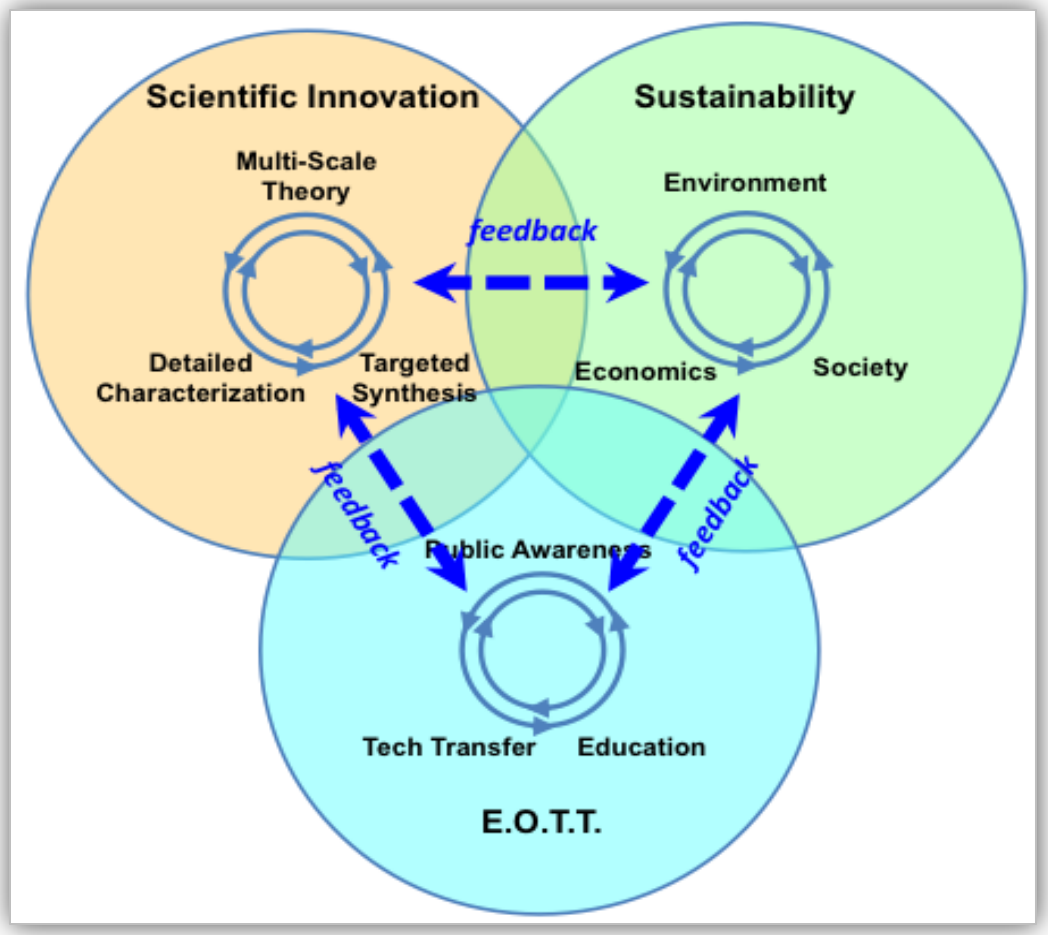
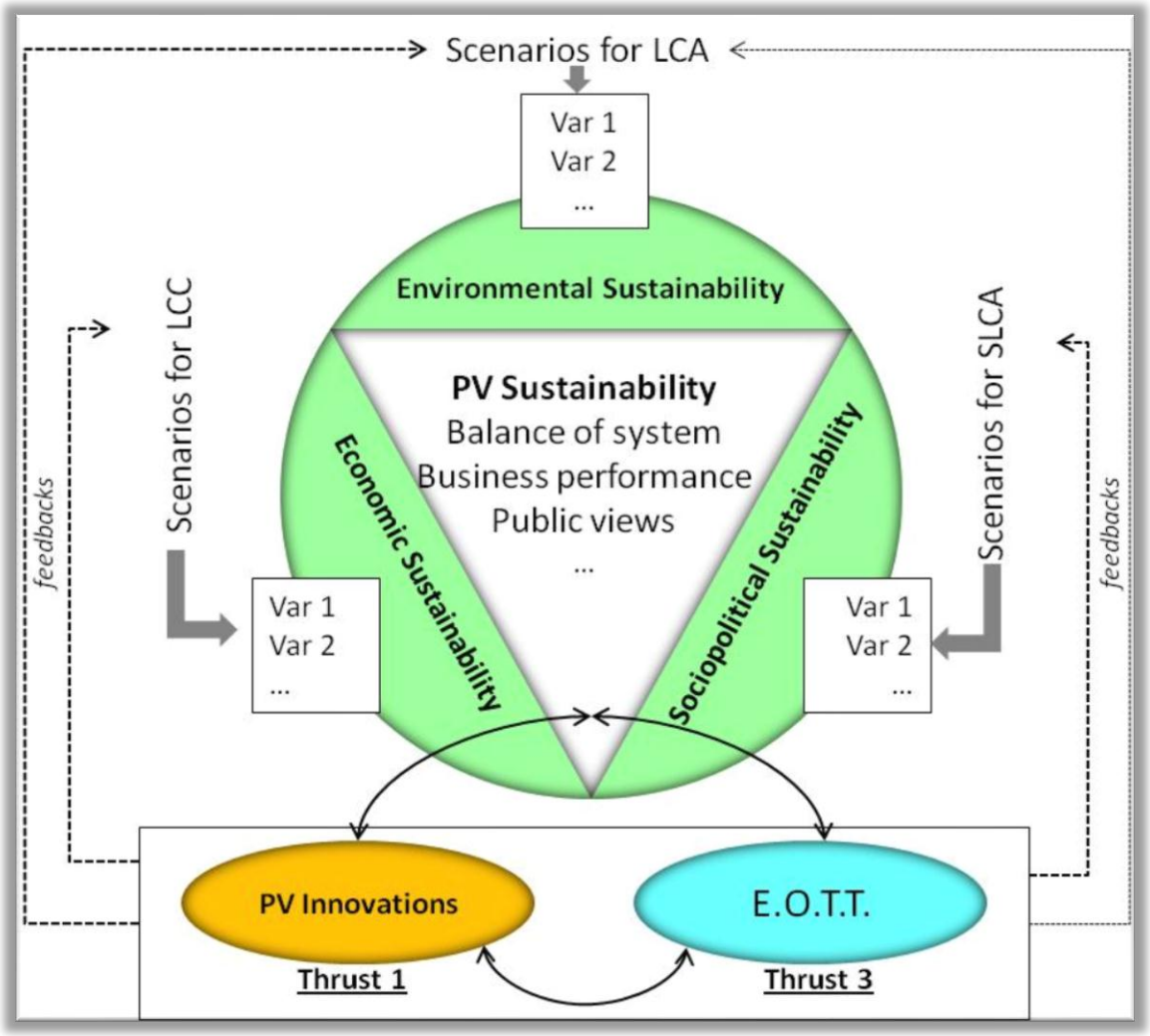
Thrust 2: Sustainability Assessment of the New PV Technology and Production

Jiquan Chen, Defne Apul, Carol A. Stepien
Jenny Collier, Undergraduate Student (Civil Engineering)
Angela Fan, Ph. D Student (Environmental Sciences)
Xizheng Ma, Undergraduate Student (College of Business)
Robert Phillips, Undergraduate Student (Civil Engineering)

PROJECT DESCRIPTION



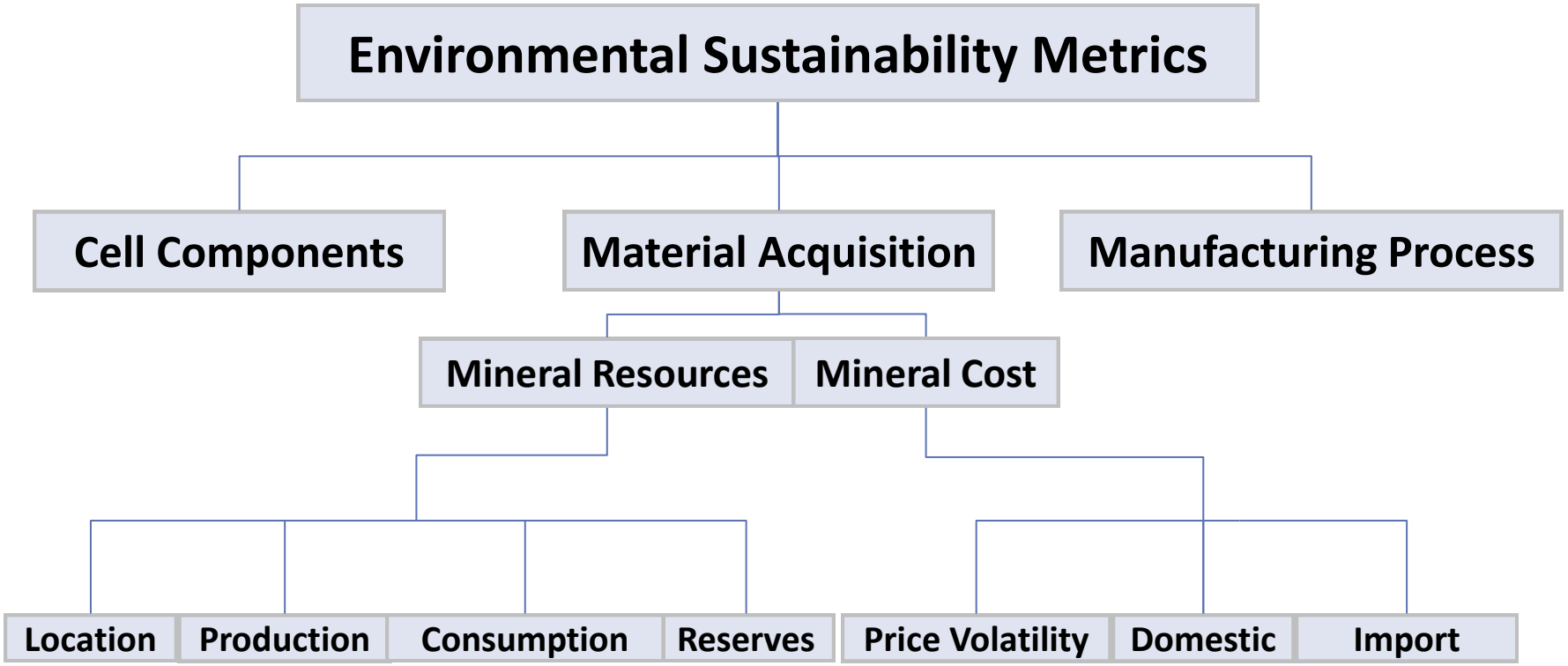
CURRENT THRUST II FOCUS



Possible Parameters Related to Each Life Cycle Sustainable Assessment Phase

LCSA phases:	1. Raw material acquisition	2. Material synthesis	3. Module manufacturing	4. Balance of System (BOS) manufacturing	5. Installation and Use	6. End of life management
Parameters related to:	Raw material type	Chemical reaction approach (e.g., inverse micellar vs. thermal injection) Solvent type	Thin-film deposition method Type of material used Material thickness Device efficiency	Required module interconnections, support structure, inverters and transformers, concrete	System lifetimes, maintenance requirements	Disassembly, material recovery processes, materials sent to landfills

CURRENT PROCEDURE



FOCUS HIERARCHY

Proposed Compounds

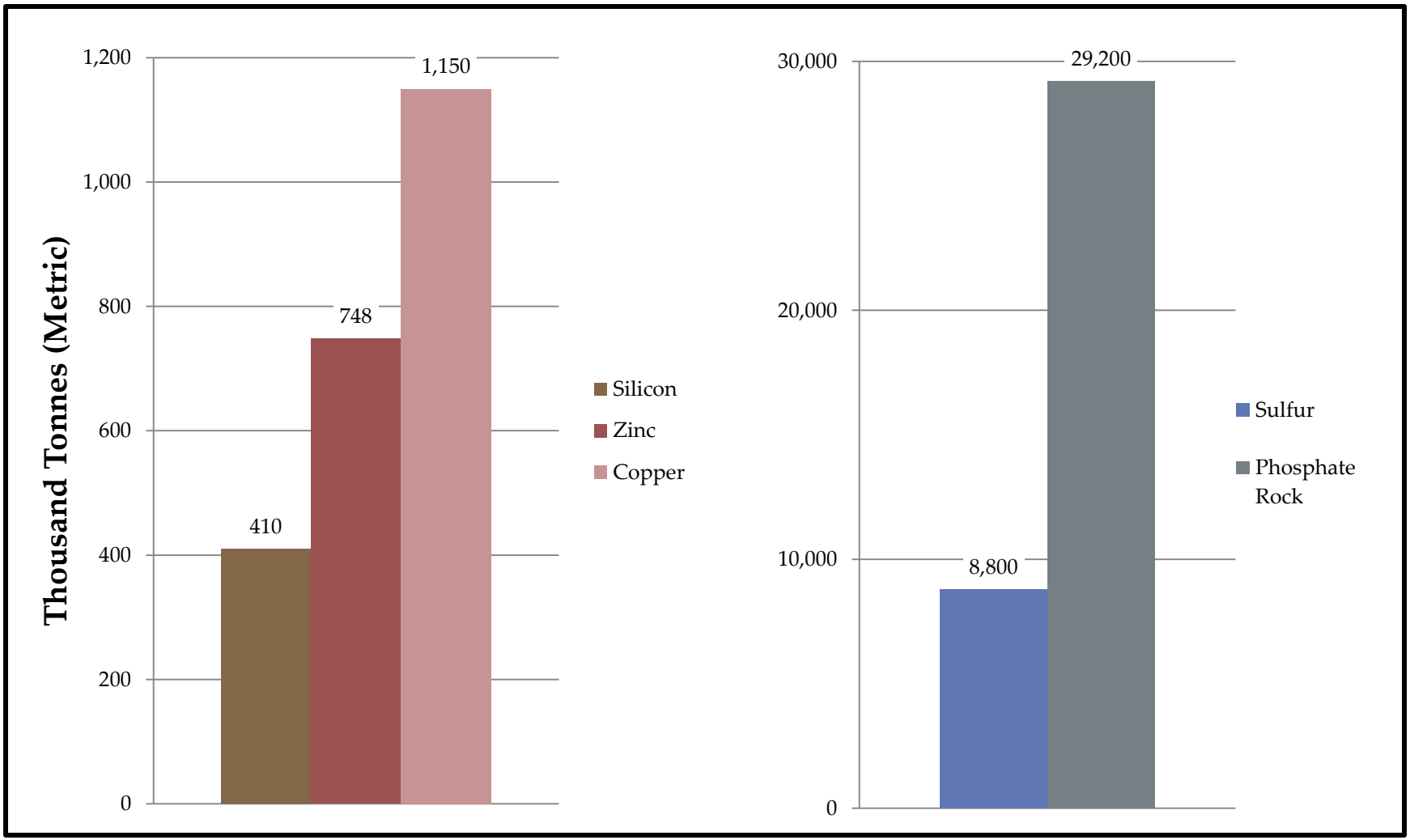
- Copper Zinc Tin Sulfide (CZTS)
- Zinc Phosphide
- Copper (II) Sulfide
- Iron Sulfide
- Copper (II) Oxide
- Copper (I) Oxide
- Nickel Sulfide
- Amorphous Silicon

Raw Material

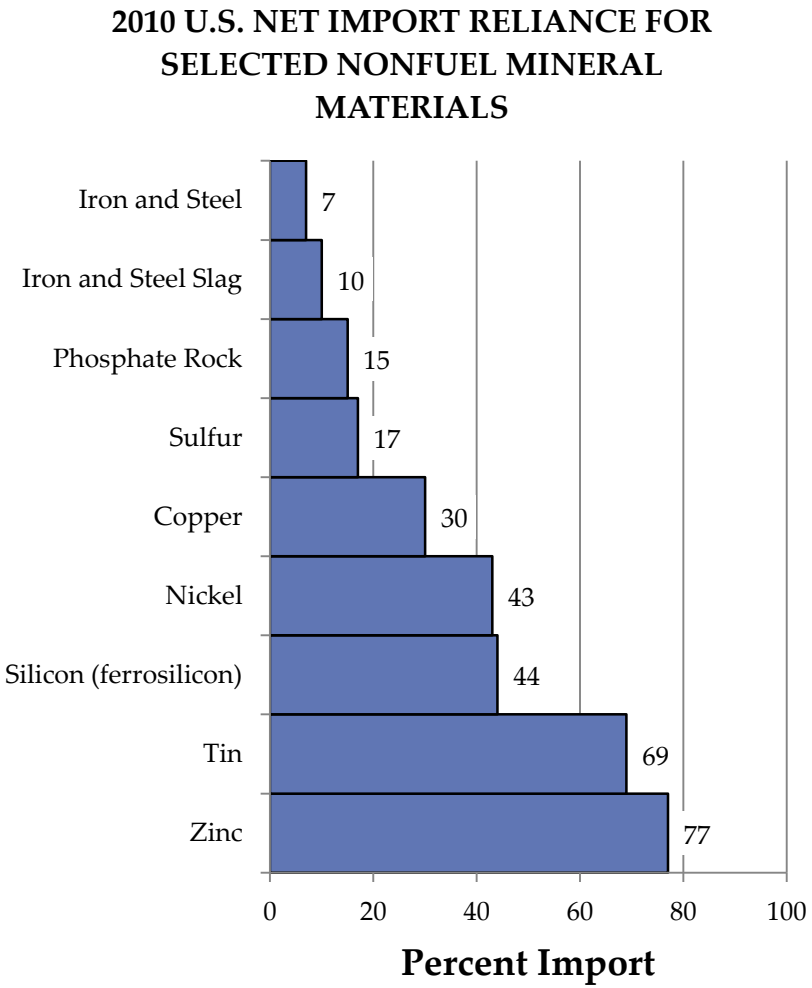
- Copper
- Zinc
- Tin
- Sulfur
- Selenium
- Phosphorous
- Iron
- Nickel
- Silicon

DOMESTIC ANALYSIS

2012 Production Statistics



Import Statistics



- Copper
- Zinc
- Tin
- Sulfur
- Selenium
- Phosphorous
- Iron
- Nickel
- Silicon

Material Costs

Average 2012 U.S. Prices for Materials of Interest	
Selenium	$127.60 per kg
Tin	$27.94 per kg
Nickel	$17.58 per kg
Copper	$8.14 per kg
Silicon	$2.86 per kg
Zinc	$2.05 per kg
Sulfur	$0.22 per kg
Phosphate Rock	$0.11 per kg

Active Mining Operation

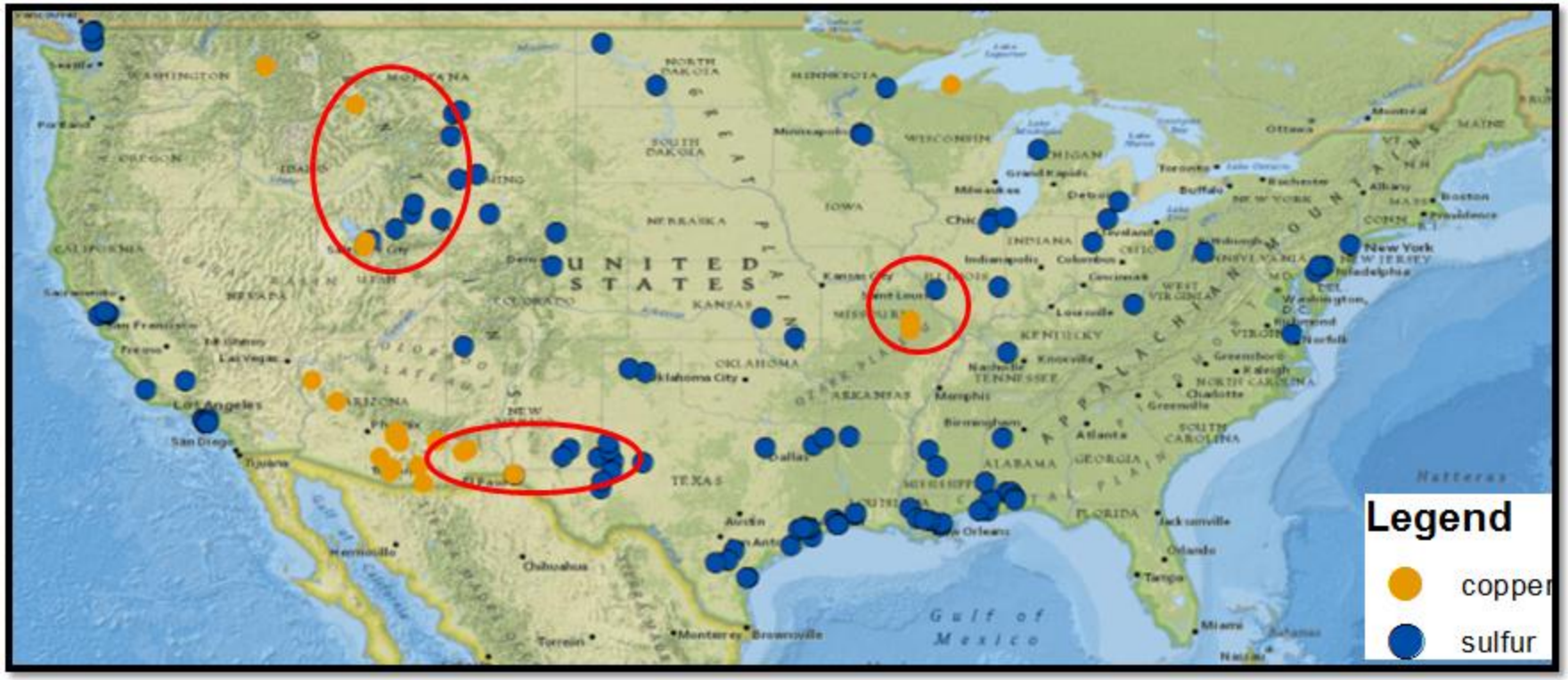
Copper Zinc Tin Sulfide (CZTS)

Active Mining Operations

Zinc Phosphate Zn_3P_2

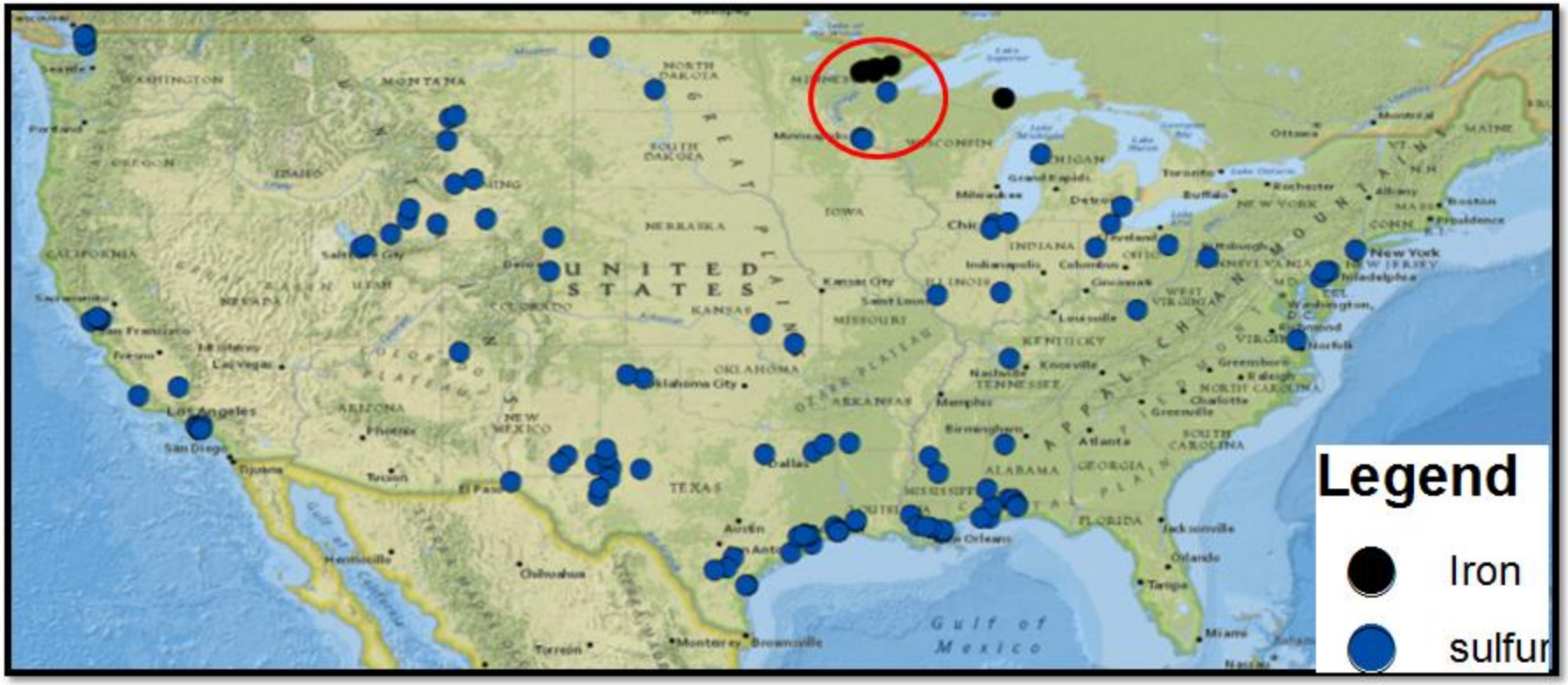
Active Mining Operations

Copper Sulfide Cu_2S



Active Mining Operations

Iron Sulfide (FeS_2)



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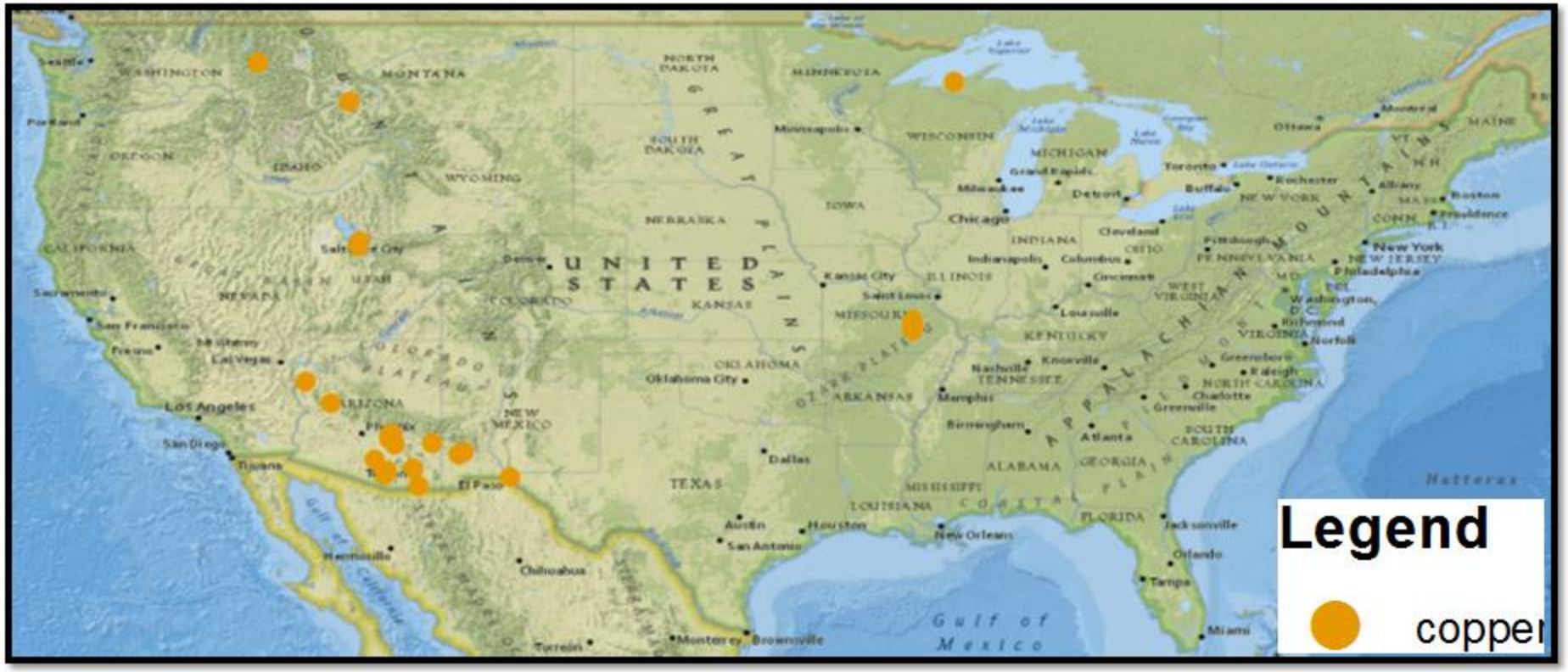
Active Mining Operations

Copper (I/II) Oxide (Cu_xO)



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Active Mining Operations

Nickel Sulfide (NiS)

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Active Mining Operations

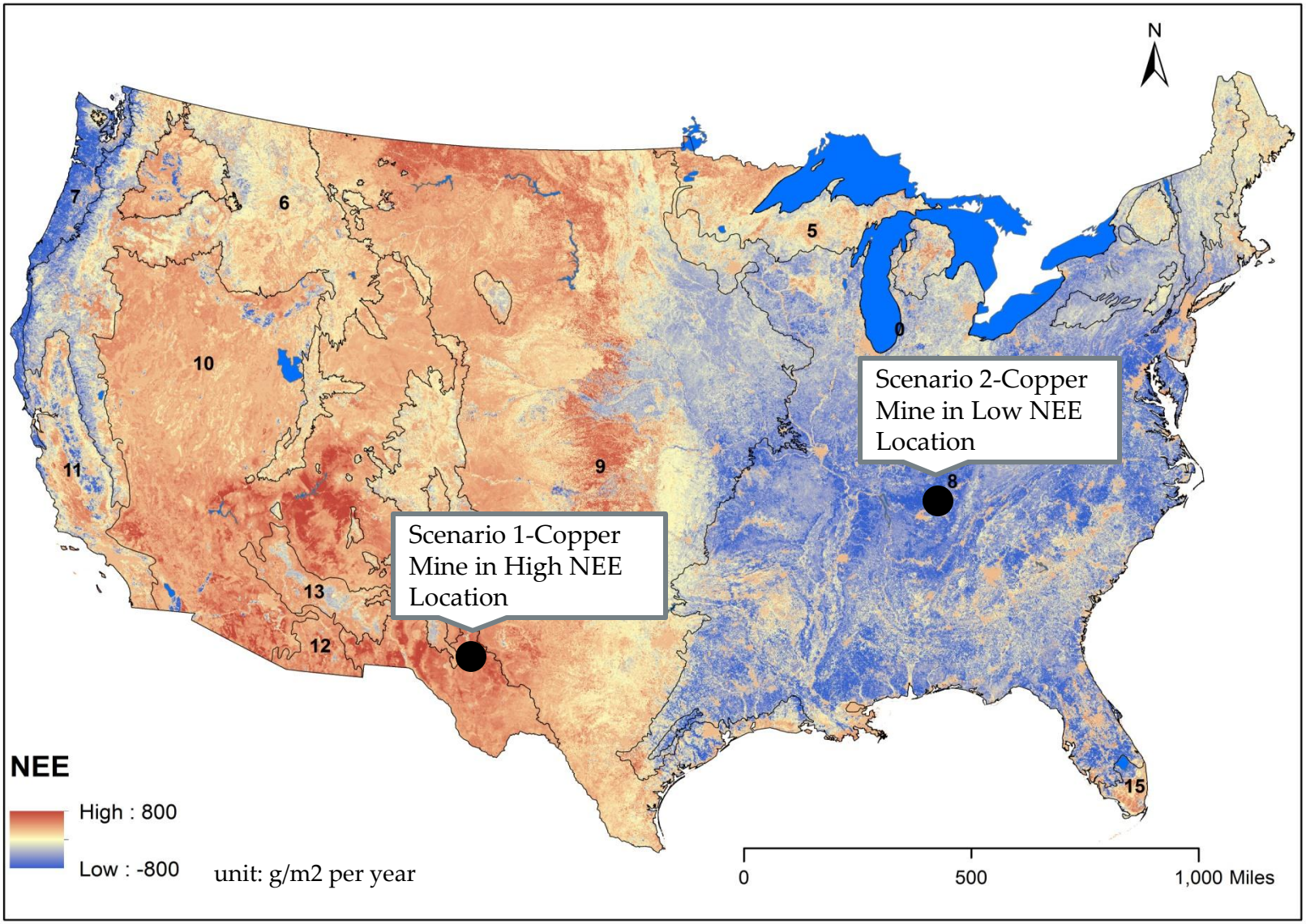
amorphous Silicon (a-Si)

United States Geologic Survey

Example Data

Id	Commodity	Compound	Site_name	Company_na	State_loca	County	Latitude	Longitude
575	Copper	CZTS, Cu2S, Cu2O, CuO	Copper Queen Branch Mine	Phelps Dodge Corp	Arizona	Cochise	31.429	-109.892
576	Copper	CZTS, Cu2S, Cu2O, CuO	Johnson Camp Mine	Nord Resources Corp	Arizona	Cochise	32.1	-110.062
578	Copper	CZTS, Cu2S, Cu2O, CuO	Miami Mine	Phelps Dodge Corp	Arizona	Gila	33.396	-110.881
579	Copper	CZTS, Cu2S, Cu2O, CuO	Miami Unit	BHP Copper Inc	Arizona	Gila	33.379	-110.956
580	Copper	CZTS, Cu2S, Cu2O, CuO	Pinto Valley Mine	BHP Copper Inc	Arizona	Gila	33.412	-110.964
583	Copper	CZTS, Cu2S, Cu2O, CuO	Miami	Phelps Dodge Corp	Arizona	Gila	33.413	-110.861
584	Copper	CZTS, Cu2S, Cu2O, CuO	Hyden/Ray	ASARCO Inc	Arizona	Gila	33.002	-110.789
585	Copper	CZTS, Cu2S, Cu2O, CuO	Morenci Mine	Phelps Dodge Corp	Arizona	Greenlee	33.067	-109.342
587	Copper	CZTS, Cu2S, Cu2O, CuO	Mineral Park Mine	Equatorial Mineral Park Inc	Arizona	Mohave	35.371	-114.152
588	Copper	CZTS, Cu2S, Cu2O, CuO	Mission Complex	ASARCO Inc	Arizona	Pima	32.001	-111.053

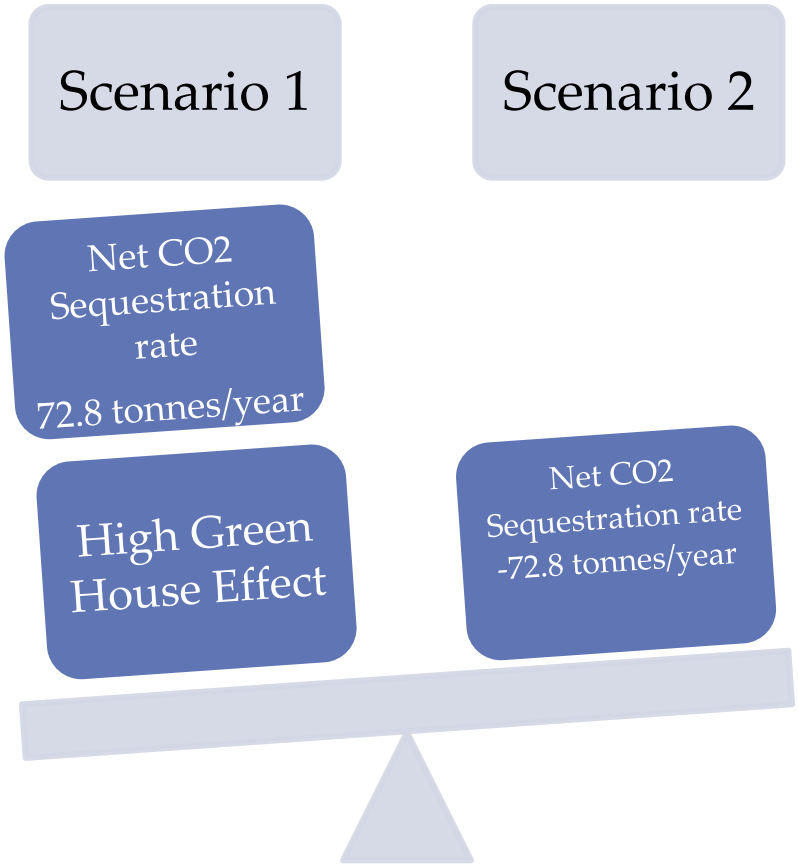
Carbon Sinks Versus Carbon Sources



Carbon Sequestration Scenario

Assumptions:

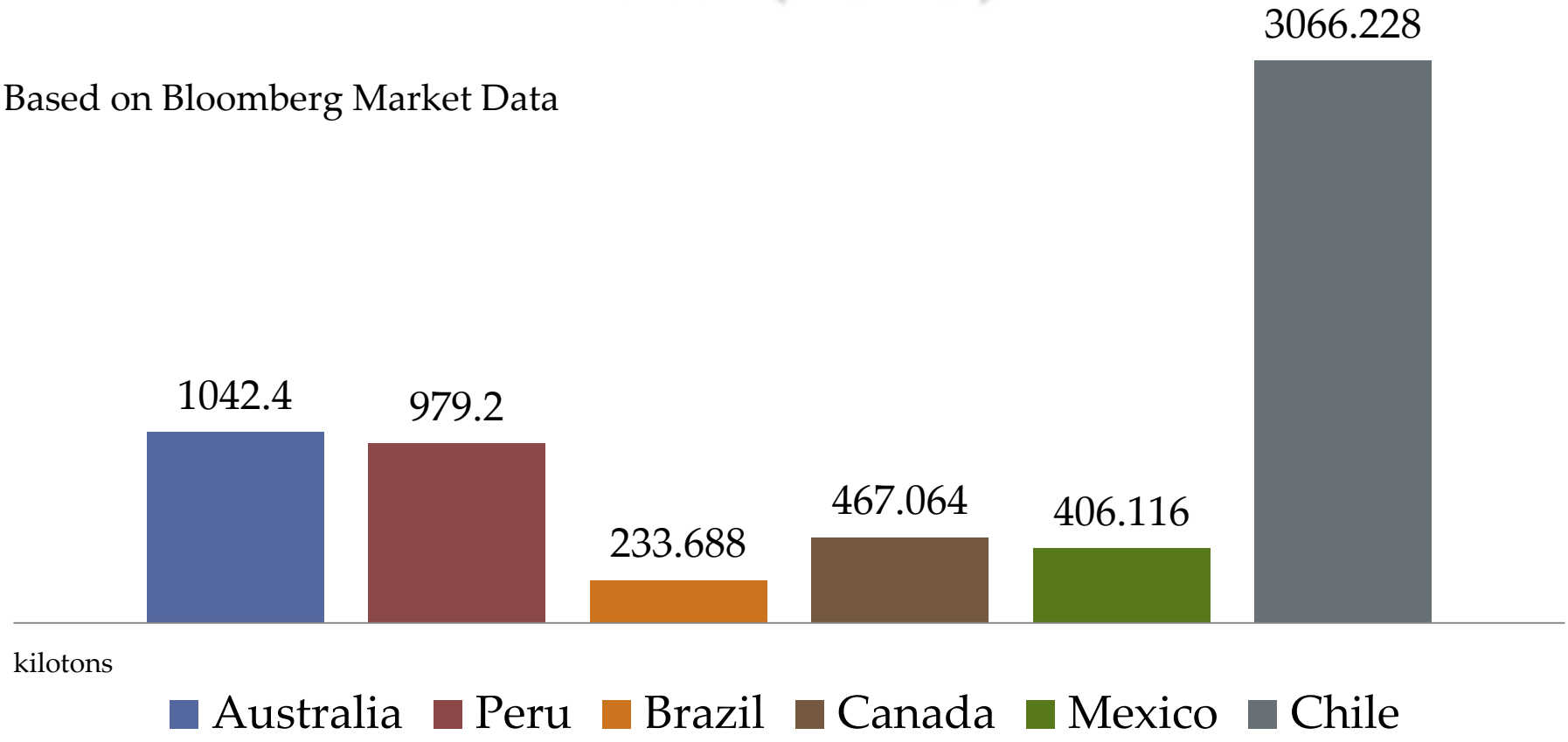
1. 30 Acres
2. High NEE
   Location: 600
3. Low NEE
   Location: -600



INTERNATIONAL ANALYSIS

Historical Copper Production Data (2013)

Based on Bloomberg Market Data



International Metal Price

From Bloomberg System

Ticker	Dataset	Description	Value	Unit	Frequency	Last	Product	Location	Data Type	Source	Last Price	High	Average	Low
CLPCTOTL Index	A	Chile Copper Production Total	420207	Tons	Monthly	2/28/13	Copper	Chile	Production	Instituto Nacional de Estadistica de Chile (INE)	0.420M	0.532M	0.451M	0.356M
CMINCOPR Index	A	Chile Mineral Copper Export Data	3381	MILLIONS	Monthly	3/31/13	Copper	Chile	Export	Banco Central de Chile	3192	4924.13	3170.42	1238.21
PRMMCOPP Index	A	Central Reserve Bank Copper Production Data	81.6	1000 M.Tons	Monthly	1/31/13	Copper	Peru	Production	Banco Central de Reserva del Peru	81.6	106.2	86.1	63.9
WMNXIMCN Index	A	Total Nickel Metal Imports China	0	metric tonne	Monthly	12/31/13	Nickel	China	Import	World Bureau of Metal Statistics (WBMS)		47262	12483	
MXMMCOPR Index	A	Mexico Copper Mining Production	33843	TONS	Monthly	1/31/13	Copper	Mexico	Production	INEGI		38105	26351	15688
AUPRZINR Index	A	ABARE Refined Zinc Australia Minerals & Metals Production Data	525.4	kilotons	Yearly	12/31/13	Zinc	Australia	Production	Australian Bureau of Agricultural and Resource Economics		571.9	374	0
CLPCREFI Index	A	Chile Copper Production Refined Total	3717	tons	Monthly	12/31/11	Copper	Chile	Production	Instituto Nacional de Estadistica de Chile (INE)	3717	15607	8932	1199
WMNXEXBR Index	A	Total Nickel Metal Exports Brazil	0	metric tonne	Monthly	12/31/13	Nickel	Brazil	Export	World Bureau of Metal Statistics (WBMS)		1886	941	0

Finding the Right Data

Product type	Price	Data type
• Ore • Refined metal	• Spot Price • Fair Price • Historical Price	• Production • Consumption • Export • Import

Available market data in Bloomberg System of related material

Reference Sources

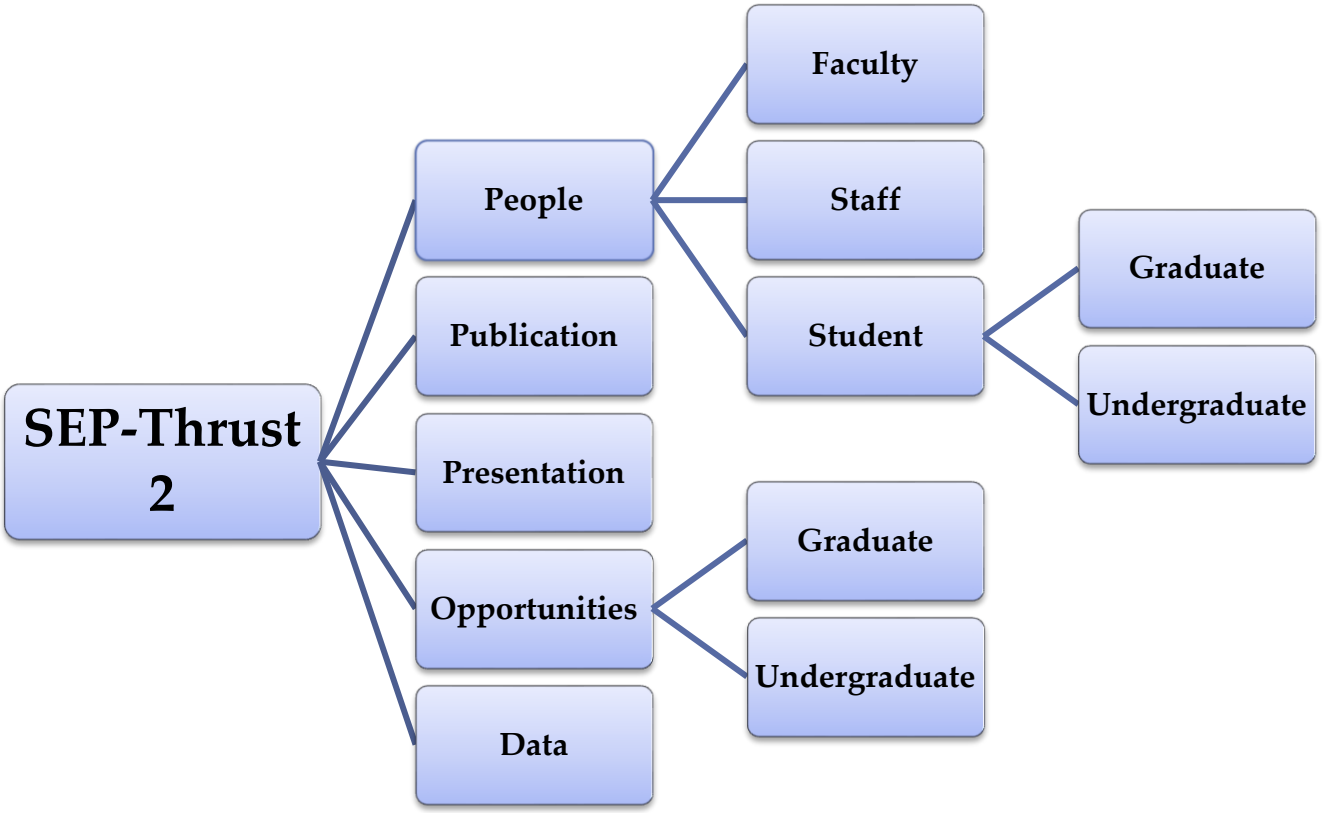
USGS Minerals Yearbook and Mineral Commodity Summaries

Literature review of previous analyses

Literature review of previous analyses

Bloomberg System - Current and historic mineral pricing

Project Webpage Structure



TAKE THE NEXT STEP

Manufacturing Process

- Mining
- Smelting
- Refining
- Secondary Consumption (recycling)
- Transportation

Material Acquisition

- Ecological Impacts
- Economic Impacts
- Social Impacts
- Reserves
- Individual production rates
- Ore grade (historic trends)

Cell Components

- Analysis of components