# Pursuing a Silver Standard for Sustainability

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**Author's Note:** This case was inspired by the various factual bits I collected about silver while working on my doctoral research. They had no place in the research I was conducting but nonetheless provided occasionally fascinating diversions from it. This case study is therefore a first attempt to connect these pieces in a useful way and probably represents a beginning rather than an ending. I would be grateful for any feedback on the content of the narrative and how the case study works as a whole as a teaching tool. Please email megwagn@umich.edu with any comments or suggestions.

**Summary:** Silver is an extracted natural resource and one of a handful of elements known since antiquity. Since approximately 3000 BC, silver has been mined, refined, and crafted into a variety of products spanning jewelry to lead-free solder. This history provides a wealth of information about the socio-environmental drivers surrounding silver extraction, as well as the costs of extraction, that provide a jumping-off point for explicitly considering biogeochemical cycles and anthropic perturbations to them. Implicitly, understanding elemental biogeochemical cycling is suggested to point the way toward more sustainable use of natural resources.

This case study offers a brief overview of silver from ancient times to the present, through the lens of silver products. Students will explore silver biogeochemical cycling using an Insight Maker model, and then reach beyond the provided model to evaluate socio-environmental perturbations to the natural cycle. The exercise concludes by challenging students to propose their own solutions for making silver consumption and use more sustainable.

This case study may be appropriate for courses involving the geosciences, especially economic geology; life cycle analysis; environmental history; waste management; and systems thinking and systems modelling. It is intended for an advanced undergraduate or graduate level course, but could potentially be used in a lower-level undergraduate course with appropriate modification of the learning activity.



**Learning Goals:**

This case study asks students to think deeply about natural resource extraction and subsequent resource use in our everyday lives. It introduces the concept of biogeochemical cycles, which inherently intersect with several socio-environmental synthesis goals:

1. Describe systems: components, flows, and feedbacks
2. Recognize role of scale across space and time

3. Develop data analysis and synthesis skills

The learning goals are directly addressed in the learning activity provided with the case. The narrative, however, provides background on historical silver use that should inform how students approach the learning activity.

**Learning Objectives:**
As a result of this activity, students should be able to:

1. Define biogeochemical cycling.
2. Identify the major reservoirs, flows, and feedbacks related to silver biogeochemical cycling.
3. Explain how social and economic factors contribute to trends in resource extraction.
4. Propose solutions for the long-term sustainability of natural resources such as silver.

**Introduction:** Silver is used as a proxy for other elements and natural resources in considering rates of extraction from the lithosphere, altered flows into and out of other reservoirs, and the consequences of altered biogeochemical cycling. Throughout silver's history, social and economic factors have determined how much silver is extracted at any one time, and in turn silver has brought both benefits and costs to human society. The case asks, "Is our history with silver indicative of our future with this natural resource? Can we continue the present relationship indefinitely, and if not, how must it change?" The full narrative can be found in the student handout. Students will explore silver cycling using an Insight Maker model, and using a jigsaw exercise, propose solutions for ensuring an adequate supply of resources into the future and managing our silver consumption.

This case is meant as an environmental history "puzzle". It aims to help students contemplate one of the questions posed by Kates et al. (2001): "How are long-term trends in environment and development, including consumption and population, reshaping nature-society interactions in ways relevant to sustainability?"

Before using this case, it may be appropriate to introduce students to the concept of biogeochemical cycling and to stock and flow diagrams (a form of concept map). Additionally, students should have a sense of scale, especially thinking about orders of magnitude. Insight Maker also has extensive documentation that may be helpful to instructors and to students.

**Classroom Management:**
This case has not yet been classroom tested so all times to complete activities are estimates.

Before class
Students should read the case study and complete the activity Parts 1-3 before coming to class.

Class period 1:

Divide students into groups of three (3). Allow about 30 minutes for students to discuss their work with each other regarding the model. Did they all agree on the answers? Did they all make the same choices? What were the results of their individual choices? At the end of 30 minutes, the students should turn in the answers to Parts I-III. The model is a bit complex and the idea of biogeochemical cycling and/or modelling may be new to some students. The intention of having students discuss their answers with one another after trying it out themselves is to have them help and learn from each other. The instructor may want to circulate among groups during this time to answer questions.

The same group of three should work together to propose a solution for using silver sustainably. For a standard 50-minute class period, the students may use the remaining 20 minutes of class time to begin work on their presentation which forms Part IV of the activity.

Class period 2:

Students present their solutions in the form of a ten-minute presentation from each group. The presentations could take many forms, with a PowerPoint talk being probably the lowest hanging fruit. However, presentations could take other forms, such as a blog, a video, or a piece of art. Regardless of the presentation mode, instructors may use the provided rubric for assessment.

**Assessment:**

Activity Parts 1 and 2

This section has more absolute right and wrong answers, which are provided in the answer key. The instructor should mark these as appropriate, and he/she may want to assign points to individual questions. Given that grading scales and point allocation schemes vary from class to class, suggested point values have not been made. This assessment addresses learning objectives 2 and 3. Whether students are able to adequately define biogeochemical cycling (learning objective 1) is not explicitly addressed, as knowledge recall demands lower cognitive effort. Whether students can define biogeochemical cycling could be assessed on an exam, or in observation by the instructor during interactions with students.

Activity Part 3

The following rubric is suggested for assessing the narrative:

| | 3<br>Excellent | 2<br>Satisfactory | 1<br>Poor | 0<br>No attempt or missing |
|---|---|---|---|---|
| Identifies all relevant reservoirs, flows, and feedbacks | | | | |
| Consistent with the model | | | | |
| Well written and clear | | | | |
| Describes interaction of natural and anthropic components in a bi-directional way | | | | |

This assessment addresses learning objectives 2 and 3.

Activity Part 4

The following rubric is suggested for assessing the presentation:

| | 3<br>Excellent | 2<br>Satisfactory | 1<br>Poor | 0<br>No attempt or missing |
|---|---|---|---|---|
| Articulates a clear solution | | | | |
| Includes social, economic, and environmental pros and cons or considerations | | | | |
| Justifies why this solution is a good idea with a well-reasoned argument | | | | |
| Presentation is neat, well organized, and professional | | | | |

This assessment addresses learning objective 4.

**Suggested Modifications:** A class discussion about the case study might be appropriate before diving into the learning activity. Suggested questions for discussion are left for future revisions to this case study. However, a number of avenues for discussion arise from the case, and instructors should feel free to create discussion questions appropriate for their course.

The silver cycle model is already built in Insight Maker (Fortmann-Roe, 2014). However, if an instructor has more time or more advanced (graduate) students, the instructor could consider assigning the students to build the model themselves. Conversely, the social and economic factors that one might consider to impact silver biogeochemical cycling are not currently built into the model. To save time or to adapt the exercise for more junior students, an instructor could add these factors into the model. An instructor or students could also consider constructing and exploring a model for a different element: carbon, nitrogen, iron, etc.

Other ideas include:

- Asking students to envision a future for silver, in much the way the Radical Ocean Futures project has done for oceans. The product could easily be a story, a blog, a cartoon, a podcast, a video, or some other creative output.
- A field trip to a mine or wastewater treatment plant.
- Asking students to take an inventory of items they own containing silver and reflect on their own resource use.

**References/Background:** The references included in the student handout should be sufficient. Additional resources describing biogeochemical cycling are easily found on the web, including this one from the National Climate Assessment: https://nca2014.globalchange.gov/report/sectors/biogeochemical-cycles. Biogeochemical cycle models are fundamentally stock and flow diagrams. SESYNC has a helpful primer at https://www.sesync.org/system/tdf/resources/tutorial_2_systems_perspectives_and_dynamics.pdf?file=1&type=node&id=968&force.

**Answer Key:** The answer key is available as a separate document.

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**References Cited in this Teaching Guide:**

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