Appendix A: Connections

Overview
Many connections exist among the tools and lessons in the book and a multitude of educational standards at national, state, and local levels. Some national standards include:

- Next Generation Science Standards (NGSS) were created through the collaboration of multiple national organizations and 26 lead states in the US.
- Common Core State Standards were created through a state-led initiative in the US to establish a set of standards for English language arts and mathematics. Even though they are no longer in use in all states, they include important educational concepts. To see how they connect with systems education, visit the CLE website at http://www.clexchange.org/curriculum/standards/commoncore.asp
- STEM Education is an initiative to encourage a focus on science, technology, engineering, and math in K-12 education. To see how STEM learning goals connect with systems education, visit the CLE website at http://www.clexchange.org/curriculum/standards/stem.asp

Specific examples that follow show only connections between the lessons in the book and NGSS. Standards for middle and high school are included, since they are the intended audience for the lessons. That said, teachers may find ways to adapt the lessons for younger audiences if desired. In addition, the content within the book is highly interconnected and included examples may apply across multiple chapters and lessons. As always, teachers will know best the standards that apply for their own situation.

Connections between Systems Thinking Tools and Crosscutting Concepts (NGSS)

<table>
<thead>
<tr>
<th>Systems Tools</th>
<th>Crosscutting Concepts</th>
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| ![Pattern](image) | 1. Patterns.  
2. Cause and effect: Mechanism and explanation.  
3. Scale, proportion, and quantity. |
| ![Causality](image) | 2. Cause and effect: Mechanism and explanation.  
3. Scale, proportion, and quantity.  
7. Stability and change. |
| ![Stability](image) | 2. Cause and effect: Mechanism and explanation.  
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7. Stability and change. |
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Connections to the “Earth Space Science Progression” (NGSS)
The following tables show an overview of the book – chapters, lessons, systems tools, systems thinking skills, and example connections to NGSS.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Systems Tool(s)</th>
<th>Skill(s)</th>
<th>NGSS Connections</th>
</tr>
</thead>
</table>
| 1.1 Sustainable Living in Cities                 |                 |          | **ESS1.C The history of planet Earth**  
Grades 6-8  
“Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth's history.”  
Grades 9-12  
“The rock record resulting from tectonic and other geoscience processes as well as objects from the solar system can provide evidence of Earth's early history and the relative ages of major geologic formations.” |
| 1.2 Transportation                                |                 |          |                                                                                                                                                |
| 1.3 Electrical Energy                             |                 |          | **ESS3.C Human impacts on Earth systems**  
Grades 6-8  
“Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things. Activities and technologies can be engineered to reduce people's impacts on Earth.”  
Grades 9-12  
“Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies.” |
<p>| 1.4 Recycling                                     |                 |          |                                                                                                                                                |
| 1.5 Environmental History                         |                 |          |                                                                                                                                                |
| 1.6 Modeling Population                           |                 |          |                                                                                                                                                |</p>
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<tr>
<td>2.1 A Parable of Environmental Disaster</td>
<td><img src="image1" alt="Diagram" /></td>
<td>Dynamic, Closed Loop, Empathic</td>
<td><strong>ESS2.A Earth materials and systems</strong>&lt;br&gt;Grades 6-8&lt;br&gt;Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources. Plate tectonics is one result of these processes. Grades 9-12&lt;br&gt;Feedback effects exist within and among Earth's systems.</td>
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<tr>
<td>2.2 Tragedy of the Commons and Other Archetypes</td>
<td><img src="image2" alt="Diagram" /></td>
<td>Closed Loop, Empathic, Generic</td>
<td><strong>ESS3.A Natural resources</strong>&lt;br&gt;Grades 6-8&lt;br&gt;Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes. Grades 9-12&lt;br&gt;Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.</td>
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<tr>
<td>2.3 Protecting the Land During the Anthropocene Epoch</td>
<td><img src="image3" alt="Diagram" /></td>
<td>Forest, Dynamic, System-as-Cause</td>
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<tr>
<td>2.4 Cities and Urban Planning</td>
<td><img src="image4" alt="Diagram" /></td>
<td>Closed Loop, Generic</td>
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<tr>
<td>2.5 Studying Rapa Nui</td>
<td><img src="image5" alt="Diagram" /></td>
<td>Dynamic, System-as-Cause, Operational</td>
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<tr>
<td>3.1 Protecting the Atmosphere</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="System-as-Cause" /> <img src="image" alt="Closed Loop" /> <img src="image" alt="Generic" /></td>
<td><strong>ESS2.D Weather and climate</strong> Grades 6-8 Complex interactions determine local weather patterns and influence climate, including the role of the ocean. Grades 9-12 The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.</td>
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<tr>
<td>3.2 Climate Change</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="System-as-Cause" /> <img src="image" alt="Closed Loop" /> <img src="image" alt="Empathic" /></td>
<td><strong>ESS3.D Global climate change</strong> Grades 6-8 “Human activities affect global warming. Decisions to reduce the impact of global warming depend on understanding climate science, engineering capabilities, and social dynamics.” Grades 9-12 “Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are ongoing and continually needed.”</td>
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<td>3.3 Bathtub Thinking</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="System-as-Cause" /> <img src="image" alt="Operational" /> <img src="image" alt="Scientific" /></td>
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<td>3.4 The Carbon Cycle</td>
<td><img src="image" alt="Diagram" /></td>
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<td>3.5 Greenhouse Effect</td>
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<td>3.6 Global Warming</td>
<td><img src="image" alt="Diagram" /></td>
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<td>3.7 Examining Climate Models</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="System-as-Cause" /> <img src="image" alt="Scientific" /></td>
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<td><strong>4.1 Protecting Water</strong></td>
<td><img src="image1" alt="System Diagram" /></td>
<td></td>
<td><strong>ESS2.C</strong>&lt;br&gt;The roles of water in Earth’s surface processes&lt;br&gt;Grades 6-8&lt;br&gt;Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing landscape features. Grades 9-12&lt;br&gt;The planet’s dynamics are greatly influenced by water’s unique chemical and physical properties.</td>
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<td><strong>4.2 Mosquito Nets and Overfishing</strong></td>
<td><img src="image2" alt="System Diagram" /></td>
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<td><strong>4.3 Sea Level Change</strong></td>
<td><img src="image3" alt="System Diagram" /></td>
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<td><strong>4.4 Altering the Ocean</strong></td>
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<td><strong>4.5 Running a Fishing Company</strong></td>
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