

Monitoring Global Soybean Production Using Elementomics to Combat Rainforest Destruction

Brian Quinn



**QUEEN'S
UNIVERSITY
BELFAST**

▸ Soybean Farming



▸ Soybean Farming



▸ Soybean Production



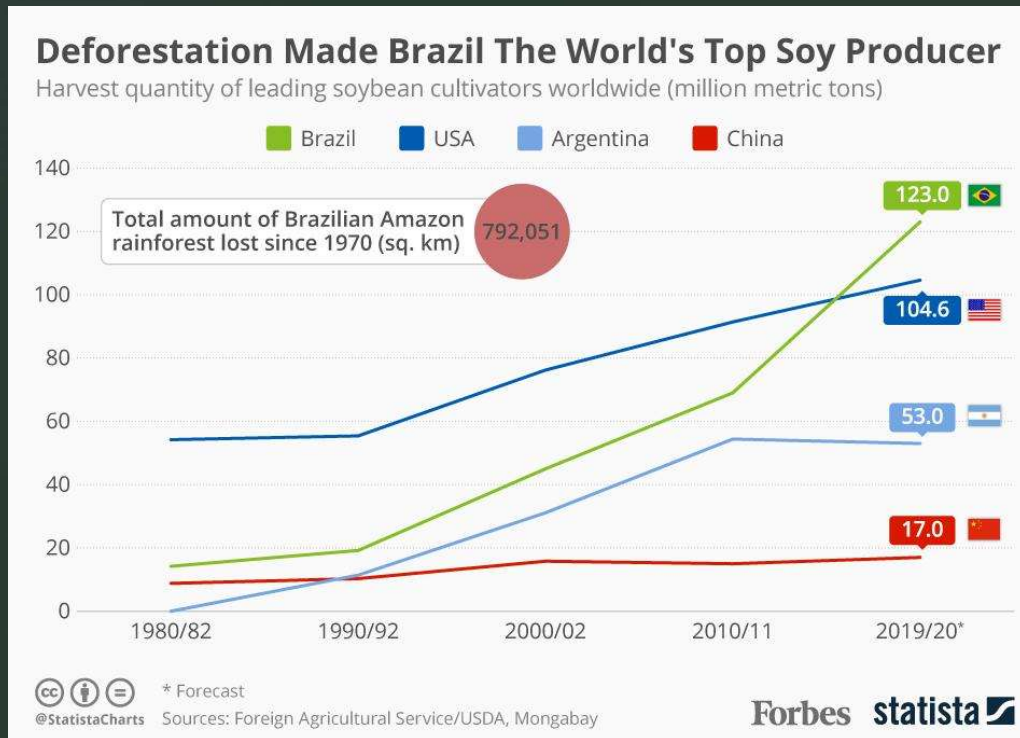
- In 2018 China slapped a 25% tariff on US soybeans in response to US taxes being added to all imported Chinese goods
- In the aftermath, China now imports 70% of Brazil's soybean production

Amazon Deforestation



- Brazil's response to the massive demand for soybeans has been to accelerate the systematic clearance of the Amazon Rainforest to create agricultural land
- Over 11 million acres of the Amazon Rainforest was destroyed from 2019-2022

Global Soybean Production

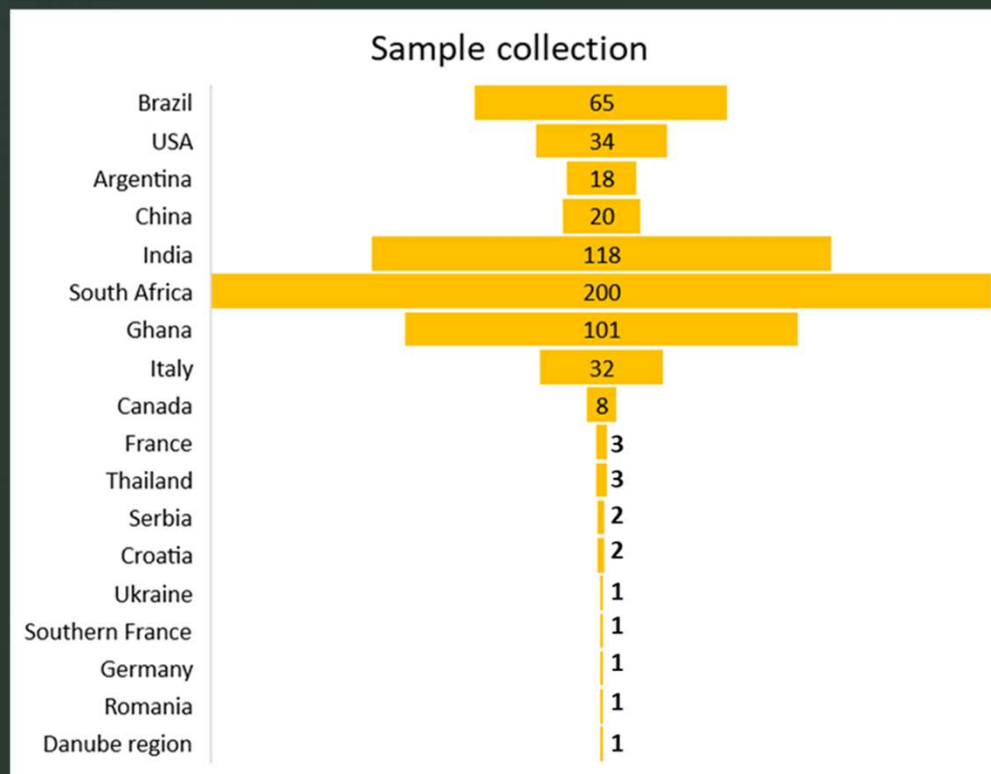


Amazon Deforestation



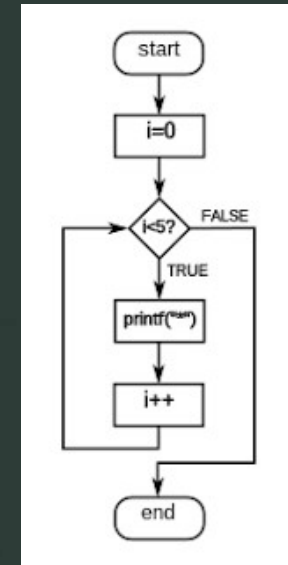
- In the EU and UK, consumers are applying significant pressure on grocery chains, livestock producers and feed companies to make sure the soya they sell is not from a recently deforested area
- No robust analytical tool exists to help protect businesses from selling soybeans grown in impacted areas

Global Sample Collection



General Analytical Workflow

- Sourced samples (10-15%) were analysed by Agilent 6546 LC/QToF, Agilent 5975C GC/MS/MS, and an Agilent 7850 ICP/MS to determine the best platform to take forward
- The ICP/MS proved to produce the best elementomic models, so it was the instrument of choice to continue this research



ICP/MS Analytical Workflow



- Sample size is 100 mg with 10 replicates per sample
- Samples are allowed to digest in 2 mL of hydrogen peroxide and 2 mL of concentrated nitric acid before microwaving for 1.5 hours and diluting to 20 mL before analysis
- A soybean CRM was purchased from Merck and used in every analytical run to evaluate the instrument performance over time
- Samples are randomised on the autosampler prior to analysis

Modelling Analytical Workflow



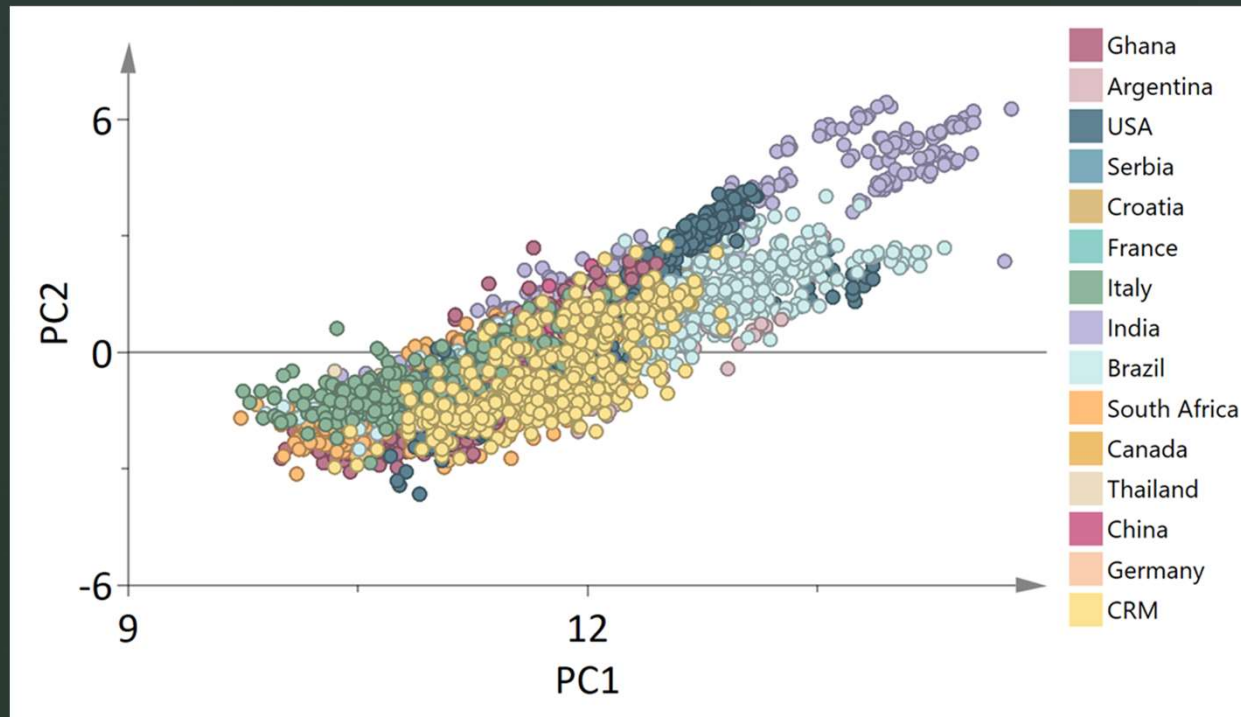
- Results from the ICP/MS are quantitated (45 elements)
- Quantitated results are log 10 transformed
- Models are created using SIMCA – unsupervised PCA first and supervised models (OPLS-DA, PLS-DA, RF, SVM, etc.) next

Model Validations

- Permutation tests (n=50) were conducted to ensure the model was not overfit
- External validation – 70% of samples were used as the training set and 30% were used as a test set to again test for overfitting
- Internal validation – Leave 20% out testing was used

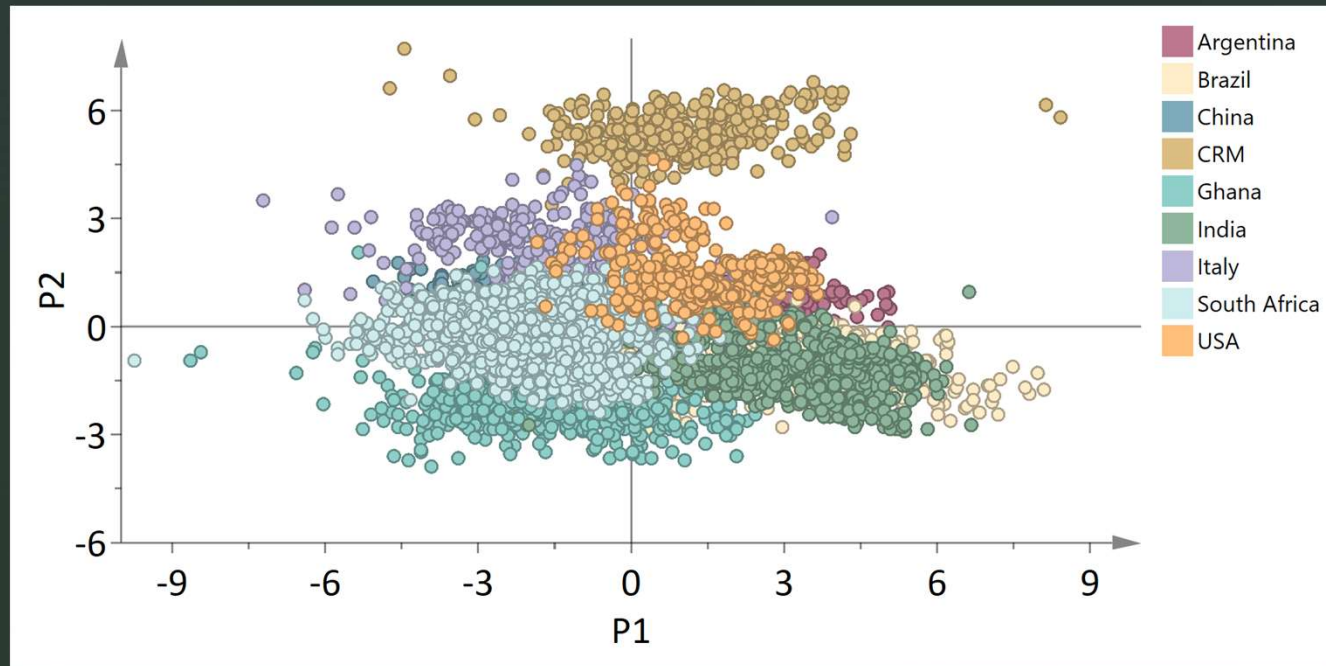
PCA Model

$R^2X=0.971$; $Q^2=0.919$; LOG10 normalization



OPLS-DA Model

- $R^2X=0.995$; $R^2Y=0.693$; $Q^2=0.69$

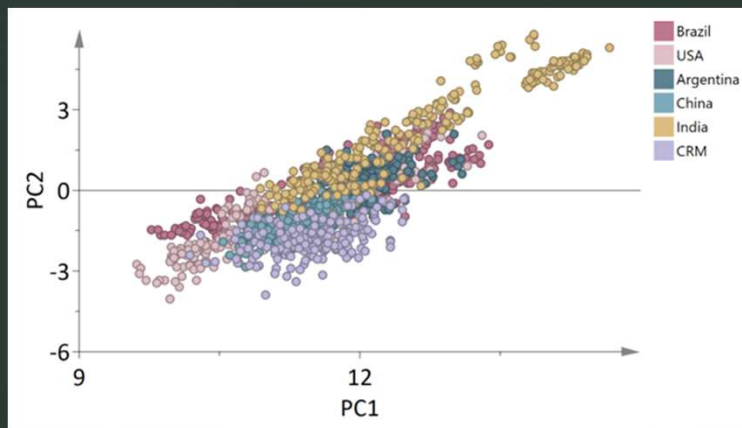


OPLS-DA Model

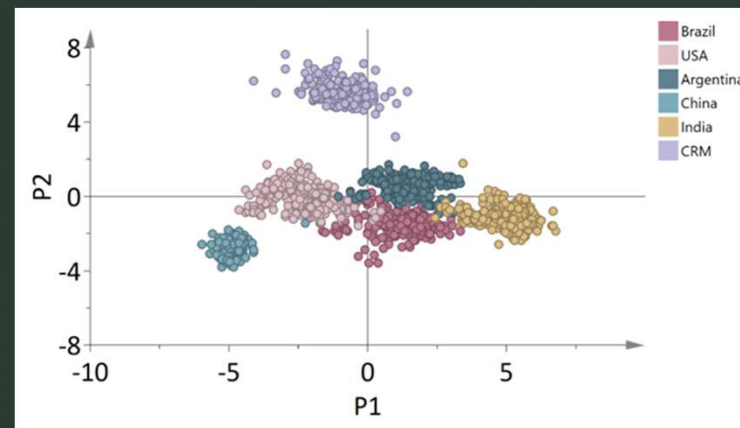
	Members	Correct	Argentina	Brazil	China	CRM	Ghana	India	Italy	South Africa	USA
Argentina	160	50.63%	81	76	0	0	0	0	0	0	3
Brazil	630	99.84%	0	629	0	0	1	0	0	0	0
China	200	100%	0	0	200	0	0	0	0	0	0
CRM	410	100%	0	0	0	410	0	0	0	0	0
Ghana	940	98.09%	0	11	0	1	922	0	0	6	0
India	760	98.56%	0	10	0	0	1	749	0	0	0
Italy	270	95.56%	0	0	0	0	0	3	258	6	3
South Africa	1760	99.94%	0	0	0	0	0	0	1	1759	0
USA	430	96.51%	0	0	0	0	0	1	4	10	415
Total	5560	97.5%	81	726	200	411	924	753	263	1781	421

Elementomic Models – Top 5 Producers

PCA: $R^2X=0.976$; $Q^2=0.916$



OPLS-DA: $R^2X=0.927$; $R^2Y=0.869$; $Q^2=0.836$



Elementomic Models – Top 5 Producers

Classification

	Brazil	USA	Argentina	China	India	CRM
Brazil	249 99.6%	0	1 0.40%	0	0	0
USA	0	250 100%	0	0	0	0
Argentina	11 6.87%	0	149 93.13%	0	0	0
China	0	0	0	200 100%	0	0
India	0	0	0	0	250 100%	0
CRM	0	0	0	0	0	200 100%

Real Groups

Group	# of samples	# of passes	# of failures	# of outliers	Classification rate
Total	1310	1298	12	0	99.1%

Future Work

- Obtain samples from impacted areas in Brazil
- Keep collecting samples to improve models
- Explore bean versus ground sample disparities
- ISO accreditation

Acknowledgements

➤ Ms Yunhe Hong

The word "THANKS" is written in a colorful, bubbly font with a 3D effect. Each letter is a different color: T (cyan), H (green), A (yellow), N (magenta), K (cyan), S (orange).

➤ Dr Nick Birse

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➤ Prof Chris Elliott

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Soya Project Summary – Coalition of the Good

