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The Economic and Environmental Impacts of Reopening the Carolina Lithium Belt

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Abstract

This case study analyzes the economic and environmental impacts of reopening dormant mines in the Carolina Lithium Belt. The study examines the accuracy of a previous impact analysis published by one of the corporate stakeholders and finds the core findings to be consistent. Further analysis using IMPLAN software finds the occupational and educational profile of the new jobs to be consistent with the workforce in the three-county region. Environmental impacts show the largest increases in nitrogen and phosphorus release and in mineral usage. Shifts in global lithium supply, innovation in competing technologies, and political tensions add volatility to any projections of lithium mining's impact.

1 Introduction and Background

This case study examines the impact of reopening the Carolina Lithium Belt, as two corporations work through the permitting process to restart dormant mines. The decisions are set within an intensifying political and economic focus on the markets for critical minerals used in the clean energy transition. Nations in North America and Europe are moving to onshore mining and production of earth metals where geologically feasible. This “security-sustainability nexus” brings together government and corporate leaders in a movement to establish green energy supply chains that are politically secure, financially profitable, and more environmentally friendly than current supply chains which are, at some point, dominated by China (Riofrancos, 2023). While lithium is nonrenewable, it is cleaner to extract and process than petroleum.

The Inflation Reduction Act, signed into law in August 2022, included significant incentives that impact the market for lithium. Federal grants are available for firms making lithium-battery related investments from mining to recycling. Mining companies excavating critical minerals (e.g. cobalt, lithium, beryllium) will be able to seek a tax credit equal to 10 percent of production costs. Manufacturers of electric vehicles (EVs) are eligible for tax credits if their vehicles meet minimum amounts of U.S.-manufactured components. The Inflation Reduction Act also sets minimum percentages for the value of battery components sourced from North America required for tax credits (Farmer, 2022; Riofrancos, 2023).

The Carolinas have become a regional hub for electric battery and electric vehicle manufacturing, spurred in part by these incentives. Since December 2022, announcements have come that Envision AESC, Pomega, and Redwood Materials will be building factories in the Palmetto state, joining existing vehicle manufacturers BMW, Mercedes-Benz Vans, Arrival, and Proterra. Toyota Battery Manufacturing, John Deere Electric Powertrain, VinFast, and Forza have construction underway in the Tarheel state to manufacture EV batteries, sport utility EVs, and electric boats (Lienert, 2022; Legatte, 2022).

North Carolina may soon join Nevada and Tennessee on the short list of lithium-producing states. The Carolina Lithium Belt, also known as the Carolina Tin-Spodumene Belt, spans three counties in the southwest Piedmont of North Carolina. Lithium occurs naturally in certain rock formations and brine (saltwater) deposits. In North Carolina, lithium deposits are primarily associated with pegmatite rock formations. The belt is about 25 miles long, less than two miles wide, with its southern end near the state border. It is conveniently near Interstate 85.

Spodumene, which is the type of rock containing lithium, is processed through several steps. After the blasting and drilling, the ore is trucked to a processing facility. There it is crushed, ground, deslimed, cleaned, and concentrated. Several more steps turn the spodumene concentrate into battery grade material (Ibarra-Gutiérrez et al., 2021). One advantage of onshoring lithium production is that the battery-grade lithium is in close proximity to battery and EV manufacturing plants.

Albemarle Corp. operates only active U.S. lithium mine at Silver Peak, Nevada. It trucks lithium from Nevada to a lithium hydroxide plant in Kings Mountain, NC (Domonoske, 2022; Donnelly, 2023). The company's Kings Mountain Lithium Materials Processing Plant received a \$149 million federal Department of Energy grant toward construction of a new, larger facility (WRAL Tech News, 2022). Albemarle Corp. is in the permitting process to reopen a pit lithium mine in Cleveland County. In Gaston County, Piedmont Lithium Ltd. is working through the process of obtaining environmental and construction permits to reopen a pit mine there, spurred in part by a contract with Tesla (Stewart, 2021). Neighboring Lincoln County does not have active projects but shares the geology.

Part of the permitting process includes informing the public. In January 2022, Piedmont Lithium published an economic impact study of the potential gains to Gaston County. Piedmont Lithium controls about 3,200 acres of land and plans to dig five, 500-foot deep pits. Once fully operational, the direct effects were reported to be annual output of \$533.6 million with employment of 428. Adding induced and indirect effects brings reported projections of annual output to \$687.4 million and 1,051 jobs. Piedmont Lithium's plans are not unanimously supported by residents. Dr. John Connaughton, the economist who conducted the study, was questioned by Gaston County Commissioners during a January 2022 meeting. Here is one exchange:

‘Did you include any negative economic impacts that occur as a result of the mining operations, such as loss of property values near the mine site, disruption to groundwater, blasting impacts to nearby businesses, and loss of developmental potential near the mine operations due to real or perceived negative impacts of Piedmont Lithium's operations?’ Commissioner Fraley asked.

‘No, I did not,’ Professor Connaughton said. ‘These economic impact studies are narrowly focused.’ (Boraks, 2022).

The objective of this study is to re-examine the impact using economic, occupation, and environmental data.

2 Methodology

IMPLAN software was utilized to analyze the potential impacts on both the local economy and environment (IMPLAN Group LLC, 2021). Connaughton's (2022) study used IMPLAN's 2016 data year and the 2022 dollar year. This study uses 2021 data, which is the most recent available, and the 2023 dollar year. Piedmont Lithium's public projections for production and employment are used. Company projections had operations beginning in 2023, though delays in the permitting process make a 2027 beginning more likely (Piedmont Lithium, 2022). The company projected peak output at two years into operations, originally 2025.

Lithium mining does not currently exist in Gaston County, so the region was customized to add IMPLAN sector 33 (Other chemical and fertilizer mineral mining) using U.S. average values as a proxy. Multi-Region Input Output (MRIO) analysis was utilized as the Carolina Lithium Belt runs through three counties. Economic and environmental impacts will likely spillover; there may also be a shared labor pool. The primary economic activity was placed in Gaston County, with Cleveland and Lincoln Counties in the region. Piedmont Lithium's public projections for output were entered as the value for IMPLAN's industry output event, modifying advanced fields for both employment and employee compensation as published in the company-sponsored report. Employment estimates were entered with no adjustment, as company did not break down full-time/part-time/seasonal jobs. Sector 33 was used for mining and sector 162 (Other basic inorganic chemical manufacturing) for aggregation and refining.

3 Results

3.1 Economic Impact

Five years into operation, the direct effects are estimated to be annual output of \$533.6 million with employment of 428 (Table 1). Adding induced and indirect effects brings total output to \$683.0 million and 1,109 jobs supported. One question is whether the estimates are reasonable for the region's economy. If this operation were underway now, it would be Gaston County's 18th largest employer and rank fourth in output. A technical note is that the results are not sensitive to the use of MRIO versus the use of Gaston County alone. Piedmont Lithium's report included the economic impact of construction. This analysis focuses upon operations. It was not clear from Piedmont Lithium's documents how much of the construction spending was used toward real estate acquisition. The decline in later years stems from output values projected by the company.

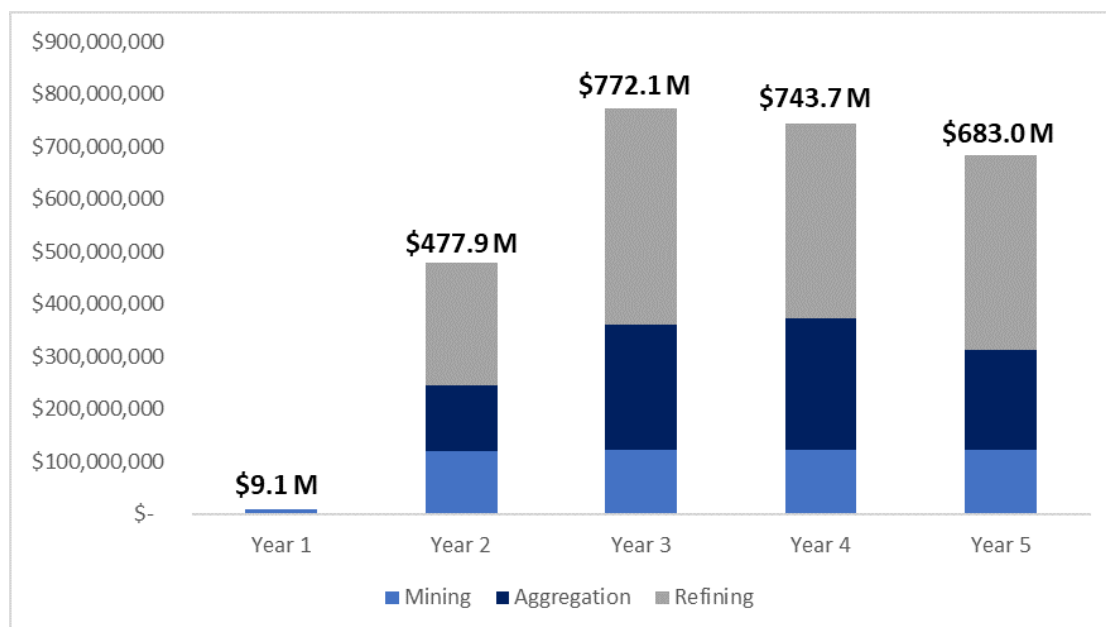
Table 1: Estimated Economic Impact by Year

Operation Year	Original calendar year	Local	State	Federal	Total
1	2023	\$325,202	\$385,233	\$568,096	\$1,278,531
2	2024	\$9,176,297	\$10,506,770	\$10,810,397	\$30,493,465
3	2025	\$13,108,591	\$15,093,406	\$15,740,819	\$43,942,816
4	2026	\$12,731,344	\$14,662,650	\$15,365,963	\$42,759,957
5	2027	\$11,932,490	\$13,760,879	\$14,682,194	\$40,375,563

Note: Results reported in 2023 dollars.

These results are consistent with results published by Piedmont Lithium's economic consultant (Connaughton, 2022).

Figure 1: Projected Economic Output by Sector and Year



The bulk of the economic impact comes from refining and aggregation (Figure 1). This is not trivial. The mining itself must occur within the geology of the Carolina Lithium Belt. Once extracted, the ore could be transported to other regions for processing. North Carolina has not provided economic incentives directly to this project; however, Albemarle Corp.'s relocation of its corporate headquarters to Charlotte in 2015 was aided by Economic Development Partnership of North Carolina (EDPNC) incentives, as was

its 2017 expansion of the King’s Mountain processing facility (Economic Development Partnership of North Carolina, 2017). Piedmont Lithium moved its headquarters to the town of Belmont in 2022.

The total economic activity will generate an expected \$11.9 million local, \$13.7 million state, and \$14.7 million federal tax receipts during a full year (Table 2). Of the total taxes, about 56% are from direct effects, 34% from indirect supply chain effects, and 10% from household induced spending effects.

Table 2: Estimated Tax Revenue

Operation Year	Original calendar year	Local	State	Federal	Total
1	2023	\$325,202	\$385,233	\$568,096	\$1,278,531
2	2024	\$9,176,297	\$10,506,770	\$10,810,397	\$30,493,465
3	2025	\$13,108,591	\$15,093,406	\$15,740,819	\$43,942,816
4	2026	\$12,731,344	\$14,662,650	\$15,365,963	\$42,759,957
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Note: Results reported in 2023 dollars.

3.2 Employment and Occupational Profile

Updates to IMPLAN software allow the user to estimate the occupational impact of events. The Piedmont Lithium project would have the largest employment gains in Production Occupations, Transportation and Material Moving Occupations, and Office and Administrative Support Occupations (Table 3). The Lithium Belt region is already more concentrated in two of these three categories than the state as a whole.

Table 3: Job Growth by Occupation Category

Occ. Code	Occupation	Job growth with lithium mining	Lithium Belt Region		North Carolina
			Wage and Salary Jobs Before	Percent of workforce	Percent of workforce
51	Production Occupations	144	18,031	12.7%	6.6%
53	Transportation and Material Moving Occupations	117	14,252	10.0%	8.8%
43	Office and Administrative Support Occupations	106	15,828	11.1%	12.6%
49	Installation, Maintenance, and Repair Occupations	81	6,892	4.9%	4.2%
47	Construction and Extraction Occupations	81	6,694	4.7%	4.0%
41	Sales and Related Occupations	63	13,001	9.2%	8.9%
37	Building and Grounds Cleaning and Maintenance Occupations	59	4,115	2.9%	3.1%
11	Management Occupations	57	7,490	5.3%	6.2%
35	Food Preparation and Serving Related Occupations	49	13,392	9.4%	8.5%
13	Business and Financial Operations Occupations	46	6,058	4.3%	6.2%

The extra jobs generated by the Piedmont Lithium project would fit within the workforce profile, as the percentage of jobs requiring a bachelor’s or graduate degree (19.2%) is covered by the percentage of

the existing workforce with the degrees (21.5%) as shown in Table 4. Overall, the workforce within the three-county Lithium Belt region is below the North Carolina average for educational attainment.

Table 4: Educational Profile

	Lithium Related Jobs	3 County Region Population	North Carolina Population
Less than high school diploma	10.9%	13.7%	11.5%
High school diploma	43.9%	31.5%	25.5%
Associate's degree or Some college courses	26.1%	33.3%	31.0%
Bachelor's degree	14.5%	14.5%	20.4%
Graduate degree	4.7%	7.0%	11.6%

3.3 Environmental Impact

Lithium mining brings spillover costs. The extraction of hard rock lithium disturbs large areas of land. The operation of mines requires the construction of roads, mining pits, and power lines. Additionally, lithium processing involves the use of toxic chemicals and produces greenhouse gases that contribute to climate change (Li et al. (2019)).

There were active mines along the Carolina Lithium Belt from the 1930s through the 1990s. The lithium was primarily used in industrial applications; Dow Corning was a key buyer. Longtime residents who live near the mines recall the noise and vibrations from blasting. High levels of arsenic in wells near the old mines is also concern (Donnelly, 2023; Stewart, 2021).

Piedmont Lithium is planning measures to address neighbors' concerns. It will utilize technologies in its lithium hydroxide operations to eliminate acid roasting, reduce waste, and improve energy efficiency. The company agreed to performing additional testing on water resources and to use more enclosed, electric-powered conveyor belt systems and fewer diesel-operated trucks (Piedmont Lithium, 2022).

Recent versions of IMPLAN provide the user with several environmental measures. The categories align with Environmental Protection Agency (EPA) data. The environmental impact is for the primary activity within the three-county study area. Any impact outside of the region is not estimated. Also, the impact does not include offsets for other parts of the supply chain or household use. For example, the quantity of greenhouse gases released through the lithium production process is not adjusted for the reduction in greenhouse gases from consumers who drive lithium-battery powered electric vehicles.

Once fully operational, the yearly environmental impact on the three-county region predicts an increase in six satellites: nitrogen & phosphorus release (+13.9%), mineral use (+8.7%), toxic chemical releases (+8.1%), greenhouse gases (+7.4%), criteria pollutants (+6.9%), water use (+4.5%). Noise and traffic changes are not estimated. The changes in Table 5 are calculated from a baseline with no mining.

Table 5: Projected Environmental Impact of Lithium Mining within the 3-County Region

Environmental Satellite	Nitrogen & Phosphorus Release	Mineral Use	Toxic Chemical Releases	Greenhouse Gases	Criteria Pollutants	Water Use	Land Use	Pesticide Emissions
Resource used	Water	In ground	Air, Soil & Water	Air	Air	Water	Soil	Air, Soil & Water
Unit of measure	kg	kg	kg	kg	kg	m3	m2*a	kg
Annual change	730,386	517,784,919	16,843	518,835,182	4,665,661	72,629,335	1,744,232	12
% change	13.9%	8.7%	8.1%	7.4%	6.9%	4.5%	0.1%	0.0%

4 Alternative Expansion Paths

What are the alternatives if public officials deny permission for lithium mining? Is there a viable path to comparable employment and output growth within the three-county region? One hypothetical scenario is the economic expansion of current industries: machine shops, other motor vehicles parts manufacturing, and truck transportation. These industries were selected as they exist within the region and have Type SAM (Social Accounting Matrix) multipliers similar to mining and lithium processing. Table 6 provides three categories of multipliers calculated using IMPLAN.

Table 6: Comparison of Multipliers by Sector

Sector	Description	Output	Employment	Labor Income
33	Other chemical and fertilizer mineral mining	1.328	1.569	1.294
162	Other basic chemical inorganic chemical manufacturing	1.284	2.020	1.424
247	Machine shops	1.288	1.320	1.220
279	Machine tool manufacturing	1.261	1.507	1.247
417	Truck transportation	1.539	1.757	1.550

What would happen if these industries grew by the same output and employment as Piedmont Lithium? The direct employment (428 jobs) and output (\$533.6 million) estimated for a full year of Piedmont Lithium's operations was divided across the three alternative industries and entered into IMPLAN. Using three industries recognizes that it would be unlikely for one new firm to operate on the scale of Piedmont Lithium. Table 7 shows the differences in economic impact results. Using the same direct employment and output, the expansion of existing industries would generate more labor income, more GDP (Value Added), and more tax revenue.

Table 7: Differences in Economic Impact for the Piedmont Lithium Project vs Alternative

	Employment	Labor Income	Value Added	Output	Combined Tax Payments
Direct	0	\$118,308,339	\$45,750,661	\$-	\$15,890,633
Indirect	495	\$18,587,904	\$11,011,366	\$12,999,974	\$5,862,737
Induced	396	\$16,805,259	\$33,027,619	\$56,674,852	\$6,965,026
Total	892	\$153,701,502	\$89,789,646	\$69,674,826	\$28,718,396

The alternative scenario would support more jobs, and the jobs would have lesser requirements for college graduates (Table 8). This could be helpful for the three-county region which is below the state average for educational attainment.

Table 8: Comparison of Educational Profiles

	Lithium Related Jobs	Alternative Expansion Jobs	3 County Region Population	North Carolina Population
Less than high school diploma	10.9%	12.6%	13.7%	11.5%
High school diploma	43.9%	45.4%	31.5%	25.5%
Associate's degree or Some college courses	26.1%	25.9%	33.3%	31.0%
Bachelor's degree	14.5%	11.7%	14.5%	20.4%
Graduate degree	4.7%	4.5%	7.0%	11.6%

Given direct output of \$533.6 million, the environmental impact would be smaller (Table 9). Criteria pollutants (+10.6%), greenhouse gases (+4.8%), and land use (+1.2%) would be the only categories increasing by more than 1%. Five of the categories would have lower environmental impact than would the lithium mining.

Table 9: Comparison of Environmental Impact

Environmental Satellite	Nitrogen & Phosphorus Release	Mineral Use	Toxic Chemical Releases	Greenhouse Gases	Criteria Pollutants	Water Use	Land Use	Pesticide Emissions
Resource used	Water	In ground	Air, Soil & Water	Air	Air	Water	Soil	Air, Soil & Water
Unit of measure	kg	kg	kg	kg	kg	m3	m2*a	kg
With Lithium Mining								
Annual change	730,386	517,784,919	16,843	518,835,182	4,665,661	72,629,335	1,744,232	12
% change	13.9%	8.7%	8.1%	7.4%	6.9%	4.5%	0.1%	0.0%
With Alternative Expansion								
Annual change	16,596	4,847,651	1,382	339,262,667	7,161,309	10,301,209	34,120,023	5
% change	0.3%	0.1%	0.7%	4.8%	10.6%	0.6%	1.2%	0.0%

The above hypothetical scenario demonstrates at least one alternative path for economic growth. Multiple projects would be needed to meet the output target. These projects would likely require tax incentives, as there is not a unique geological feature being utilized. As an example, Bosch Power Tools announced an expansion that will add 400 jobs to its factory in Lincoln County; the Economic Development Partnership of North Carolina (EDPNC) provided support (Economic Development Partnership of North Carolina, 2023).

5 Discussion

A comprehensive cost-benefit analysis of reopening the Carolina Lithium Belt would also consider market alternatives on both the demand and supply sides of lithium mining.

Variability in the price of lithium makes projections difficult. The price peak of 2022 was followed by a 30% decline in early 2023 (Daily Metal Price: Lithium Price (USD / Kilogram) Chart for the Last Max). A key reason is that China's demand for electric vehicles has slowed, impacting not only lithium but also nickel and cobalt prices (Patterson and Ramkumar, 2023).

If the Carolina lithium belt remains dormant, the global demand for lithium would be met in the short run by mines in other countries. Australia was the largest producer of lithium in 2022 [61k tons], followed by Chile [39k], China [19k], and Argentina [6.2k] (US Geological Survey, 2023). Within the "lithium triangle," a region crossing the borders of Argentina, Bolivia and Chile, miners use a low-tech method of pumping water to the surface and evaporating the brine in the sun to concentrate the lithium carbonate (International Council on Mining and Metals, 2018). In the arid region of the high Andes, water tables are being lowered at a rate that geologists predict will drain local ecosystems and endanger indigenous communities (Pearce, 2022). Keeping the Carolina Lithium Belt dormant likely means a higher global environmental cost.

Operating in the "lithium triangle" also brings geo-political risk. Chilean President Boric has announced plans to place lithium mining and processing under the umbrella of a new state-owned company (Dube, 2023). Officials in Argentina and Mexico, among others, are considering forms of resource nationalism (The Economist, 2023). Bolivia has larger lithium reserves than its neighbors, but state control gives pause to corporate investors (Lunde Seefeldt, 2020).

In the long run, the supply of lithium will be more elastic. Technological innovation will make substitutes more viable. Geologists and engineers are developing methods to extract lithium from oil-field brine. Site testing is underway both in Canada and in the southern U.S., namely Arkansas. Direct lithium extraction could provide a second wave of activity in depleted natural gas and oil fields (Morenne, 2023). In a different approach, sodium ion batteries are being developed that would drastically reduce the demand for earth metals (Wilmot, 2023).

Political tensions within the U.S. add to uncertainty. The Inflation Reduction Act of 2022 is a key source of incentives, but its longevity depends upon the outcome of the November 2024 Presidential election. National regulatory standards shift when control of the White House changes parties. Moreover, local and North Carolina officials are not rubber-stamping permits. In 2021, Gaston County officials placed a temporary moratorium on mining after it leaked that Piedmont Lithium's operating plans would involve multiple blasts per day, which had not been disclosed in prior zoning applications (Scheyder, 2021). State

officials are moving forward slowly. In May of 2023, state regulators made a third request for additional information regarding Piedmont Lithium’s environmental permits (Scheyder, 2023).

6 Conclusion

The unique geography of the Carolina foothills created a prime commodity resource. Two corporations are actively seeking permits to reopen lithium pit mines. This case study focuses upon the economic impact of Piedmont Lithium’s project. The re-opening of the King’s Mountain mine by Albemarle Corp. would magnify impacts discussed here.

Carolina Lithium’s project would have an estimated annual economic output of \$683.0 million, support 1100 jobs, and generate \$75.9 million labor income. Of that, direct employment is 428 and direct output is \$533.6 million. Residents who object to the mines reopening have concerns regarding noise, traffic, and other spillovers. Piedmont Lithium’s project would likely have its largest environmental impacts on water pollution (+13.9%) and mineral usage (+8.7%).

An alternative economic expansion path could generate the same output and support the same number of jobs with less environmental impact; however, other economic expansions would likely require incentive packages. The local analysis is set among changes in the global lithium supply, competing technologies, and shifting regulatory frameworks that make the lithium mining more volatile.

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