Systems Processes Theory (SPT) and Sustainability:
II. Application of Flow Processes to Carbon Storage in Urban Forestry

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Systems Science and Sustainability

• Certain patterns of relationship and information, energy and material flow exist in all living systems: in plants, animals, ecosystems, social groupings, communities, and organizations.

• In this poster material and energy flows will be represented through the carbon cycle in the comparison of the urban and forested environments.

• Definitions will be presented and trends in the literature since 1980 will be summarized. Principle identifying features and functions will be displayed. Odum diagrams of the flows processes will be presented. Finally, the carbon cycle in relation to urban and forested settings will be studied with the hope that solutions will arise from new understandings of flows in the human environment.

Definitions and Principals:

• Flows are pushed by forces.

• Flows delivered from storage are in proportion to the driving force, which is in proportion to the stored quantity.

• Some external energy sources are said to be *flow limited* because it is their flow that is externally controlled rather than their driving force.

• A system using a *flow-controlled energy source* can draw from the source only the flow that is incoming and no more.

• Any storage of matter, fuel, or information is also a concentration of energy which tends to disperse or diffuse through flows.

Types of flows:

A. Linear pathway with force from the left

B. Linear pathway with available energy losses

C. Linear pathway with energy transformation

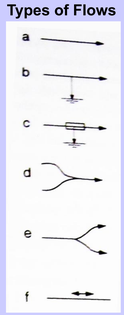
D. Two flows of the same kind joining together

E. Split of one flow into two of the same kind

F. Reversible pathway with force at both ends

*Thin lines are energy flows. Thick lines represent material flows.

Types of Flows



Application Domain

Urban forestry has commonly been proposed as a practical solution to climate change and the increasing rates of atmospheric carbon. However, estimates of sequestration rates by vegetation species and by growing conditions are often projected based on estimated root structures, age of the tree and other factors. My thesis project attempts to measure the actual rates of sequestration in a collection of trees, which will help substantiate projected data and offer a better understanding between sequestration rates and the amount of water required. Ultimately, by utilizing trees with high sequestration rates in urban areas with high concentrations of carbon dioxide (mostly caused by burning fossil fuels and other human activities) my research will contribute to a better balance in the carbon cycle in the urban setting.

This project is regenerative in that it considers plant material a crucial storage device for carbon dioxide and proposes a natural solution to the chronic urban problem of air pollution. The project also considers the holistic loop of the system between human activity, air quality, and vegetation and attempts to approach the problem regeneratively with a long term storage plan instead of finding a short term solutions.

Example of a typical Carbon Cycle in an urban setting, which includes biomass fuels an additional source of CO2.

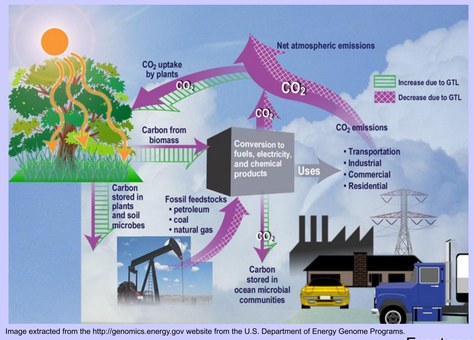


Image extracted from the http://genomics.energy.gov website from the U.S. Department of Energy Genome Programs.

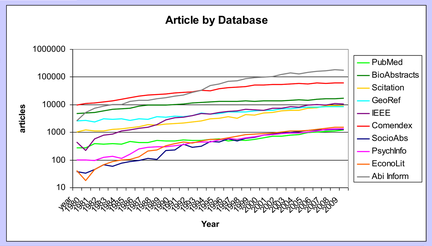
Selection of Systems Process

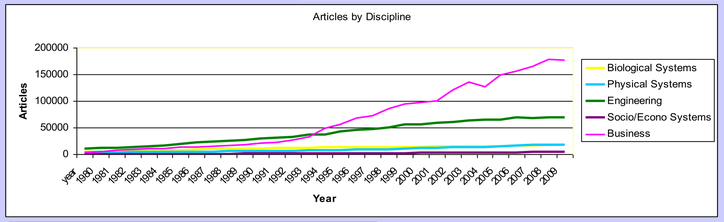
All living systems respond to change. Most plant communities are adaptable and survive within constantly changing environmental conditions, and with the constant flow through them of energy, substances, materials and information. This in-and-out flow would result in the immediate collapse of a system if it could not maintain its structure, but living systems maintain their form in a kind of fluctuating balance. Plants, like all living creatures, take in nourishment in some form and manage to carry out the necessary responses to receive that nourishment, such as absorbing sunlight (photosynthesis). The flow process is crucial for the life cycle of all plants.

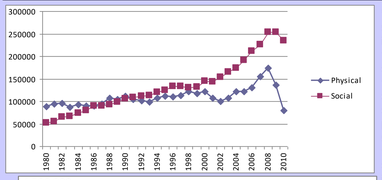
The flow between humans and plants is also important; specifically, the air exchange between the two and the actions that can be summarized in the depiction of the carbon cycle. The systems theory concept of material and energy flows is linked closely with urban forestry and carbon sequestration research.

Literature Search on “Flows”

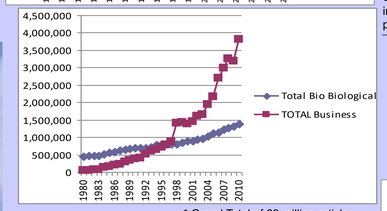
Use of terms: “Flows” searched in full citation. Notice the dramatic upsurge in articles that include “flows” in the business database over the last 15 years. The term is most likely due to cash flows and other monetary flows. Caveats for the baseline graph due to same journals: redundancies in disciplinary domain; total number of articles in database (did not restrict to only scholarly or peer reviewed journals which would result in half the articles; slightly different numbers each day. Caveats for Systems Processes searches: major effect of keyword used.





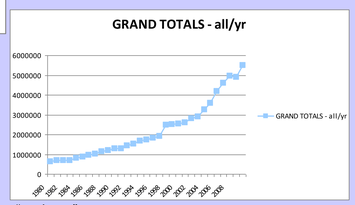


* Restricted to two of the smallest article activity domains i.e. "physical systems" and "social systems" to better allow discrimination of trends in smaller domains.
* Ignore drop off shown for most recent two years; anomaly of databases.
* Note that physical sciences only represented by geology pending obtaining data on total articles in chemistry, astronomy, and physics databases which may account for virtual flatline growth of total lit. in physical sciences until mid-current-decade; any jumps in target lit. searches show significant increases in interest in key systems process.
* Note gradual and steady increase in lit. of social science domain especially pronounced since 2000; any jumps in target lit. searches indicates distinction from baseline showing greater interest in systems processes that was subject of search.



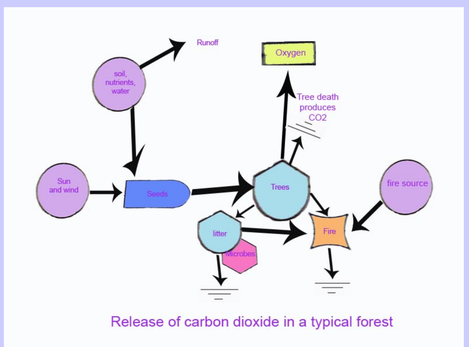
* Restricted to two largest domains i.e. "living systems" and "business/industry" to better allow discrimination of trends in smaller domains (note high numbers on X axis).
•Note gradual and steady increase in lit. of bio. domain; any jumps in target lit. searches indicates distinction from baseline.
* Exponential increase in "business domain" after about 2002.

* Grand Total of 68 million articles were searched across eleven key databases.
* Average per year searches ranged from about 1 to 6 million per year.
* Trends across the totals show arithmetic increases up to roughly 2002 and then an exponential increase pattern.

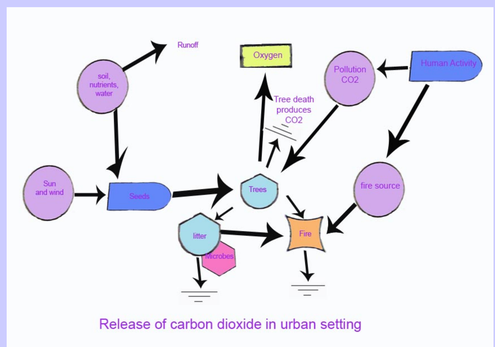


• Exact search term: “flows” not restricted by "scholarly journals" or “reviews”
• The total articles for “flows” from 1980-2010 across all databases was 5,910,248
• There was a distinct drop in articles on “flows” in 1981 in economics and engineering and a distinct rise in 1991 in sociology
• There were significantly lower results when “flows” was searched in combination with "sustainability," total articles from all databases: 7,836.
• Searches with “flows,” “sustainability,” and “review” resulted in only 124 articles.

Systems Diagram of Application Domain



Release of carbon dioxide in a typical forest



Release of carbon dioxide in urban setting

SPT & Systems Pathology Collaborative

•The *International Council on Systems Engineering* and the *International Society for the Systems Science* agreed to cooperate in exploring and developing systems science as an informational base for engineering and systems science. Representatives from both organizations have met in Canada, Arizona, and England to plan these joint efforts.
• *The Systems Science Working Group* has identified five official projects, two of which will focus on Systems Processes Theory and Systems Pathology, which are also goals of the ISSS.
• This poster is an example of the joint Systems Processes Theory project to enable several graduate students in systems science, systems engineering, or other related new fields to share their literature reviews on the large number of systems processes.
• By working together on search and analysis of the literature and especially by integrating, preserving, and displaying their individual products, all thesis students benefit as do the practicing fields of systems engineering, regenerative studies and etc.

Twelve Info. Categories on “Flows”: Exemplar Info Bits

1. Identifying Features: a system that maintains a structure, despite constant in -and –out flow of material, energy, and information.
2. Identifying Functions: a function of flows is to transport materials and energy into and out of an organism or a system to perpetuate life.
3. Examples and Exemplars: in a forest, soil organisms can only use the litter fall controlled by processes beyond their control, the tree shedding leaves, an example of limited flow on the forest floor.
4. Current Consensus Knowledge: all living systems must utilize flows in order to adapt and survive.
5. Literature Database: varied.
6. Linkage Propositions: flows are closely linked to other system theory processes including, networks, storage, and cycles.
7. Role in Systems Pathology: unknown.
8. Formal Development: In a secure system, information flows can be explored in formal development if the interactions at the first users’ interface are able to affect interactions at the second users’ interface.
9. Types and Taxonomies: there are many different types of flows, described previously.
10. Research Workers and Institutions: ISSS, INCOSE, IASS, and others
11. Discinyms and Transdisciplinary Tests: flows seem to be most important to the following disciplines: engineering, business, and physical sciences.
12. Future Questions: how will flows play a bigger role in future studies? How can studying flow processes guide the field sustainability?

Conclusion

Important Citations for studying “Flows”:

Books-
1. Fredrik Ullén et al., “The physiology of effortless attention: Correlates of state flow and flow proneness.” in Effortless attention: A new perspective in the cognitive science of attention and action., ed. Brian Bruya (Cambridge, MA US: MIT Press, 2010), 205-217.
2. Parker, D.F. (2003). "Fields, Flows and Waves: An Introduction to Continuum Models (Book)." Choice: Current Reviews for Academic Libraries 41(4): 745. Reviews the book "Fields, Flows and Waves: An Introduction to Continuum Models.”
3. Howard T. Odum, Systems Ecology: An Introduction, Wiley-Interscience, 1983.
4. Howard T. Odum, Ecological and General Systems: An Introduction to Systems Ecology. University Press of Colorado, Niwot, CO, 1994.

Journal Articles-
1. Haifeng Ji et al., “Flow Pattern Identification Based on EMD and LS-SVM for Gas–Liquid Two-Phase Flow in a Minichannel.,” IEEE Transactions on Instrumentation & Measurement 60, no. 5 (April 15, 2011): 1917-1924.
2. M. Tsuru, T. Takine, and Y. Oie, “Inferring arrival rate statistics of individual flows from aggregated-flow rate measurements,” in Applications and the Internet, 2003. Proceedings. 2003 Symposium on, 2003, 257-266.
3. Michael T. Todinov, “Analysis and Optimization of Repairable Flow Networks With Complex Topology.,” IEEE Transactions on Reliability 60, no. 1 (March 3, 2011): 111-124.
4. Sungwon Yi et al., “HaTCh: a two-level caching scheme for estimating the number of active flows,” in Decision and Control, 2003. Proceedings. 42nd IEEE Conference on, vol. 3, 2003, 2829-2834 Vol.3.

Finding databases specifically on flow processes, or even specifically on systems theory processes was difficult. We resorted to searching databases of traditional, academic disciplines. It was also difficult to find the right search terms for the desired result. “Flows” could apply to many general topics, but ultimately was specific enough to find sufficient data.

The global carbon cycle constitutes most of all life, is a main component for the fossil fuels, and is being changed by human activity, which makes it the ideal system to represent the flow processes of carbon in the urban and forested environments. As the Odum diagrams to the left show, the trees in the forested setting are able to store more carbon compared to the urban setting. Not only are there far less trees available in the urban setting, but human activity produces more carbon dioxide by burning fossil fuels. Even in an urban forestry setting, the proportion of forested area to surrounding development is not enough to control atmospheric levels of carbon.

After completing my thesis and obtaining actual data of sequestration rates in certain tree species, a more detailed Odum diagram with real amounts of carbon, oxygen and inputs such as water and sunlight can be represented. Ultimately, the systems theory concept of material and energy flows is linked closely with urban forestry and carbon sequestration and will help with future research.