead of HCl. Corrosion inhibitors, emulsion blockers, and iron control agents are common additives to the acid treatment. During the treatment, all of the acid is chemically consumed, and this spent acid is returned to the surface in the produced water, the highly saline water that recovered alongside oil and gas during drilling or production (API, 2014; Earthworks, n.d.).

Fracture acidizing, or acid fracturing, is used in wells with low permeability in the surrounding rock (API, 2014). Like fracking, the treatment uses pumping pressures high enough to fracture the formation. However, instead of a proppant, acid is used to roughly etch the edges of the fracture, creating channels that allow the free flow of oil and gas. For matrix acidizing, a reactive acid is pumped into a well at low pressures to increase the permeability of the surrounding rock

by dissolving sediment blockages. This low pressure means that the treatment does not penetrate more than twenty feet from the wellbore for a large matrix acidizing operation (API, 2014).

Impacts of Oil and Gas Production

Environmental and Public Health Impacts

Oil and gas exploration and extraction can industrialize landscapes, pollute the air and water, and threaten the quality and quantity of water supplies, among other impacts. Substantial machinery is brought to explore for oil and gas resources, construct well pads, and complete any well stimulation operations. Roads constructed to reach new drilling sites fragment habitats, and the increased vehicular traffic raises the number of fatal collisions with endangered species such as the Florida panther (Meng, 2016).

This is a particular concern for endangered species such as the Florida panther and Florida bonneted bat, as new oil production is proposed in habitat for both species. The large machinery and vehicular traffic travelling to and from the proposed new oil wells in panther habitat, particularly in "focus areas" for panther habitat defined by the U.S. Fish and Wildlife Service (US Fish and Wildlife Service, 2017), increases the potential for vehicular collisions – a leading cause of death for the Florida panther (Atkins, 2018). Fifteen production wells are operating in an area proposed for critical habitat of the Florida bonneted bat (see U.S. Fish and Wildlife Service, 2020). The Florida bonneted bat is sensitive to loss of its roost trees and foraging area and to chemical contamination (NPS, 2021), both potential consequences of oil and gas development.

These impacts to the delicate Greater Everglades ecosystems put already-endangered species at further risk of extinction. (See Figure 4).

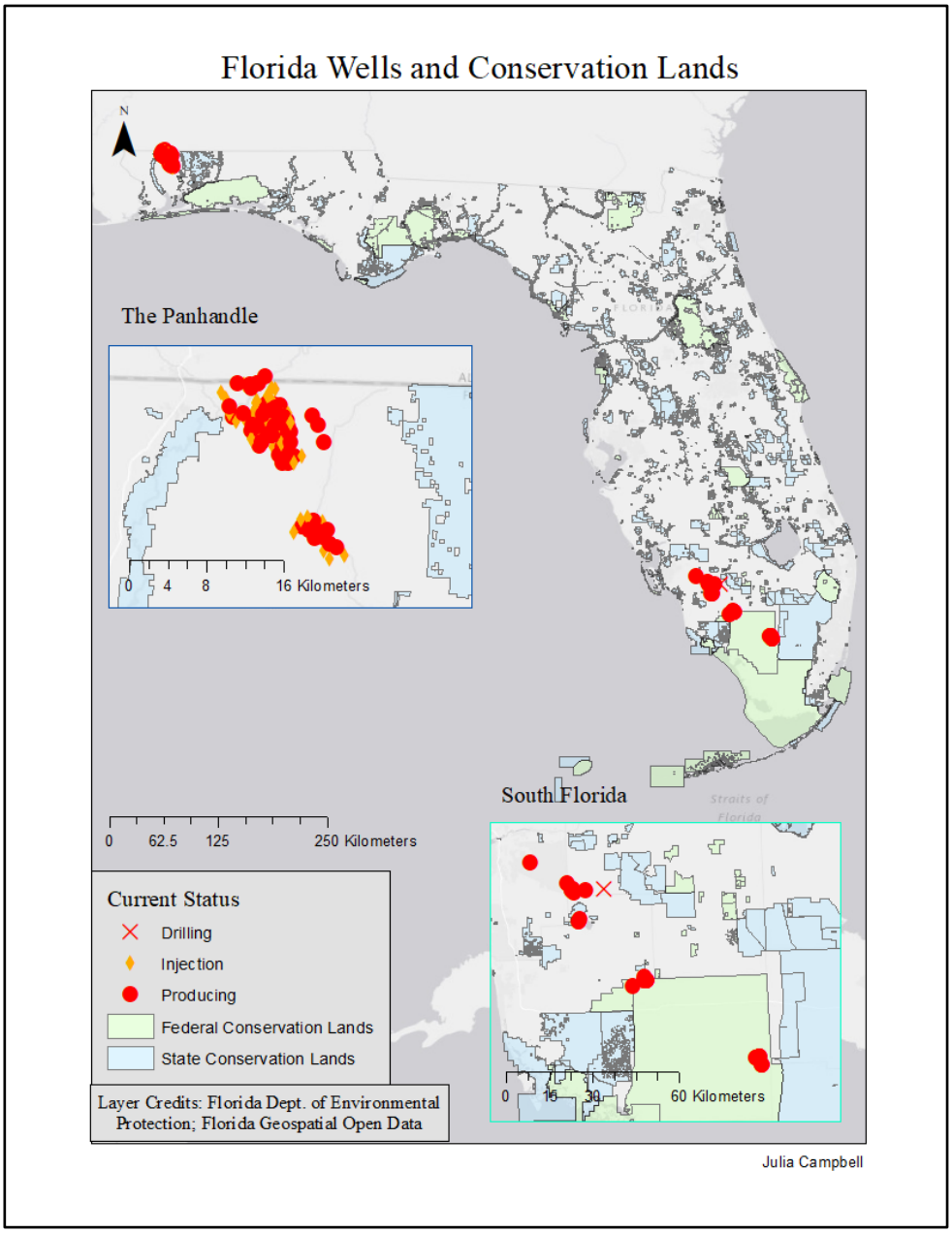

Figure 4: Federal and state conservation lands in South Florida are encroached upon by producing oil wells. In the Panhandle, conservation lands appear untouched by oil and gas operations, but producing and injection wells are located in close proximity to state conservation lands.

Emissions from oil and gas extraction equipment typically include volatile organic compounds (VOCs), nitrous oxides (NO_x), particulate matter (PM), sulfur oxides (SO_x), and various toxins, carcinogens, and metals (Thompson, 2017). In general, these air pollutants can cause a host of respiratory illnesses, cancer, and reproductive and developmental harms (Johnston et al., 2019).

Moreover, the extraction and combustion of these fossil fuels releases carbon dioxide, methane, and other potent greenhouse gases that contribute to climate change (IPCC, 2021).

In Florida, one of the the greatest threats from oil and gas development stems from the use of well stimulation techniques, which pose additional threats to public health and the environment, particularly to local water quality and quantity. Potential harms from well stimulation practices are well documented at this point – for example, in Oklahoma, where fracking has induced earthquakes (Widener, 2018), or more broadly, the potential for fracking to contaminate drinking water sources (U.S. EPA, 2016). Acidizing may carry with it additional concerns; similar to fracking, acidizing chemicals are often hazardous to human health (Denchak, 2019). Chemicals found in both fracking and acidizing operations commonly include solvents, such as methanol, and petroleum distillates, as well as carboxylic acids, biocides, and corrosion inhibitors, among other potentially hazardous compounds. For acidizing operations, HCL and HF are additionally used in large volumes (*see, e.g.*, Stringfellow, et al. (2017)).

> Due to the more permeable nature of Florida's carbonate geology, matrix acidizing is a more suitable form of unconventional oil and gas extraction to be utilized in the state. But improper well construction or drilling processes, improper wastewater management, and disposal of the chemical-laden fluids all risk leakage into both groundwater and surface water, potentially contaminating important sources of drinking water in the state. This is notable because roughly 93 percent of Florida's population depends on groundwater for drinking water, far more than any other state in the nation. Florida aquifers are vulnerable to contamination because large areas are characterized by well-drained sandy soils overlying porous limestone. A shallow water table and high rainfall increase the potential for contamination to reach the groundwater. (Kelly & Mordick, 2019)

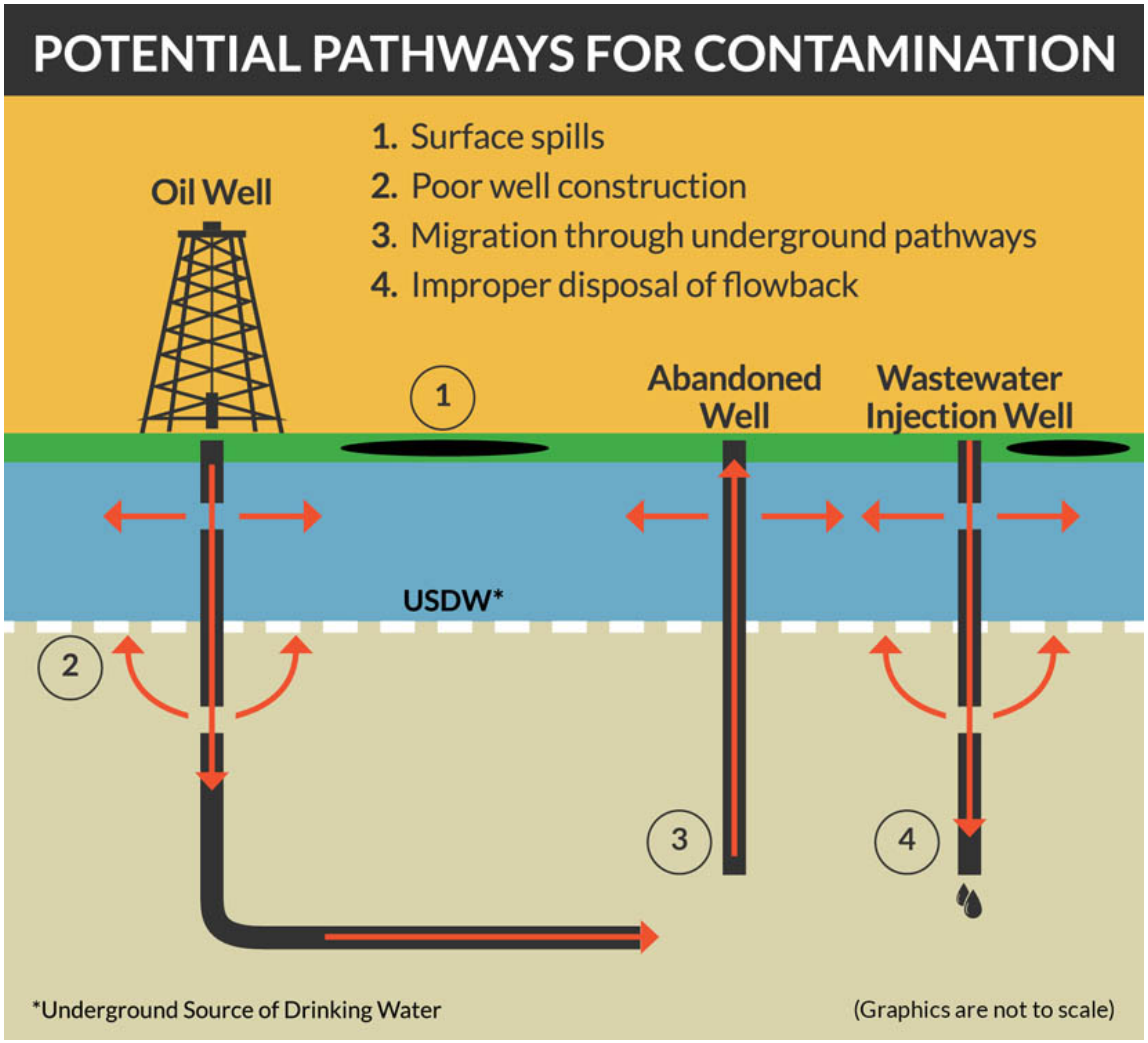

Figure 5: Acidizing operations have the potential to reach and contaminate underground sources of drinking water as a result of surface spills, poor well construction, migration of fluids through abandoned wells or natural underground fracture pathways, and when the flowback fluid is improperly disposed of. Image Source: Conservancy of Southwest Florida

Surface and groundwater in south Florida are connected. Big Cypress provides "42 percent of the water flowing into Everglades National Park," which travels both above-ground in marshes and sloughs and below-ground in porous aquifers (Ackerman, 2018, p. 7). This means that hazardous pollutants released from acidizing operations in Big Cypress National Preserve could spread across the wetland ecosystem and into groundwater aquifers (Ackerman, 2018). Florida's particular vulnerability is illustrated by past incidences of contamination, such as a 1983 event in which the pesticide ethylene dibromide, which bound to soil after application and was flushed into groundwater aquifers by rain, was found in over 1,000 public wells in the state (Irwin & Bonds, 1987). The Florida Geologic Survey has conducted multiple dye-tracing studies to understand the interactions between surface and groundwater in the state, finding that the waters

are readily and rapidly exchanged in the Floridan aquifer system, increasing the risk of contamination spreading when released (DEP, 2020b). Contamination is not the only water-related concern – infrastructure, such as pipelines and roads, could alter the flow of water south from Big Cypress and counteract the billions of dollars, including federal funding, being spent on Everglades restoration efforts.

Economic Impacts

Harms to tourism and the related economic impacts in south Florida are also of concern. Florida ranked only 22nd out of 31 states for crude oil production in the U.S., contributing less than 0.04% of total U.S. crude oil (U.S. EIA, 2020). Additionally, oil and gas production comprise 0.0002 % of Florida's GDP and contribute only about 700 jobs in the state (Hjerpe, 2022). In comparison, in 2019, out-of-state visitors, both domestic and international, spent $99 billion in Florida and supported 1.6 million jobs. (Hjerpe, 2022). Oil pads, diesel truck traffic, and helicopters could reduce tourism to the region, causing more tourism money to be lost than could be gained by any oil and gas venture (Widener, 2018). In 2017, the year that the Burnett Oil Company began oil and gas exploration in Big Cypress, tourism in the Preserve dropped by one-sixth (Ackerman, 2018).

Impacts on Indigenous Communities

The Seminole Tribe of Florida and Miccosukee Tribe of Indians of Florida reservations border the Big Cypress National Preserve, but the impacts of existing oil and gas drilling on these communities have not been well documented. According to the National Park Service, both tribes continue to have access to Big Cypress resources, including "using timber for the construction of traditional shelters called 'chickees,' or harvesting plants and animals for personal use" (NPS, 2018). Betty Osceola, an environmental activist and Miccosukee Tribe of Indians of Florida member, led a prayer walk along one of the proposed new oil well sites in Big Cypress in April 2021 (Schneider, 2021). According to Osceola, the proposed well pad would be located near sacred sites.

Regulating Oil and Gas Production

Federal Laws

The Clean Air Act (CAA) and Clean Water Act (CWA) are laws intended to control pollution and protect human and environmental health from oil and gas development. In general, the CAA regulates air pollution "to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population" (42 U.S.C. § 7401(b)(1)). It primarily achieves this through establishing National Ambient Air Quality

Standards (NAAQS). The NAAQS set primary and secondary standards limiting the ambient air concentration of six criteria pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, sulfur dioxide, and particle pollution – split into PM2.5 and PM10. When regions do not reach attainment with the NAAQS, emission sources of criteria pollutants in the area are subject to additional regulation (U.S. EPA, 2021c).

In addition, the EPA works with states to limit hazardous air pollutants (HAPs), which are toxic or harmful air pollutants outside the six criteria pollutants (U.S. EPA, 2021b). Regulation of HAPs is primarily carried out under Title V of the CAA, where "major sources" of air pollution are required to apply for an operating permit and annually demonstrate their compliance with that permit. This applies to single sources or groups of sources in a contiguous area. However, individual oil and gas wells are exempted from this aggregation requirement and thus are not considered major sources that require CAA permits (Kosnik, 2007).

The intent of the CWA is to protect the environment from harmful pollutants, stating as its primary goal "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. § 1251(a)). The CWA limits the amount of water pollution coming from a "point source," defined as an easily identified and confined source of pollution such as a discharge pipe or drainage ditch, by requiring the polluter to apply for a permit before they can discharge into a Water of the United States (U.S. EPA, 2021f). Notably, however, the Clean Water Act generally does not cover or address pollution to groundwater and provides exemptions from permitting for stormwater runoff - the drainage from sites or infrastructure when it rains - for many oil and gas activities, including construction and exploration (33 U.S.C. §1342(l)(2)) (Kosnik, 2007).

States are generally responsible for implementation of both the CAA and CWA, while the EPA oversees the programs. In Florida, CAA permitting and Section 404 CWA permitting is managed by the Florida Department of Environmental Protection (DEP) (U.S. EPA, 2021a; EPA, 2021e).

Unlike the CWA, which substantively excludes protection for groundwater, the Safe Drinking Water Act (SDWA) protects both aboveground and underground drinking water sources (U.S. EPA, 2021d). To protect drinking water from underground fluid storage and disposal, the EPA regulates injection wells through its Underground Injection Control (UIC) program. Injection wells for fluids associated with oil and natural gas production are designated as Class II wells and are broken into three categories: disposal wells, enhanced recovery wells, and hydrocarbon storage wells. Disposal wells are for the long-term disposal of brine and hydraulic fracturing wastewater. Enhanced oil recovery wells those in which "brine, freshwater, steam, polymers, or carbon dioxide," are injected to thin or displace residual oil and natural gas for recovery (U.S. EPA, 2021d). Unlike fracking and acidizing, enhanced oil recovery does not alter the rock formation. Since the passage of the Energy Policy Act of 2005, hydraulic fracturing is not

considered underground injection unless diesel fuel is included in the injected fluids, and it is not regulated under the UIC program (SDWA § 1421(d)(1)(B)).

Finally, the National Environmental Policy Act (NEPA) requires federal agencies to analyze and disclose to the public the environmental impacts of oil and gas development (see, e.g., 42 U.S.C. § 4332). Under NEPA, each federal agency is tasked with evaluating the environmental impact of any proposed land use decisions on public lands, including oil and gas permitting (Abdullah, 2016). Federal agencies, such as the National Park Service, that are responsible for permitting oil and gas drilling or development, usually conduct a NEPA review on specific parcels once the operator requests to conduct surface activities. Some oil and gas development activities are categorically exempt from requiring NEPA review, such as "drilling an oil or gas well at a location or well pad site at which drilling has occurred previously within 5 years prior to the date of spudding the well" (42 U.S.C. 15942(b)(2)). Oil and gas related exemptions generally require that there be no significant environmental impact and the prior completion of an environmental assessment in the past five years or during the land acquisition process (Abdullah, 2016). Environmental analysis must include historical and cultural impacts in addition to ecological impacts (40 C.F.R. § 1508.8).

Florida Laws

Florida regulates oil and gas exploration and development through its Oil and Gas Program in Chapter 377, Florida Statutes, which is managed by DEP's Division of Resource Management (DEP, 2020a). The primary objectives of the Oil and Gas Program are to manage oil and gas natural resources, to protect the rights of landowners and companies, and to preserve citizen's health, welfare, and property (Fla. Stat. § 377.28). These goals are primarily accomplished through the requirement of permits and field inspections to determine compliance. Failure to abide by the objectives outlined above could result in civil action, in which the offender could be required to complete corrective actions and face civil penalties of up to $10,000 per day, per violation. Fla Stat. §§ 403.141, 403.161.

Several state-issued permits are required to authorize oil and gas operations.[1] For example, an oil and gas permit is required prior to beginning work on any drilling operation (Rule 62C-26.003, Florida Administrative Code). Exploration activities for oil and gas or other hydrocarbons require a separate permit (Rule 62C-26.007, Florida Administrative Code). Releases or spills must additionally be reported to DEP (*see, e.g.,* Rule 62-780-210, Florida Administrative Code).

[1] *See, e.g.*, Environmental Resource Permits (Part IV of Chapter 373, Fla. Stat.); Consumptive Water Use Permits (Part II of Chapter 373, Fla. Stat.); Oil and Gas Permits (Chapter 377, Fla. Stat.).

The Florida Department of Environmental Protection regulates well stimulation techniques, including acidizing, through 'workover operation,' procedures that "restore, sustain or increase production, disposal, or injection rates." (Rule 62C-25.002(61)). Operators are required to notify DEP prior to beginning a workover operation and must submit a revised Well Record (Oil and Gas Form 8) within 30 days after the procedure is completed (Rule 62C-29.006, Florida Administrative Code). Since not all workover procedures involve well stimulation, the "perforation and stimulation records" section of the DEP Form 8 is necessary to determine whether acidizing occurred. DEP Form 8 and other publicly available oil and gas documents are published on OCULUS, DEP's electronic document management system. The official documents and records in OCULUS include, but are not limited to, oil and gas exploration and development permits, contingency plans, and workover reports. Documents can be sorted and filtered by individual well permit numbers and by various other parameters such as document subject and county location.

Over the past several years, bills have been introduced by both houses of the Florida legislature to ban both fracking and matrix acidizing (Committee on Environment and Natural Resources, 2019; *see* Florida SB 546 (2021)). Although none have passed thus far at the state level, at least 77 local bans or resolutions opposing fracking have been adopted by local government entities in the state (Ackerman, 2018). The introduction of these bills in the legislature shows a potential for change in Florida oil and gas regulation regarding unconventional drilling methods.

Comparison between Florida's and California's Regulatory Approach to Acidizing

While still limited in its oversight of acidizing or well stimulation, the state of California has an at least minimally more developed oil and gas regulatory program than Florida. The California Geologic Energy Management Division (CalGEM) oversees well stimulation treatments in the state, which includes hydraulic fracturing, acid fracturing, and matrix acidizing (Cal. Pub. Res. Code § 3001). In California, acid well stimulation treatment refers to "a well stimulation treatment that uses, in whole or in part, the application of one or more acids to the well or underground geologic formation" (Cal. Pub. Res. Code § 3158). The definition does not include well cleaning, and explicitly distinguishes between matrix acidizing and acid fracturing. Operators must apply for a permit for any well stimulation treatment, including acid well stimulation (Cal. Code Regs. Title 14 § 1783). The permit application requires the operator to specify details of the operation, including time frame, the names and concentrations of chemicals, and a water management plan and groundwater monitoring plan.

In California, once an operator receives a permit to conduct well stimulation, it must hire an independent third-party contractor to contact the surface property owners and tenants on any land within a 1500-foot radius of the wellhead and within 500 feet of the surface representation of the below-ground horizontal portion of the well. Those contacted must be provided with an approved

permit and a Well Stimulation Treatment Neighbor Notification Form 30 days prior to the commencement of the well stimulation operation (Cal. Code Regs. tit. 14 § 1783.2). A nearby property owner can request water quality testing on any existing water well or surface water that can be used for drinking or irrigation for their property.

In California, well stimulation techniques must be monitored during and after the operation to prevent the acid from reaching waterways. Well stimulation treatment fluids and waste must be stored in containers instead of in sumps or pits that allow for seepage into the groundwater. The operators must monitor and inspect for breaching, and any leaks are reported to the Office of Emergency Services. Within 60 days of completing the well stimulation treatment, the operator has to disclose to CalGEM the location of the well, total volume of base fluid, radioactivity of well stimulation fluids, and a complete list of the names and identifiers for each chemical constituent of the well stimulation fluids used (Cal. Code Regs. tit. 14 § 1788).

For well stimulation treatments, operators in California must file for a satisfactory certification in accordance with California Senate Bill 4 (Pavley, 2013-14), which publicly discloses groundwater testing, well history, location, and chemicals not deemed to be a trade secret. Effective December 2020, publicly available well stimulation treatment documents are available on WellSTAR, the state's Well Statewide Tracking and Reporting System (DOC, n.d.). Since January 2014, operators in California have been required to disclose hydraulic fracturing drilling and chemical use to the website FracFocus and to CalGEM.

In contrast, oil and gas operators in Florida do not have to apply for a permit from the Department of Environmental Protection to obtain advance authorization to conduct well stimulation techniques, such as acidizing, or notify nearby communities prior to commencing operations, or disclose the chemicals used. The state of Florida also does not require any water management plans or testing of surrounding groundwater sources prior to operations. Further, OCULUS, Florida's public database for oil and gas documents, cannot be sorted by well stimulation type. Therefore, it is difficult for members of the public to obtain information about oil and gas operations taking place in their communities.

OUR RESEARCH

Identifying Acidizing Wells

As discussed above, in Florida, acidizing is regulated as a "workover," which requires operators to notify the Department of Environmental Protection prior to beginning the operation and to submit a revised "Form 8" document after the operation is complete. Per Rule 62C-25.002.(61), Florida Administrative Code (F.A.C.), all DEP Form 8 documents are filed with the state and should then subsequently appear on Oculus. Our research focused on reviewing DEP Form 8 documents to identify wells where operators utilize acidizing techniques. The records we reviewed frequently included daily workover reports, historical records, and maintenance plans.

An initial problem we discovered is that the DEP Form 8 does not appear to identify whether acid is used in any given well for cleaning purposes versus production. Each DEP Form 8 includes a section called "Perforation and Stimulation Records," which, if acid was used, requires a brief description of the quantity and strength of the acid. However, reports varied in how operators reported the acid quantity used, such as by stating the number of barrels or by describing how many feet per gallon. Since none of the DEP forms reviewed explicitly stated whether acid was used for cleaning versus well stimulation, we were unable to fully assess potential risks from the production process.

An initial search of Oculus in February 2021 for DEP Form 8 workover records returned 278 unique documents, ranging from as early as the 1920s to the present. They covered a wide range of topics including correspondence, permits, geophysical logging, drilling reports, inspections, and repairs. Of these documents, 129 discussed the use of acid on or near a wellbore. However, we suspect that a substantial portion of the state's workover records are missing from the Oculus database. According to the bill analysis section of Senate Bill 200 (2020), Advanced Well Stimulation Treatment, a bill which attempted to ban certain well stimulation methods in Florida, DEP received 196 workover notifications between January 2016 and October 2019, 41 of which involved the use of acid "for near wellbore cleanout purposes" (Florida Senate, 2020). Yet our Oculus search only returned 35 of the 278 total workover documents from the same time period.

Moreover, in several cases, we found the use of acid mentioned in daily reports, which are a description of all operations occurring each day for the duration of a workover operation. In those cases, however, we could not identify a corresponding DEP Form 8 document for the workover operation, suggesting those documents were missing from the record or had not been filed.

In order to fill in the gaps in our data, we first attempted to contact DEP staff over the phone in its Northwest and South District Offices. When we did not receive a response, on March 19,

2021, we filed a Public Records Request with DEP, pursuant to Chapter 119, Florida Statutes, which provides that "all state, county, and municipal records are open for personal inspection and copying by any person," and that "[p]roviding access to public records is a duty of each agency" (Fla. Stat. § 119.01). We specifically requested:

> all forms labeled 'Form 8' beginning from 2010 to the present day, which mention the use of acid, acidizing, HCL, hydrochloric, HF, or hydrofluoric, under the sections 'Chemical or Shooting Record', 'Summary of Work Performed', 'Formation Tops', or 'Perforation and Stimulation Records.'

On March 26, 2021, DEP responded by stating, "The documents you are seeking are available in our OCULUS Document Management System." This began a multi-month saga of phone calls and emails with DEP personnel, which culminated in our conclusion that the Oculus database is strikingly incomplete.

Communications with the Florida Department of Environmental Protection

On April 1, 2021, we replied to DEP's email response to our public records request by asking for assistance in using the Oculus system to search for DEP Form 8 records. At this point we established a series of weekly or bi-weekly communications with DEP staff by both phone and email. DEP personnel assisted us in this period with navigation of the Oculus database. DEP staff was generally cooperative and answered a number of our questions regarding search operations. However, much of our effort was hampered by limitations of the Oculus data management system's interface. While Oculus is searchable by terms generally, it is not searchable by permit type, well stimulation method, or many other specific categories or attributes. As a result, following search suggestions identified by DEP personnel, , we expanded our search to cover any oil or gas document that contained the term Form 8, well record, or workover, or an abbreviation of the term. We recovered a total of 390 documents.

Despite the initial assistance from DEP personnel, we still were unable to identify how the 2019-2020 Florida legislative analysis of Senate Bill 200 had reached its finding that there were 196 total workover procedures from 2016 to 2019 (our original search had returned only 35 results) (see, Florida Senate, 2020). When we asked DEP personnel about this specific discrepancy on April 13, 2021, both in writing and by phone, they responded only a month later and provided us with an updated list of DEP Form 8 documents, on May 26, 2021. This list included workovers from 2016 through May 2021, totaling 239 total workovers.

Many of these newly identified records could not be found in a search of the Oculus database. DEP explained that this was because, though not clear from the regulatory language regarding workovers, the initial notification given by oil and gas operators can consist of informal

communication, such as a phone call, rather than written notification. As a result, DEP informed us that an electronic record of the notification may not appear on Oculus, rendering it nearly impossible for a member of the public to adequately assess the use of acidizing in wells through DEP's primary public facing data portal.

Acidizing Used in Well Production in Florida

As stated earlier, a further problem we encountered in our review of DEP Form 8 and workover orders was that the documents do not specify whether acid, if mentioned at all, was used for cleaning processes versus well stimulation. During a phone call with DEP personnel on May 13, 2021, a DEP representative mentioned that they knew of only two instances in which acid had been used specifically for production in Florida. They identified the wells that used acid for production as OG_1013 and OG_1349. In a follow up call with DEP on May 21, 2021, staff stated that they could determine the type of activity occurring at these wells based on the quantity of acid used and the amount of equipment involved, as a significant number of trucks were needed to transport fluids for matrix acidizing and acid fracturing to the well sites. According to DEP, the first instance of acid used for production occurred at the well identified as OG_1013, located in Santa Rosa County, which employed matrix acidizing between 2006 and 2007. The second operation, which involved acid fracturing, took place at well OG_1349 in Collier County between 2013 and 2014. DEP stated that both of these wells failed to produce a profit.

DEP staff had previously informed us on numerous occasions that all information relevant to our search for DEP Form 8 or workover documents was "available in our OCULUS Document Management System." But we could not find any documentation on Oculus that would have indicated either of these wells had used acid for production. There were no relevant DEP Form 8s available on Oculus for public viewing for either well OG_1013 or well OG_1349. Following a May 13, 2021 call with DEP staff, we requested all relevant documentation, including DEP Form 8s, for the two wells in Santa Rosa and Collier Counties from the DEP, but only received forms pertaining to well OG_1349 in Collier County. According to DEP, the information on well OG_1349 did not appear in the Oculus database because a lawsuit had been filed by DEP against the well operators, the Dan A. Hughes Company. Despite numerous follow up emails to DEP, we never received any documentation pertaining to well OG_1013 in Santa Rosa County.

Of further concern, although DEP officials insisted that only two wells had ever used acid for production in the state, our continuing review of workover operations from documents obtained through Oculus ultimately found multiple instances of what appears to be acid well stimulation. The three largest acid stimulation operations took place in Santa Rosa County. Each used over 1700 barrels (71,400 gallons) of acid in multi-stage operations (identified as facility sites OG_1078, OG_1748, and OG_1107). Two of these three operations referred to the work

conducted as an “acid job,” which specifically refers to matrix acidizing. In Collier County, the county where Big Cypress National Preserve is located, three different wells used 1000 barrels (42,000 gallons) or more acid during a workover order (facility sites OG_962, OG_1082, and OG_1190).

Case Study - The Collier-Hogan 20-3H Oil Well

Acidizing operations at the Collier-Hogan 20-3H oil well in Collier County in December 2013 and early January 2014 drew widespread attention to well stimulation techniques used in Florida. The well, located approximately 15 miles northwest of the Big Cypress National Preserve, was originally drilled by the Dan A. Hughes Company in the first half of 2013 (ALL Consulting, 2014). In 2014, ALL Consulting was engaged by DEP to “evaluate whether the workover procedure,” acidizing that occurred from December 30, 2013 to January 1, 2014, “was designed and carried out in such a way that it was not likely to result in violations of applicable groundwater quality standards in the freshwater aquifers present at the wellsite.” (ALL Consulting, 2014).

According to the ALL Consulting report on the Collier-Hogan 20-3H oil well workover procedure, on September 16, 2013, the Dan A. Hughes Company submitted an acidizing proposal for a total of 1,295.5 barrels of fluid in 17 stages at maximum pressure of 6,270 psi. Some type of acid stimulation then took place in the well on September 29, 2013, but troublingly, there were no available records from the service company regarding the type of treatment completed. The completion report termed this procedure a “small-scale acid stimulation job” (ALL Consulting, 2014).

Following the procedure, the operator proposed a second well stimulation event in a submission to DEP on November 11, 2013, which it then withdrew on December 12, 2013, following a request for more information by the DEP Oil and Gas Program. On December 23, 2013, the operator sent DEP a proposed completion procedure with seven stimulation stages, including 90,909 gallons of water, around 49,500 pounds of sand per stage, and HCl and other acids (ALL Consulting, 2014, at 25). They began this workover operation on December 30, 2013. DEP subsequently issued a “Cease and Desist Order” on December 31, 2021, but the workover procedure continued until late in the afternoon on January 1, 2014 (ALL Consulting, 2014).

The seven-stage operation pumped a cumulative 662,298 gallons (15,769 bbl) of fracturing fluid into the ground, of which 2.2% by volume was chemical additives (in addition to 637,399 pounds of sand). This combination of fluid and proppant resembles fracturing fluid, and according to the Post-Stimulation Report, “formation breakdown pressures approached approximately 9,000 psi,” which exceeds the pressure needed to fracture the rock formation (ALL Consulting, 2014). As such, ALL Consulting considers this operation to be a “multi-stage

'High Volume Hydraulic Fracturing' (HVHF)." *Id*. Despite a workover design stating that the well would be tested for pressures of 10,000 psi prior to stimulation, we could not find any record of this. The only existing record for testing states the well casing was tested to a limit of 8,000 psi, meaning the fracturing event may have occurred at a pressure exceeding the maximum tested (ALL Consulting, 2014).

The ALL Consulting report reviewed the potential risk for the acidizing event to have impacted shallow groundwater aquifers in the vicinity of the well, and concluded, looking at a variety of potential pathways for the vertical migration of well-stimulation fluids, that "the likelihood of this actually occurring is extremely limited." (ALL Consulting, 2014, at 38.) However, the risk of this occurring here or in other acidizing procedures is significant, and the state's apparent poor oversight of workover procedures and acidizing processes more specifically poses a potentially serious threat to the state's underground drinking water supplies.

Additional Records: Reviewing Spill or Release Reporting on OCULUS

In order to more fully assess the state of Florida's oversight of the potential risks posed by acidizing and its record keeping for potential spills, releases, or other incidents that could pose a risk to groundwater or other resources, we also reviewed records of federal agencies for comparison with the state's records maintained in the OCULUS database. Specifically, our team reviewed documents produced by the National Park Service in response to Freedom of Information Act (FOIA) request submitted by the Natural Resources Defense Council (NRDC) (FOIA request No. NPS-2019-00926). The documents included a total of 4,354 individual files, each of which was manually reviewed for mentions of spills, releases, or other incidents related to oil and gas exploration or development. After removal of duplicate events, a total of 25 unique spill events were identified in the federal records, all occurring in south Florida between 1974 and 2009. The largest oil spill identified in the documents occurred in April 1974 when a leak in the main Sunniland Trend pipeline released 600 barrels of crude oil (bbl) into a marsh along Florida State Road 82, located 10 miles northwest of Immokalee.

Our team then conducted a document review through Oculus using the "Public Log-In" portal, searching for documents under the "SPILL RELATED" or "DISCHARGE REPORTING RELATED" category labels. The OCULUS search yielded 138 unique spills, 33 of which occurred in south Florida between 1974 and 2020, However, in comparing the federal FOIA and state OCULUS documents, there was no overlap between the reported events–in other words, none of the spills identified in the National Park Service records were present in the State's OCULUS search results, or vice versa.

At a minimum, this result suggests poor coordination and communication between the federal and state agencies tasked with overseeing oil and gas exploration and development in Florida.

But potentially more problematic, the lack of reference to any of the spills or releases identified in the National Park Service documents amplifies our concerns that DEP's OCULUS system's database is incomplete or contains substantive information gaps, and that records related to oil and gas operations are not readily accessible to the public.

CONCLUSION AND PRELIMINARY RECOMMENDATIONS

Our investigation into the use of acid in oil and gas production in Florida and the hurdles we faced in obtaining basic records related to oil development activities, highlight some of the serious issues concerning regulatory oversight and public access to information involving oil and gas development in the state. Oculus, the Florida Department of Environmental Protection's electronic document management system and primary public facing portal to records regarding oil and gas exploration and development in Florida, is unorganized and unintuitive to navigate, and much of the relevant information to our survey we encountered was mislabeled or missing entirely. In addition to deficiencies of the database itself, we encountered sizeable, substantive information gaps which arise, at least in part, as a result of poorly defined or regulated operator reporting requirements. Overall, over a three-month period, it was extremely difficult to identify or obtain information related to use of acid in oil and gas wells. This is a significant, ongoing concern for any effort to ensure public access to information regarding the use of well stimulation techniques, including acidizing, and the potential risks they pose in Florida. We recommend that the Department of Environmental Protection review its data management system to ensure all relevant records are properly organized and made available to the public, in order to allow for more transparent decision-making.

More broadly, our research calls attention to the general lack of state regulation or oversight over well stimulation activities, such as acidizing. Though limited in its own right, California law, for example, requires substantially greater controls over the permitting, data collection, and transparency of information for well stimulation operations. Poor regulation of activities and inadequate record keeping pose a substantial threat to the environment and public health, and broadly inhibit transparency and public oversight of those activities. We recommend that the Florida Department of Environmental Protection review and update its current regulations concerning the use of well stimulation techniques, including acidizing, to ensure greater agency oversight and make all documents available to the public and surrounding communities.

Appendix A
Florida Permitted Oil and Gas Wells

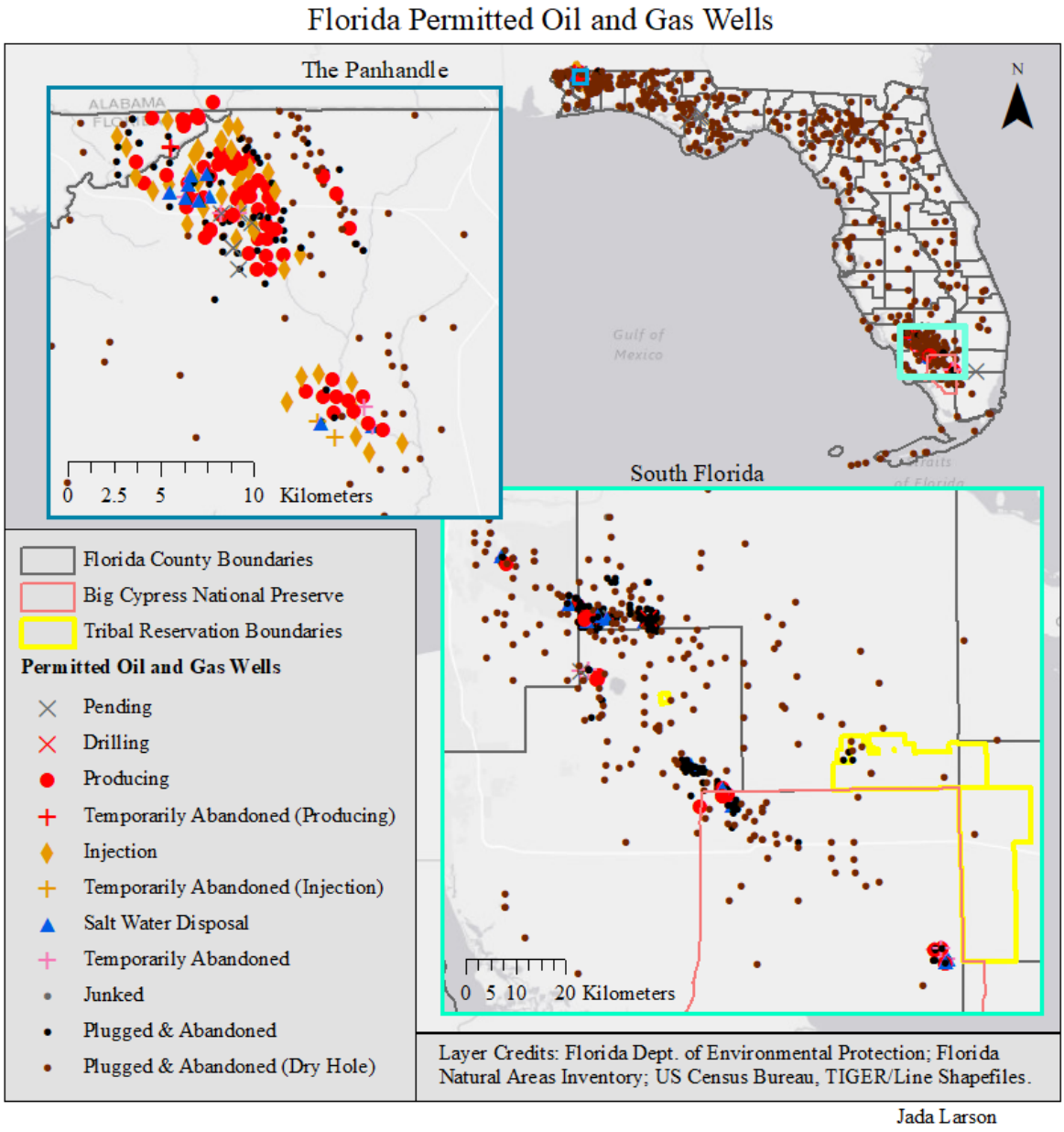

Figure A1: The location and types of oil and gas wells permitted by the Florida Department of Environmental Protection as of February 19, 2021. In the Panhandle, the majority of producing wells are concentrated at the northwestern corner of Santa Rosa county. In South Florida, the Sunniland Trend crosses Big Cypress National Preserve and Tribal reservations, including the Miccosukee Indian Reservation and the Seminole Tribe's Big Cypress and Immokalee Reservations.

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