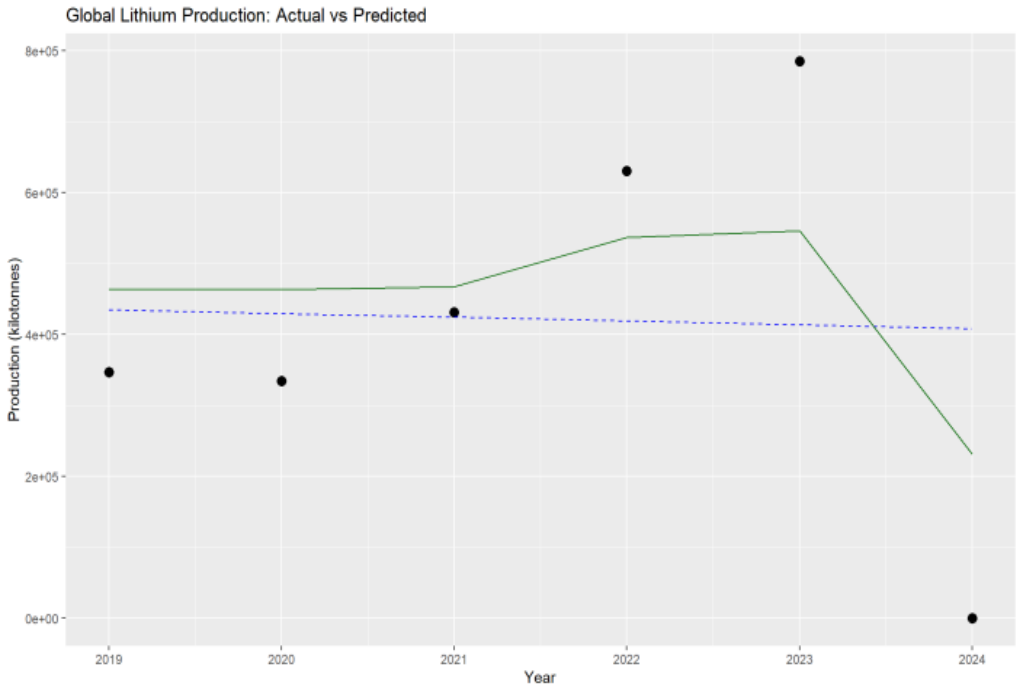
LITHIUM ION

- We chose these data because lithium is a critical mineral with rapidly growing demand due to electric vehicles and energy storage, making it ideal for analyzing resource security, production trends, and economic impacts.
  - It is important to research and collect data about lithium-ion batteries as it is a nonrenewable resource. We can address how lithium is finite; we take a deeper look at trends in global nonrenewable energy consumption through comparison and we can conclude what implications lithium mining may have on the economy or the environment.

We focus on how world lithium production changed year over year and what we can conclude about future lithium resources.

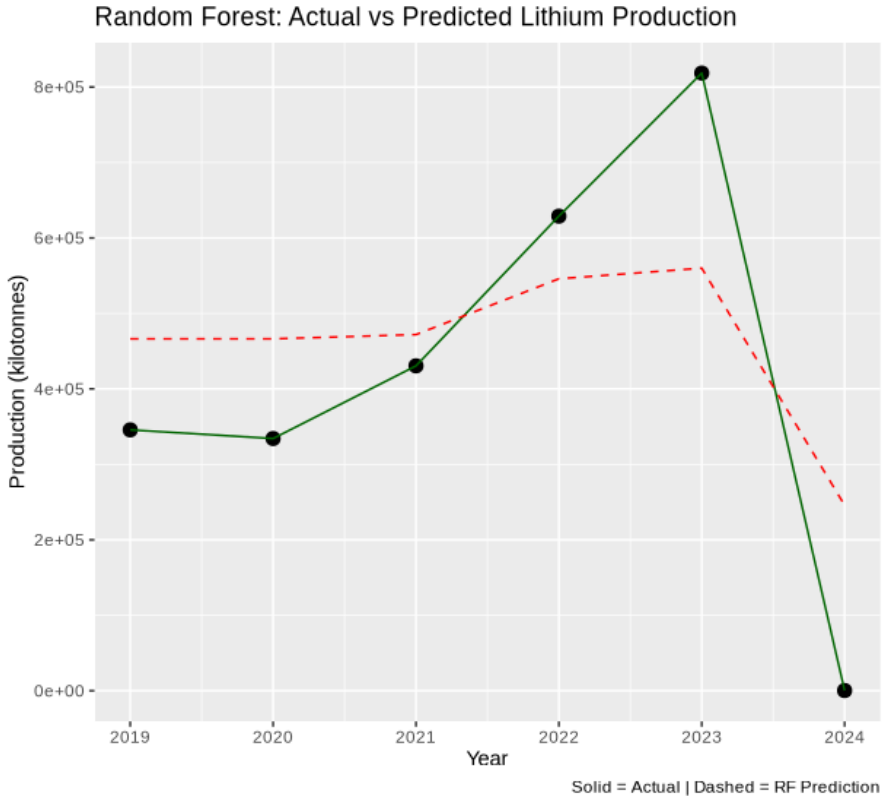
Linear Regression

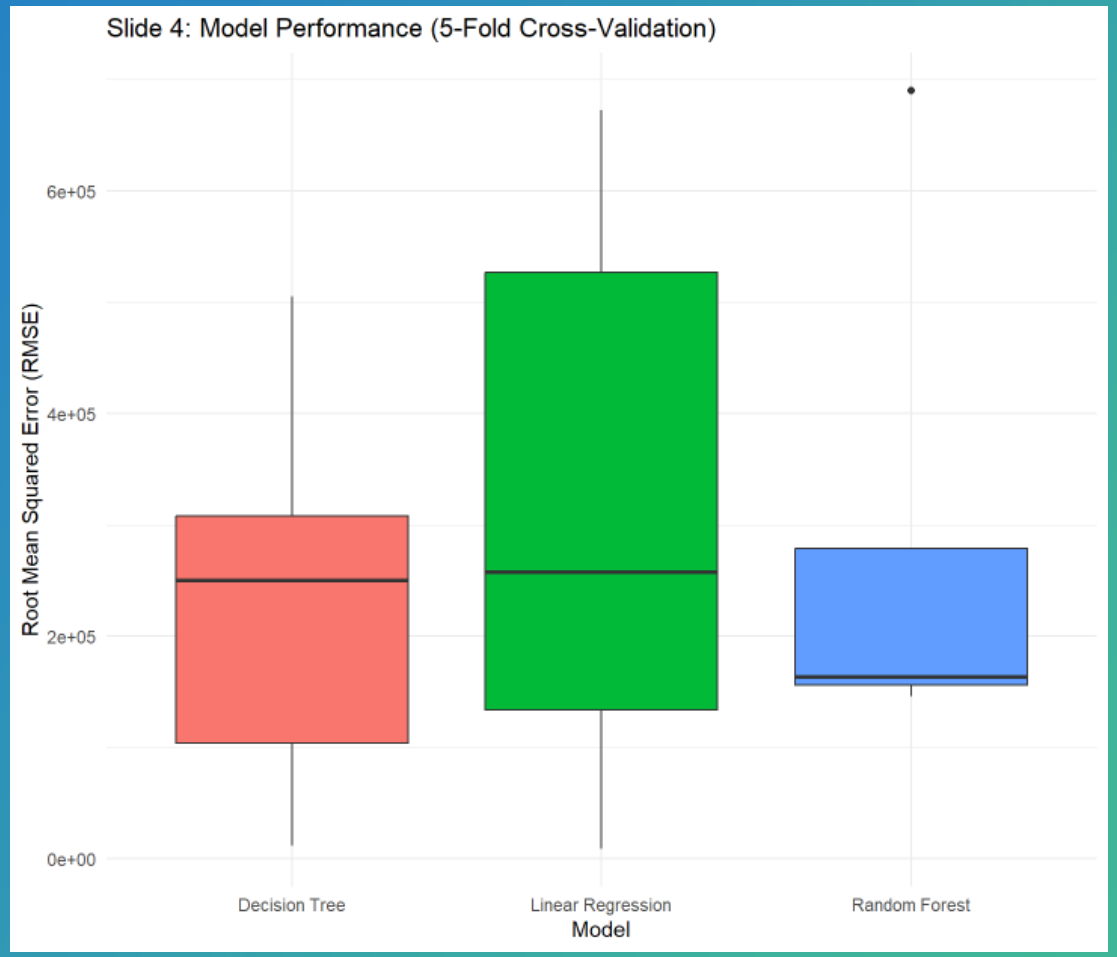
- Lithium production has rapidly increased, particularly since 2020. A drop observed in 2024 was likely due to incomplete or estimated data, rather than an actual decline, as the U.S. withheld its production figures. This may reflect a shift in how or where countries are sourcing their lithium, though more data would be needed to confirm this trend.
- We centered the Year feature (Year_c = Year - 2019) for model stability.
- Built a simple linear regression model to predict lithium production based on time.
- The black dots show actual global lithium production (2019–2024).
- The blue dashed line is the linear regression prediction.
- The green line shows actual year-to-year production.



Decision Trees or Random Forests

- Used both decision trees and random forests to allow for nonlinear modeling.
- These models are useful for detecting non-obvious patterns and improving prediction.
- Benefits of Random Forest:
  - Handles noise and outliers better than linear models.
  - Reduces overfitting via averaging across trees.
- Compared performance using Mean Squared Error (MSE) and R^2 scores.
- Found Random Forest slightly more accurate than linear regression.





k-fold cross-validation (e.g., 5- or 10-fold) to assess and compare model performance on predictive accuracy

- Used k-fold cross-validation (k = 5 & 10) to assess performance.
- Goal: check how well each model generalizes to unseen data.
- Metrics analyzed:
  - Root Mean Squared Error (RMSE)
  - R^2 (goodness of fit)
- Results:
  - Linear Regression: simple, interpretable, strong performance.
  - Random Forest: slightly better predictive accuracy on small dataset.
- Cross-validation confirms both models are stable, but Random Forest is less sensitive to anomalies like 2024

Conclusion

Linear Regression showed:

There is a positive relationship between year and global lithium output. Meaning each year, on average, more lithium is being produced.

This trend reflects growing global demand, especially from sectors like electric vehicles, energy storage, and consumer electronics.

If the trend continues, we can expect continued or accelerated growth in production.

Random Forests:

Random Forest shows that while the overall trend is upward, real-world lithium production is not perfectly predictable year to year likely because of the U.S withholding their productions and resources rates.

Future Implications.

The conclusion about our dataset of choice can draw focus on the economic and environmental impacts of lithium production and depletion.

As a finite, nonrenewable resource, lithium has a growing demand for electric vehicles, energy storage and consumer electronics. Our analysis shows that production has steadily increased year over year, highlighting lithium's rising market value and importance. However, this upward trend also raises concerns about long term resource scarcity and the ecological consequences of expanded mining. These findings emphasize the need for sustainable extraction practices, investment in recycling technologies, and exploration of alternative materials.