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an analytical approach

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Ecosystem Services Partnership Conference
Portland, Oregon, US – July 31 to August 4, 2012

Solving the Sustainability Problem with Root Cause Analysis

There are a thousand hacking at the branches of evil to one who is striking at the root.
Henry David Thoreau, *Walden*, 1854

Abstract

Countless solutions to the environmental sustainability problem have been tried over the last forty years. While there have been some small successes, the overall problem remains unsolved. The global ecological footprint is at 50% overshoot and rising, with no credible solution in sight. Why is this?

Because popular solutions do not resolve root causes. Root cause analysis has worked spectacularly well for business problems. So why can't it work for large-scale social system problems like sustainability?

All problems arise from their root causes. For example, consider the autocratic ruler problem. The root cause of despicable autocratic rulers like kings, warlords, and dictators was that there was no easy way for an oppressed population to replace a bad ruler with a good one. Democracy resolved the root cause with addition of the voter feedback loop. If you've spent decades trying to solve a problem and have failed, then the only possible reason is failure to resolve root causes.

This paper presents the results of a seven year root cause analysis of the complete sustainability problem. The paper thus contains a huge amount of novel information, much more than is normally in one paper.

A formal problem solving process was developed specifically for this type of problem. Process execution identified four main subproblems. For each subproblem the analysis found a main root cause, a high leverage point for resolving the root cause, and one or more solution elements for pushing on the high leverage point. The key solution element is Common Property Rights, a comprehensive approach to sustainable management of ecosystem services in a generic, efficient, self-replicating manner. Common Property Rights are the mirror image of Private Property Rights, so they promise to be just as generic, efficient, and self-replicating.

The Solvability Hypothesis

The book *Beyond Reason: Eight Great Problems that Reveal the Limits of Science* (Dewdney, 2004) argues there are natural barriers beyond which "reason cannot go." There are some problems that are simply not solvable. The book presents eight such problems, including squaring the circle and perpetual motion machines. These were long thought solvable. But as science matured they were proven to be insolvable, due to application of reason and the iron laws of science.

Does environmental sustainability fall into the class of problems that are inherently insolvable? Have environmentalists, like the many scientists that worked for centuries on the Eight Great Problems, been fooling themselves? Is the sustainability problem actually the Ninth Great Problem that is impossible to solve? If so,

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that would explain why millions of dedicated activists, scholars, NGOs, and agencies have been totally stymied for over forty years.

This paper proposes the hypothesis that **the environmental sustainability problem is solvable because root cause analysis has never been properly applied.** Analysis shows the reason popular solutions have failed is they do not resolve root causes. Accordingly, this paper presents an example of how root cause analysis can be applied.

In the analysis method presented in this paper, a solution element "pushes" on a high leverage point to resolve a specific root cause. The analysis identified four root causes whose high leverage points have never been pushed on in a concentrated, prolonged, correctly sequenced manner. It appears that doing so will resolve the root causes of the sustainability problem. After that the system will shift into an entirely new mode, one that is inherently sustainable.

Line of Analytical Attack

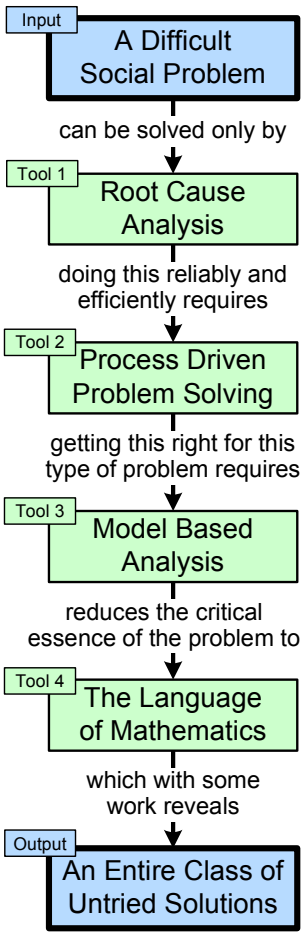
Figure 1 explains the line of attack used to arrive at the above hypothesis. Let's walk the diagram.

A Difficult Social Problem

There is a class of social problems so difficult they defy all attempts to solve them for generations. Past members of this class include the Malthusian Trap problem (temporarily solved by the Industrial Revolution, as described so well in Clark, 2007), the authoritarian ruler problem (solved by invention of democracy), slavery, civil rights, and the universal suffrage problem. Present members include environmental sustainability, endemic corruption, the recurring wars problem, the recurring large recessions problem, the institutional poverty problem, and the failed state problem.

What makes difficult social problems so difficult is the presence of systemic root causes. For social problems, **systemic** means originating from the structure of the system in such a manner as to affect the behavior of most or all social agents of certain types, as opposed to originating from individual agents (Harich, 2010, p39). Systemic root causes, because their causal chains run throughout a complex social system, are notoriously hard to identify. Thus a difficult social problem can be solved only by:

Fig. 1 **Line of Analytical Attack**



Root Cause Analysis

The most fundamental law of all of science is the **Law of Cause and Effect**: *Every effect has a cause.* A corollary is the **Law of Root Causes**: *All problems arise from their root causes.* Therefore the only way to solve a problem is to resolve its root causes. If you're not working on systematically finding and resolving root causes you're not working scientifically. You're working intuitively and, if it's a difficult problem, in vain.

The Law of Root Causes applies to the sustainability problem. Popular solutions fail because they do not resolve root causes.

The business world perfected root cause analysis long ago. It has become standardized into forms like Six Sigma, the Five Whys of Kaizen, and replicable institutional forms like the Toyota Production System:

"Culture is the catchall phrase for an amalgam of organizational values, beliefs, and norms. It rests upon, is shaped by, and draws its power from underlying systems and structures. While it is most certainly a contributing source, it is not the root cause of the problem. Since culture is closer to the surface of the issues, explicit, and thus more readily observed, it naturally and understandably becomes the target of attention.

"But as Toyota Production System engineer Taiichi Ohno always counseled: 'Address root cause rather than source. Root cause is hidden beyond the source.' That is to say, if you want to change the culture, start by examining the power base on which it rests." (May, 2007, p56. Here source means the intermediate causes. "Examining the power base" will lead to the root causes.)

If root cause analysis can work for business it can work for activism.

The goal of root cause analysis is to *strike at the root* of a problem by finding and resolving its root causes. "As the name implies, the **root cause** is that most basic reason a problem has (or could) occur. The term **'root cause analysis'** encompasses a variety of techniques, both informal and structured, that may be used to determine these causes." (Wilson et al, 1993, p3)

How are we going to apply root cause analysis to this type of problem? That's so difficult that doing it reliably and efficiently requires:

Process Driven Problem Solving

A **process** is a reusable series of steps to achieve a goal. **Process driven problem solving** is the use of a formal process as your central approach to solving problems. The key advantages are:

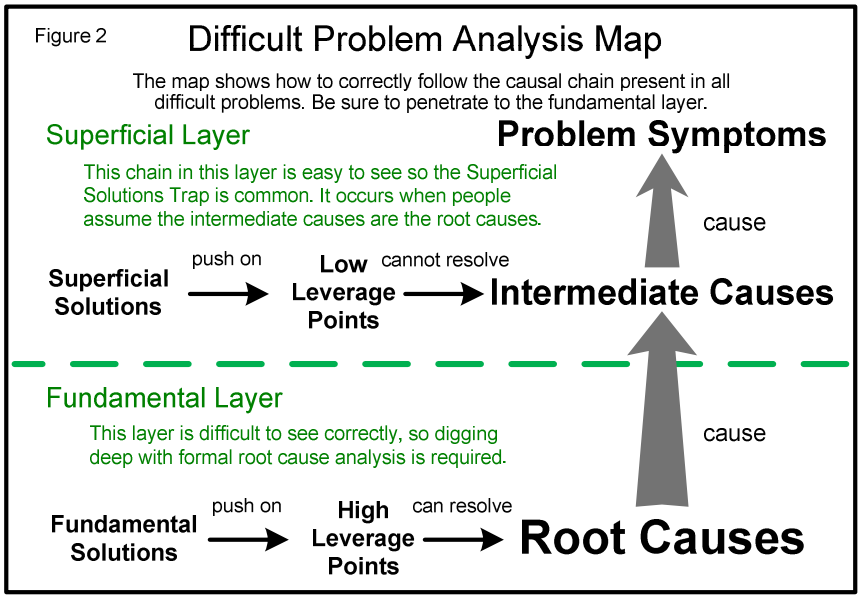
1. *A formal process can be much more easily learned and executed than an informal one.* This makes the approach replicable and scalable to large teams.
2. *Since the process is formally defined it can be continuously improved.* Over time such a process can evolve to become your most important asset, as it is for many companies like Toyota, Intel, and Exxon, and for all of science via the Scientific Method.

Whatever process is used, it must be a wrapper for root cause analysis. Driving your process should be the conceptual structure shown in Figure 2. To solve a problem start at problem symptoms. Using the Law of Cause and Effect, follow the causal chain down to the intermediate causes and then to the root causes. For difficult problems this takes time. *In general, difficult problems are difficult because their fundamental layer is so incredibly hard to conceptualize.* This can cause the analyst to bog down at the superficial layer without realizing it. The map provides a standard conceptual framework designed to overcome this common trap.

Using this framework, the analyst constructs a simulation model of the causal chain leading from root causes to problem symptoms. Careful inspection, simulation, and evolution of the model then reveals the high leverage points that most advantageously affect system behavior. "Pushing" on these points with fundamental solutions will resolve root causes. The chain running from fundamental solutions to problem symptoms is the "solution causal chain."

A high leverage point is a high level solution strategy. High leverage points correspond to the hypothesis phase of the scientific method. The hypothesis is experimentally tested and improved in three main ways: simulation runs with different parameters and model construction, laboratory experiments with groups of people, and small-scale pilot programs. Iterative testing continues until the solution hypothesis works in all three ways. This insures that theory (the model) agrees with practice (the experimental solutions). Once the two are sufficiently close, analysis/solution convergence ends and implementation begins.

If the analysis is correct, then once the solutions are implemented the undesirable forces emanating from the root causes will be greatly reduced or gone, causing the system to undergo a radical mode change. In the new mode the problem is inherently, efficiently, and permanently solved because we have struck at the root.



On Figure 2 we see that superficial solutions apply pressure to low leverage points to resolve intermediate causes. This can work for easy problems if the pressure can be sustained. But it cannot work for difficult problems because the force superficial solutions exert on intermediate causes is far less than the force exerted by the root causes.

Superficial solutions are attractive because they are so much easier to see and make so much common sense. This

causes the **Superficial Solutions Trap**. This trap has snared the entire environmental movement for the last forty years. *The movement is stuck on the superficial layer because it has no conception of the deeper layer below*. That causes it to assume the intermediate causes are the root causes. This guarantees solution failure.

For example, the underlying cause of environmental unsustainability is widely seen to be externalized costs: "In common with many other environmental problems, human-induced climate change *is at its most basic level an externality*. Those who produce greenhouse-gas emissions are bringing about climate change, thereby imposing costs on the world and future generations, but they do not face directly, neither via markets nor in other ways, the full consequences of the cost of their actions." (Stern, 2007, p27, italics added)

This conclusion led to solutions like regulations and market-based instruments. But these are superficial solutions because externalized costs are an intermediate cause. This is why popular solutions have failed to solve the problem. Problem solvers must instead dig deeper and ask WHY do we see so many externalized costs? Is there a deeper cause that may be the root cause? It turns out there is. It's high transaction costs for managing common property sustainably, as explained later.

The reason environmentalism is stuck on the superficial layer is the field has no standard formal process centered on root cause analysis. This has resulted in widespread disagreement on problem definition, what the real causes are, and what the solutions should be: "By the mid-1990s, there were well over 100 definitions of sustainability. This definitional chaos has nearly rendered the term sustainability meaningless and is distracting from the need to address ongoing environmental degradation." (Marshall and Toffel, 2005) "Put ten environmentalists in a room and you'll get ten different opinions on the topic of your choice.... These differences are often quite pronounced.... (Thiele, 1999, pxxi, quoting Carl Pope)

To fill this void and serve as a starting example, Thwink.org has developed the **System Improvement Process** (SIP). SIP is a wrapper for root cause analysis for difficult complex system social problems. SIP is not meant to be the only possible process, but an illustrative example of how the sustainability problem can be systematically analyzed and solved. Figure 3 summarizes how SIP works. (Harich, 2011, hereafter called the *Common Property Rights* book)

SIP is a flexible COMPLETE problem solving process with four main steps. In step one SIP defines the problem using a standard format. Step two is analysis. This first decomposes one big problem into the three subproblems present in all difficult large-scale social problems. That way you're no longer trying to solve multiple problems simultaneously without realizing it. This can transform a problem from seemingly insolvable to solvable. It's the old strategy of divide and conquer.

Now we can define what solving the COMPLETE problem means. For those working on the superficial layer, complete has come to mean all three pillars of sustainability: economic, environmental, and social. However this is not enough. From the viewpoint of the System Improvement Process, **COMPLETE** means all three subproblems are solved at the root cause level, instead of just proper coupling at the intermediate cause level, which is the only subproblem and the level conventional approaches address. These approaches are so incomplete solution failure is guaranteed. "To

Figure 3

The four main steps of SIP

The five substeps of system analysis

The three subproblems of the main problem

1. Problem Definition		**The System Improvement Process (SIP)**		
Subproblems		**A. Change Resistance**	**B. Proper Coupling**	**C. Model Drift**
2. Analysis	A	Find the immediate cause of the problem symptoms in terms of the system's dominant feedback loops.		
	B	Find the intermediate causes, low leverage points, and superficial (symptomatic) solutions.		
Spend about 80% of your time here. The problem solving battle is won or lost in this step, so take the time to get the analysis right.	C	Find the **root causes** of why the loops in A are dominant.		
	D	Find the feedback loops that should be dominant to resolve the root causes.		
	E	Find the **high leverage points** to make those loops go dominant.		
3. Solution Convergence				
4. Implementation				
Continuous Process Improvement – The foundation of the entire process				

date, however, virtually all efforts to produce sustainable development have been little more than Band-Aids." (Ehrenfeld, 2005, p23) Or as ISEE President John Gowdy (ISEE Conference, 2010, p4) lamented: "Presently, we are so far from 'sustainability' it is almost futile to talk about making the present system sustainable."

The three subproblems present in all difficult large-scale social problems are:

A. *How to overcome change resistance*. **Change resistance** is the tendency for something to resist change even when a surprisingly large amount of force is applied. Why is the human system so strongly resisting changing from an unsustainable to a sustainable mode of behavior?

B. *How to achieve proper coupling*. **Proper coupling** occurs when the behavior of one system affects the behavior of other systems properly, using the appropriate feedback loops, so the systems work together in harmony in accordance with design objectives. In the environmental sustainability problem the economic system is improperly coupled to the greater system it lives within, the environment.

C. *How to avoid excessive model drift*. Solution **model drift** occurs when a solution model gradually drifts away from its original ability to solve a problem, due to the problem changing, the solution being watered down, mismanaged, etc. If too much drift occurs the solution no longer works. The phenomenon is well known: "There is no automatic mechanism by which political systems adjust themselves to changing circumstances." This causes "political decay. [This leads to] failure to adjust, and thus the phenomenon of political decay." (Fukuyama, 2011, p9) Liberal democracy was invented to solve important common good problems and did well at first, but now cannot solve the sustainability problem.

Next the five substeps of analysis are applied to each subproblem to find its root causes and the high leverage points for resolving them. A **high leverage point** is a node on a feedback loop that, when its value is changed by application of a solution element, causes that feedback loop to change significantly in strength and resolve the root cause associated with that loop. Due to the amplification and goal seeking effects provided by a system's feedback loops, this can cause a tiny amount of force to change the fundamental behavior of the system with the problem. That's how systemic problems can be solved by activists, who by definition are a non-powerful minority and can exert only a small amount of force.

There's no standard definition of root cause so SIP provides one. A **root cause** is that portion of a system's structure that, using the checklist below, explains why the system's behavior produces the problem symptoms. The **Five Requirements of a Root Cause** are:

1. *It is clearly a (or the) major cause of the symptoms*.
2. *It has no worthwhile deeper cause*. This allows you to stop asking why at some appropriate point in root cause analysis. Otherwise you may find yourself digging to the other side of the planet.
3. *It can be resolved*. Sometimes it's useful to emphasize unchangeable root causes in your model for greater understanding and to avoid trying to resolve them without realizing it. These have only the first two requirements.
4. *Its resolution will not create other equal or bigger problems*. Side effects must be considered.
5. *There is no better root cause*. All alternatives have been considered.

This checklist allows numerous unproductive or pseudo root causes to be quickly eliminated. If analysis shows there are no root causes meeting these requirements, then what you have is not a real problem. Nor is it an unsolvable problem. It's the way things are. That's what Ernst Mach meant by: (Mach, 1898, p308)

> Every real problem can and will be solved in due course of time without supernatural divination [and] entirely by accurate observation and close, searching thought.

SIP provides a standard framework for the "accurate observation and close, searching thought" required to solve difficult problems like sustainability.

After analysis comes step three, solution convergence. Here solution elements are developed to push on the high leverage points. This requires experimentation and iterative analysis refinement.

Once the solution elements can be experimentally proven to work, implementation (step four) begins.

This is done by scaling up the experiments used to produce the solution elements. This allows a seamless transition from solution convergence to implementation.

Systemic social problems require systemic solutions. These are so governance related and so critical to a society's well being that implementation is usually handed off to government via policy recommendations and expert assistance. Activists using SIP on the sustainability problem will spend little time in implementation, which will be a large difference from where they spend most of their time now.

What makes or breaks the entire problem solving effort is analysis, so you should spend about 80% of you time there. Get your analysis right and all remaining steps are relatively easy. However, on difficult problems the analysis step is typically so hard to do that getting it right requires:

Model Based Analysis

The need for model based analysis arises directly from:

> ...Von Neumann's suggestion that very complex behaviors may be explicable only by providing the algorithm that generates that behavior, that is, explanation by way of simulation. (Dawkins, 2008, p45, quoting Sydney Brenner)

Complex problems arise from complex causal chains. These require modeling to understand their fundamental layer correctly. **Model based analysis** occurs when, as an analysis proceeds, a model is constructed for the purpose of generating and representing the key analytical insights. The model drives the analysis and helps communicate the results.

An amazing transformation occurs once your model reaches a certain level of comprehensiveness: The model, and not your intuition, starts generating new ideas in the form of intermediate causes, low leverage points, root causes, high leverage points, new subproblems, new types of social agents, additional feedback loops needed, and so on. Those who have never used model based analysis may have some trouble believing this is true until they've tried it.

Model based analysis is widely used on the sustainability problem. However, it's not used at the fundamental level. Nor is it used on the change resistance and model drift subproblems. Climate models, economic models like those in *The Stern Review* (Stern, 2007), pollution models, collective management models (such as in Ostrom, 2005), ecosystem services models, World3 of *The Limits to Growth*, and so on focus only on the superficial layer of the economic proper coupling problem. They attempt to better understand why the world's economic systems are so improperly coupled to the environment, as well as what the symptoms are in more detail.

Our task is to go much further. Entirely new models are needed to analyze the COMPLETE sustainability problem.

The five substeps of analysis in Figure 3 require modeling the feedback loop structure of the problem. Causal loop diagramming may be used. However, as soon as dynamic behavior becomes non-trivial simulation modeling is required so you can see how the model behaves, given different assumptions. Each different simulation run is an experiment. Model based analysis thus allows continuous application of the Scientific Method as your analysis proceeds. This transforms your analysis from one based largely on intuition to one based on systematic inspection of the system to rationally determine why it works the way it does.

The great benefit of model based analysis is it reduces the critical essence of the problem to:

The Language of Mathematics

Science also has its two layers: the soft and the hard sciences. These equate to the superficial and fundamental layers of the causal chains (Figure 2) that explain all phenomenon. The soft sciences, which today include sustainability, are stuck on the superficial layer due to lack of a sufficiently powerful model of explanation. This causes relatively poor problem solving ability. By contrast, the hard sciences work on the fundamental layer and routinely enjoy problem solving success because they're driven by a model of the problem expressed by the language of mathematics.

One by one, the hard sciences moved from soft to hard when they developed their foundational *quantified* models of explanation. For physics this required Newton's three laws of motion and the universal law of gravity. While chemistry made great progress due to Boyle's *The Skeptical Chymist* and Lavoisier's *Elements of Chemistry*, it required Dalton's atomic model and Mendeleev's Periodic Table to give the field its necessary *quantified* model of explanation.

What will it take for the young science of sustainability to move from soft to hard? Precisely the same thing: *a correct comprehensive quantified model of explanation* that's sufficient to move the field from Thomas Kuhn's pre-science or pre-paradigm stage (where it is now) to normal science (where it needs to be to begin solving its central problems). In normal science a field's practitioners base their work on a shared paradigm that works and is (mostly) accepted uncritically by the field.

Moving sustainability science from a soft to a hard science is well worth the struggle because now the language of mathematics can be applied to the COMPLETE sustainability problem. With some work the emergent result is:

An Entire Class of Untried Solutions

The preliminary analysis has uncovered a rather pleasant hypothesis: *There is an entire class of solutions that have never been tried*. These would push on high leverage points to resolve what appear to be the four main root causes of the sustainability problem. *Because these root causes have never been identified before in a comprehensive manner, resolving them has heretofore been impossible*. That may be about to change.

Below are the twelve sample solution elements from the *Common Property Rights* book. Solution elements push on a specific high leverage point (HLP) to resolve its related root cause. These pushes must be made in the right sequence or the system will successfully resist change. There is some overlap.

Push 1 – HLP is *correctness of goals for artificial life forms*.

1. Common Property Rights

Push 2 – HLP is *ability to detect political deception*.

2. Freedom from Falsehood
3. Truth Test
4. Politician Truth Ratings
5. Politician Corruption Ratings
6. No Competitive Servant Secrets
7. Sustainability Index
8. Corporation 2.0 Suffix
9. Servant Responsibility Ratings
10. Quality of Life Index

Push 3 – HLP is *correctness of goals for artificial life forms*.

11. Corporation 2.0

Push 4 – HLP is *maturity of decision making process*.

12. Politician Decision Ratings

It may come as a shock that the environmental sustainability problem can be solved by solutions that seemingly have nothing to do with sustainability, except for elements 1 and 7. Even those are nothing like the most popular classes of solutions proposed today: regulations and economic instruments. So how can the above twelve solutions possibly work?

They work by solving the Broken Political System Problem, as explained later. That's why the solution set is so vastly different. Once the Broken Political System Problem is solved its most dire symptom, the environmental sustainability problem, will no longer occur because the world's political systems (its governments) will no longer be broken. They will no longer be working for short term minded special interests. They will instead be working for what modern democracy was designed to work for: the long term common good.

All twelve solution elements have been proposed or even tried in some small way. However, none have ever been strongly implemented at the level of nations. None have been implemented with the single minded intent of resolving specific root causes.

For example, no nation has seriously proposed to reengineer the modern corporation from its present version, Corporation 1.0, into Corporation 2.0. The goal of that artificial life form would be to serve its master, *Homo sapiens*, in some beneficial way by providing a needed good or service. Gone would be the short term profit maximization goal, which is the current implicit goal of the human system. This would resolve the central root cause of the Broken Political System Problem.

The Corporation 2.0 solution element is so radically different it's never been tried. But once you see what the root causes of the problem are, it's the only obvious way forward. Some problems, once fully analyzed, have only one solution.

The same can be said of the other eleven elements. None have been seriously tried at the national or international level, because there is no shared vision of what the root causes are.

Let's see if it's possible to change that vision.

Summary of Analysis

What follows is an example of a fresh new paradigm that could work. It consists of a novel method of solving difficult large-scale complex system social problems. Table 1 summarizes the results of applying the key tool, SIP. Table cells correspond to steps in SIP. The process is essentially a fill-in-the-blanks framework. Key output is the two gray rows. For a full description see the *Common Property Rights* book.

The Search for the Fundamental Forces

Philosophically, solving the sustainability problem requires seeing it as yet another scientific problem that will eventually yield to solution as so many others have. It will yield for the same reason. *Once the problem's fundamental forces are well understood,* proper paths to solution will snap into clarity. HOW to solve the problem will become blindingly obvious, because now we understand WHY the system works the way it does.

Thus the history of solving the sustainability problem may be seen as a long search for the fundamental forces causing the problem. Find the forces, understand them deeply, and the problem is solved.

The search for the fundamental forces began in earnest in 1953 with publication of Eugene Odum's classic textbook, *Fundamentals of Ecology*. This systematically codified the fundamental principles of ecosystems for the first time. Odom concluded that:

> The idea of the ecosystem and the realization that mankind is a part of complex "biogeochemical" cycles with increasing power to modify the cycles are concepts basic to modern

Table 1 **Summary of Analysis Results of Executing SIP on the Global Environmental Sustainability Problem**

							Prob. Def.
1. Problem Definition			How to achieve global environmental sustainability in terms of the desired system goal state				
2. Analysis	Subproblems		**A. How to Overcome Change Resistance**	**B. How to Achieve Life Form Proper Coupling**	**C. How to Avoid Excessive Model Drift**	**D. How to Achieve Economic Proper Coupling**	Superficial Layer
	A. Find immediate cause loops	Subproblem symptoms	Successful opposition to passing proposed laws for solving the problem	Large for-profit corporations are destructively dominating political decision making	Failure to correct failing solutions when they first start failing	The economic system is causing unsustainable environmental impact	
		Improperly coupled systems	Not applicable	Corporate and human life forms	Not applicable	Economic and environmental systems	
		Analysis model	Basic Dueling Loops of the Political Powerplace	Complete Dueling Loops model. This adds the Alignment Growth loop.		The World's Property Management System	
		Immediate cause dominant loops	The Race to the Bottom among Politicians		Intelligent Adaptation loop in evolutionary algorithm model	Growth of Industrial Technology and Limits to Growth (the IPAT factors)	
	B. Find inter. causes, LLPs, SSs	Intermediate causes	The universal fallacious paradigm, primarily Growth Is Good	Pressure from corporate proxies for business friendly legislation	Laws giving corporations advantages over people	Externalized costs of environmental impact	
		Low leverage points	More of the truth: identify it, promote it, magnify it	Logical and emotional appeals and bargaining	Trying to directly reverse laws that favor corporations	Internalize costs	
		Superficial solutions	Technical research, environmental magazines and articles, awareness campaigns, sit-ins, marches, lawsuits, lobbying, etc.	Corporate social responsibility appeals, green investment funds, NGO/corporate alliances, etc.	Media use, campaigns, lobbying to get old laws repealed	Main solutions at system level: regulations and market-based, like pollution taxes and tradable permits. At agent level main solutions are 3 Rs and collective mgt.	
	C. Root cause of why loops in A are dominant		High political deception effectiveness	Mutually exclusive goals between top two social life forms, *Corporatis profitis & Homo sapiens*	Low quality of political decisions	High transaction costs for managing common property sustainably	Fundamental Layer
	D. Loops that should be dominant to resolve root cause		You Can't Fool All of the People All of the Time	Goal Alignment Growth		Growth of Sustainable Technology and Impact Reduction	
	E. High leverage point to make loops in D go dominant		General ability to detect political deception	Correctness of goals for artificial life forms	Maturity of the political decision making process	Allow firms to easily appear to lower transaction costs	
3. Solution Convergence			Nine solution elements	Corporation 2.0, *Corporatis publicus*	Politician Decision Ratings	Common Property Rights	
4. Implementation			Not yet ready for implementation because process execution is incomplete.				
Continuous Process Improvement – The foundation of the entire process							

> ecology and are also points of view of extreme importance in human welfare generally. Conservation of natural resources... must be built around these viewpoints. (Odum, 1953, p26)

In 1971, just as the environmental movement was picking up considerable steam from *Silent Spring* in 1962 and the first Earth Day in 1970, Georgescu-Roegen's *The Entropy Law and the Economic Process* appeared. Georgescu-Roegen argued the earth is a closed system, subject to the same second law of thermodynamics (total entropy in a closed system increases over time to its maximum value) as any other closed system. Over time the earth's entropy (disorder) will increase until no subsystem can extract energy from another subsystem, at which point (or long before) life in the total system will cease. While consideration of solar input changes the earth to an open system, the law of entropy still points toward the difficulty of a sustainable open system: "New technologies do not 'create' new resources, they simply allow us to degrade energy, material order, and biological richness more rapidly." (Costanza et al, 1997, p57) Thus the most fundamental force of the sustainability problem was thought to be entropy.

1971 also saw publication of Howard Odum's *Environment, Power, and Society*. In this work:

> "...he laid out a comprehensive integration of systems with energy flow being the integrating factor. He even developed his own symbolic language (similar in intent and use to Forrester's system dynamics symbols) to help describe and model the common features of systems." (Costanza et al, 1997, p60)

This gave sustainability science two fundamental forces, ecosystem cycles and energy flow, as well as an integrated system modeling perspective and the limits imposed by the law of entropy. But how close to the limits was the human system? What were the causal forces of growing environmental degradation?

The very next year, 1972, saw the answer in what has become the most influential book in all of environmentalism: *The Limits to Growth*, now in its third edition. The book modeled the causal forces using a system dynamics simulation model. This produced graphs for various scenarios. For the first time the public could clearly see what the result would be if the forces causing the environmental sustainability problem were not proactively resolved in time. The model saw these forces as essentially being the IPAT equation forces of population, affluence, and technology growth.

Now the young field had its initial paradigm. *The Limits to Growth* put it all together by defining the problem using model driven analysis and Forrester's simulation modeling tool of system dynamics. All it would take to solve the problem was to reduce the IPAT factors to below the limits of the ecosystem services the biosphere could sustainably provide. Or so the field thought.

Environmentalism was on a roll. The 1972 Stockholm Conference drew 114 out of 132 United Nations members. It went so well that:

> The conference in Stockholm accomplished almost everything the preparatory committed had planned. It was widely considered successful, and many observers were almost euphoric about the extent of agreement.

This premonition of success, however, was premature. While significant progress was made on portions of the sustainability problem, particularly solution of the stratospheric ozone layer problem and local problems like acid rain and water pollution, the overall trend continued to grow worse. Sometime in the 1970s the world's ecological footprint crossed the one planet limit. The footprint has since continued its relentless march upward and is now at about 50% overshoot. Collapse is thus inevitable unless drastic action is taken soon. As the third edition of *Limits to Growth* reported in 2004:

> ...we are much more pessimistic about the global future than we were in 1972. It is a sad fact that humanity has largely squandered the past 30 years in futile debates and well-intentioned, but half-hearted, responses to the global ecological challenge. We do not have another 30 years to dither. Much will have to change if the ongoing overshoot is not to be followed by collapse during the twenty-first century. (Meadows et al, 2004, xvi)

This dire outcome can only mean sustainability science has not yet found the fundamental forces causing the sustainability problem. You can't solve a problem is you don't know what's causing it. The field lacks a problem solving paradigm that works. It's thus not yet

in its normal science stage. It's in pre-science, the pre-step of Thomas Kuhn's theory of how fields of science advance (Kuhn, 1962), as modeled in Figure 4. Model drift has been added to clarify the cycle and allow use of the model drift subproblem in SIP.

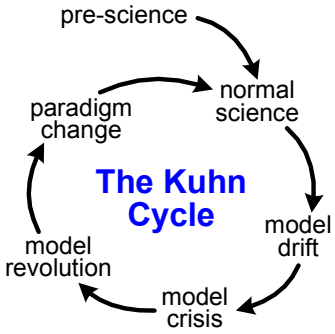


Figure 4 – The young field of sustainability science is still in its pre-science step, because it's never had a paradigm that works. In Table 1 civilization is in the model crisis step because its self-governance model previously worked reasonably well. It even solved the cold war problem. But it is now failing to solve the sustainability problem.

Why have the fundamental forces not been found, after over forty years of searching? Because no formal process that fits the problem was used. Can scientists solve their toughest problems without use of formal application of the Scientific Method? Could Toyota have created the Prius without strict allegiance to the Toyota Production System?

Sustainability problem solvers are running blind and guessing because they have no equivalent of the System Improvement Process. Since they have no standard formal process, they have nothing that can be continuously improved. Since they have no concept of root cause analysis or proper problem decomposition, their work has long been stuck in the mud of the superficial layer.

For further proof this is so let's examine one of the very best recent works on solving the sustainability problem: *Global Sustainability: A Nobel Cause (*Schellnhuber et al, 2010). Published in 2010, the project brought together nine Nobel laureates and dozens of other luminaries in a 2007 three day symposium. This should represent the world's very best and latest thinking on the problem. But what does it contain? Sadly, more thinking on the superficial level and no use of root cause analysis, process driven problem solving, or model based analysis.

For example: "The *root cause* is the explosive growth of human material turnover and population in the last several decades." (Schellnhuber et al, 2010, p20) This is the same conclusion *The Limits to Growth* reached in 1972, that the IPAT factors are the underlying cause. But WHY are those factors growing so excessively? WHY is the system so biased toward IPAT factor growth? WHY is the world refusing to adopt the many perfectly sound solutions that would radically lower the IPAT factors? Questions like these indicate the above quote identifies an intermediate rather than a root cause. This indicates the field has not yet found the real root causes.

Global Sustainability concluded with a dash of inspiration and exhortation:

> We are standing at a moment in history when a Great Transformation is needed to respond to the immense threat to our planet. This transformation must begin immediately and is strongly supported by all present at the Potsdam Nobel Laureate Symposium. (p360)

This was followed by sections on "The need for a Great Transformation; Crucial sustainability challenges and responses; [and] A global contract between science and society." But this only repeats similar solution wish lists that have long been promoted. [1] None have succeeded because as this paper hammers home again and again, none of the solutions resolve root causes. Instead, they attempt (in vain) to resolve intermediate causes. Wish lists like this are also blind to the fact that systemic change resistance must be overcome first, before the system will accept proper coupling solutions like those proposed in *Global Sustainability*.

Still, one must give credit where credit is due. The field has successfully raised a great hue and cry. The problem *must* be solved. There's a veritable army of activists of all kinds clamoring at the gates to solve the problem any way they can.

Let's pinpoint the fundamental forces of the problem so that army can grab the right battering ram, break down those gates, rush in, and solve the problem just in time to avoid collapse. We begin with the keys to the castle: proper problem decomposition.

The Four Subproblems

SIP first decomposes the one big problem into three subproblems: (1) How to Overcome Change Resistance, (2) How to Achieve Proper Coupling, and (3) How to Avoid Excessive Model Drift. Each of these subproblems has its own root cause or causes, which are the fundamental forces. See earlier in this paper for the definition of the three subproblems. Here's why these three subproblems are always present:

Subproblem 1 - Change resistance is always present in an unsolved difficult social problem because past solutions have failed to change the system enough to solve the problem. The system has resisted change. *Change Resistance as the Crux of the Environmental Sustainability Problem* (Harich, 2010) argues, in exhaustive model based analysis detail, that overcoming *systemic* change resistance is the crux of any difficult social problem. Once that resistance is overcome the system will "want" to solve the problem, just as strongly as it doesn't want to solve it now. Therefore the change resistance subproblem must be solved first. It must be treated as a separate and distinct problem to solve.

Subproblem 2 - A proper coupling subproblem is always present because systems thinking is employed. What most people see as the main problem to solve is always an improper coupling of some sort. Two or more systems are not working together in harmony. For example, in the autocratic ruler problem of pre-democracy, The People were improperly coupled to The Ruler or The Ruling Class. The right feedback loops were missing. There was no easy routine way to replace a bad ruler with a good one or to promote the general welfare of The People over that of The Ruler.

Defining the sustainability problem as an economic proper coupling problem has come to be the *de facto* viewpoint:

> The economic system is a subsystem of the global ecosystem, and one of the major goals of ecological economics is to determine when the benefits of continued growth in the economic subsystem are outweighed by the increasing opportunity costs of encroaching on the sustaining ecosystem. (Daly and Farley, 2011, p61)

SIP elevates this viewpoint to the formal concept of proper coupling, so as to define the subproblem in a manner most advantageous to successful analysis.

Subproblem 3 - Excessive solution model drift is always present in difficult unsolved social problems. If it wasn't the problem would already be solved or on a path to solution. Model drift refers to the solution model a society uses to solve its major problems. When a successful new society is formed it cranks up its solution model and aggressively solves its plate of current problems. This causes that society's solution model to mature to where it can handle future problems. This it will do reasonably well for awhile. But then various social agents begin figuring out how to exploit the new solution model. Other problems also appear.

Over time, history has demonstrated that all societies rise and ebb. They flourish and wane. Some cannot recover from excessive model drift and die, while others rise to the challenge, strengthen their solution model, and solve the problem. Global civilization has flourished for 200 years, due to the Industrial Revolution. It is now entering a waning period due to its inability to solve the sustainability problem. While most industrialized nations have good or average solution models, global civilization has a poor one. The best it can offer is the United Nations, which is so poorly self-managed that except for budgetary decisions its General Assembly decisions are non-binding. Its Security Council can make binding decisions, but these may be vetoed by any of its five permanent members. As a result the UN is ineffective on any but the most routine problems.

These three subproblems are present in all difficult large-scale social problems. For the sustainability problem, *analysis revealed there are two proper coupling subproblems:* the one just described plus the life form proper coupling subproblem [2] of column B. The improperly coupled systems are the corporate and human life forms. The symptoms are "large for-profit corporations are destructively dominating political decision making." These symptoms have drawn considerable attention, as documented in books like these:

- *When Corporations Rule the World*, David Korten, 1995.
- *Global Spin: The Corporate Assault on Environmentalism*, Sharon Beder, 2002.
- *Gangs of America: The Rise of Corporate Power and the Disabling of Democracy*, Ted Nace, 2003.
- *Suiting Themselves: How Corporations Drive the Global Agenda*, Sharon Beder, 2006.

Decomposition into four subproblems splits the sustainability problem wide open. Deep and correct analysis is now possible because we can focus on one distinct subproblem at a time. This allows us to cut through the forty year fog and find:

The Fundamental Forces

The decomposition led to the biggest surprise of the analysis: *The environmental sustainability problem is itself a symptom of yet an even bigger problem*: *the Broken Political System Problem*. Others call it "stuck in a dysfunctional institutional equilibrium." (Fukuyama, 2011, p45)

Study Table 1 closely. Notice how only subproblem D mentions environmental sustainability. The other subproblems are generic and could apply to any problem whose solution would benefit the common good, i.e. any *bona fide* public interest problem. Note also that a side effect of the symptoms of subproblem B is the symptoms of subproblems A, C, and D, because not solving those problems benefits corporations.

Note especially symptom B. That "large for-profit corporations are destructively dominating political decision making" indicates democracy is broken. That political system, designed for the people, by the people, and of the people to promote the general welfare of the people, no longer serves the people. Instead, it serves the corporate life form, who has learned how to invisibly manipulate the political system to maximize benefits to itself rather than people.

Figure 5 shows the fundamental forces of the Broken Political System Problem and its most ominous symptom: the environmental sustainability problem. We could also add subproblems E and F for social and economic sustainability, since the Broken Political System Problem also causes those problems. Then we'd have all three pillars of sustainability represented. Subproblems E and F could also be added to Table 1.[3]

Each arrow is a line of force. The forces originate from the root causes. The main root cause is that of subproblem B. Essentially the world's political systems have been exploited by a new dominant life form, *Corporatis profitis*, who grew exponentially in numbers and strength as it filled the niche created by the Industrial Revolution. The old dominant life from was *Homo sapiens*.

Root cause B is mutually exclusive goals between the top two social life forms, *Corporatis profitis* and *Homo sapiens*. The goal of *Corporatis profitis* is maximization of the short term value (really the net present value) of profits. The goal of *Homo sapiens* is optimization of long term quality of human life for those living and their descendents. These goals are so mutually exclusive they cannot be achieved in the same system. One life form will win and one will lose.

The important behavior of a social system is determined by the goals of its dominant social agents. Since the corporate life form dominates culture, production, politics, and invention in industrialized nations, it

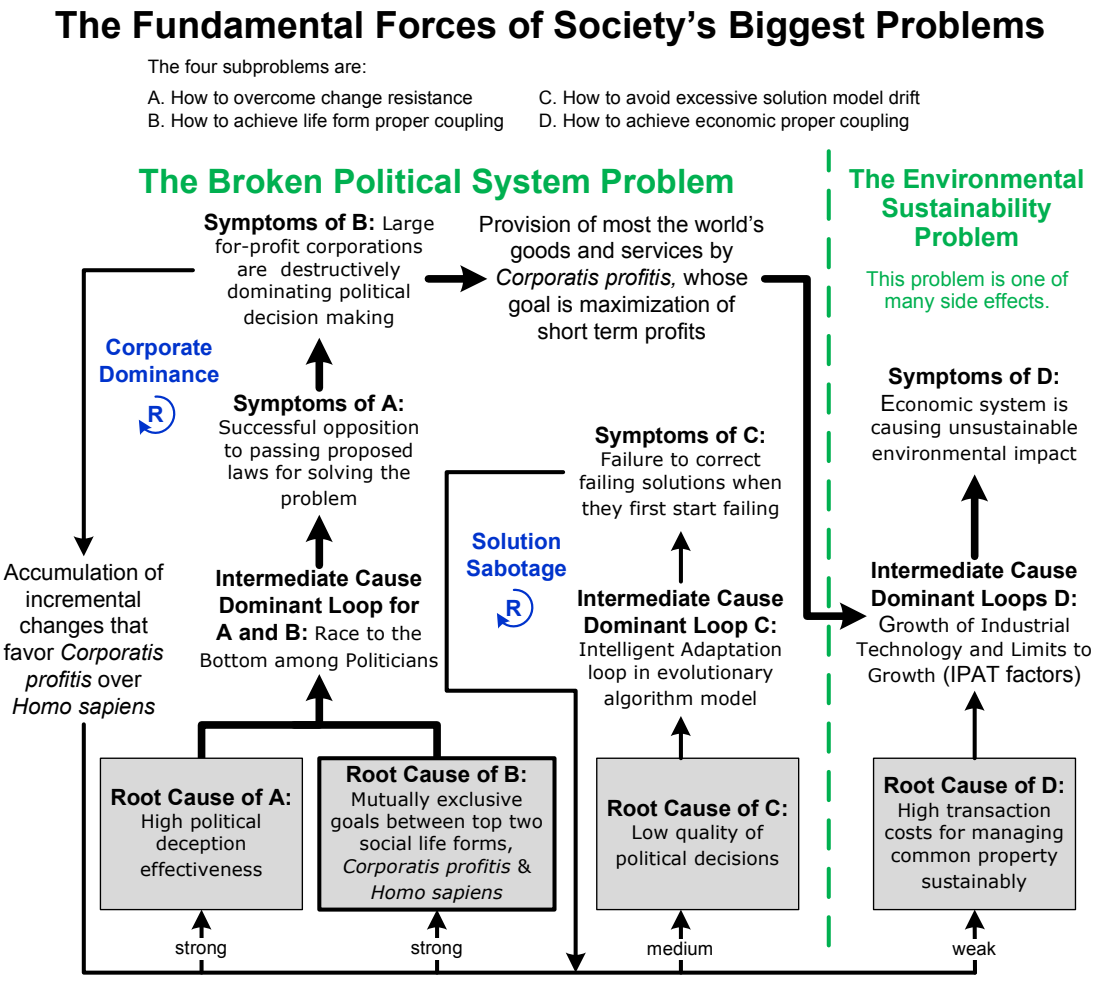


Figure 5 – These forces are as real as gravity and just as invisible. Like gravity, they rule our lives. The fundamental forces arise from the root causes. Resolve the root causes and the system will shift into a fundamentally different mode, one that is inherently sustainable.

dominates the system. Humans play only compliant consumer, employee, and voter roles. Thus the implicit goal of the human system is maximization of the short term value of profits.[4] This causes unsustainable system behavior.

How do corporate proxies (Supporters Due to Degeneration in Figure 6. Node names are underlined in this paper.) convince people to follow corporate goals instead of theirs? That's so obviously self-destructive it requires mass political deception. As Thomas Frank asked in *What's the Matter with Kansas,* "Why do so many Americans vote against their economic and social interests?" (Frank, 2004, back cover) It's because of mass deception, pure and simple. Frank documents one form of how it's done: (p5-6)

> ...the backlash mobilizes voters with explosive social issues—summoning public outrage over everything from busing to un-Christian art—which it then marries to pro-business economic policies. ...The leaders of the backlash may talk Christ, but they walk corporate. Values may "matter most" to voters, but they always take a backseat to the needs of money [corporations] once the elections are won.

The structural reason deception works so well is explained by the simulation model of Figure 6. The model shows how the root cause of subproblem A works and how it can be resolved by pushing on its related high leverage points.

The model has reduced the problem to the language of mathematics. The equations used for each node are relatively simple. Here are three of the key equations:

```
false memes = degenerates
influence x false meme size

undetected false memes = false
memes - detected false memes

true memes = rationalists
influence x constant true meme
size
```

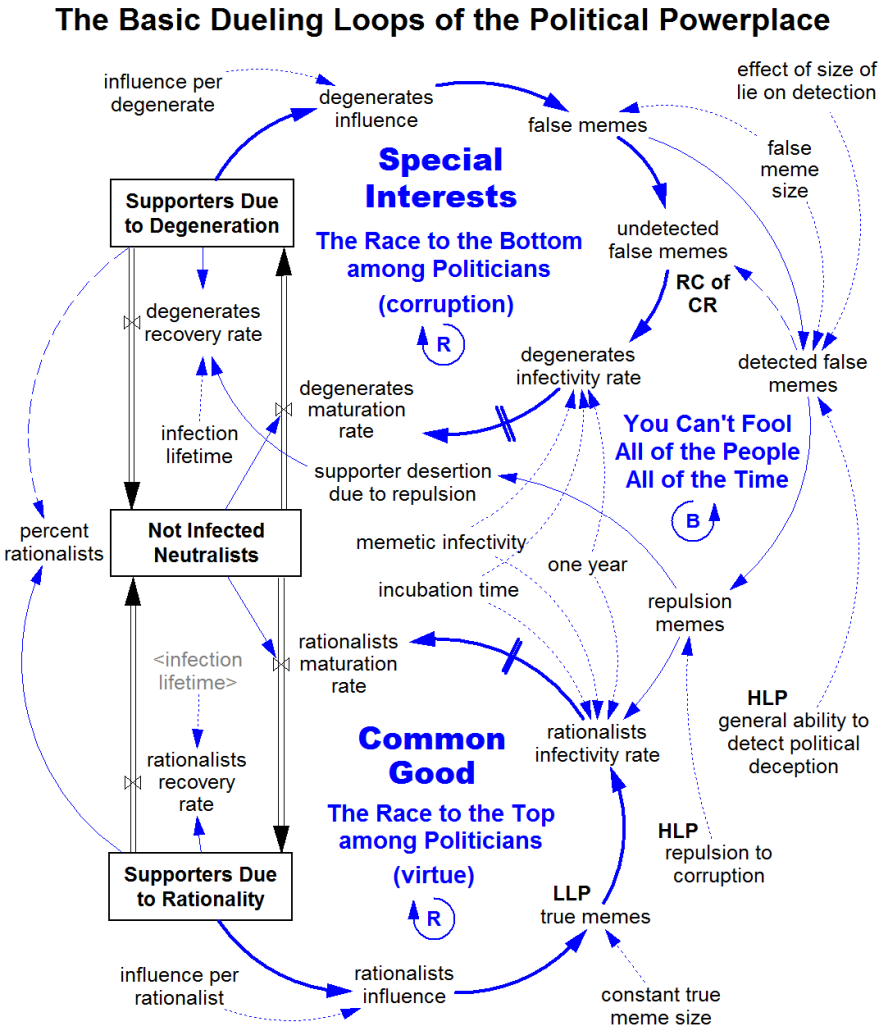


Figure 6 – This structure models the fundamental forces present in all large political systems, both ancient and modern. Over time, all large-scale political systems stratify into two groups: those favoring special interests (like the rich, corporations, and long ago the aristocracy) and those favoring the common good. *This is the famous Left-Right spectrum of politics.* Special interests are a minority by definition, so the only way they can convince a majority to vote for them is deception and favoritism. Deception works so well and favoritism is so expensive that favoritism plays a lesser role and is not modeled.

Meanwhile, those favoring the common good use the truth to win supporters. This fails most of the time because *the race to the bottom contains an inherent advantage.* The size (and hence the appeal) of a falsehood can be inflated but the size of the truth cannot. Corrupt politicians can promise two chickens in every pot, while virtuous politicians must be realistic and can promise only one. Corrupt politicians can promise to balance the budget in one year without raising taxes, while virtuous politicians know it will take longer and will require raising taxes. Corrupt politicians use *ad hominem* fallacies to demonize their opponents, while virtuous politicians can only tell the truth. Corrupt politicians reject science because science allows people to base arguments on the truth. "Climate change is a hoax." And so on. Since it's currently easy to fool most of the people most of the time, deception usually wins.

The root cause of the inherent advantage is modeled by the undetected false memes node. Those memes are just as infective as true memes. Since general ability to detect political deception is low, about 20%, the result is the race to the bottom is dominant most of the time.

A high leverage point (HLP) resolves its related root cause. The model contains two HLPs. Pushing on them easily resolves the root cause. Simulation runs show that one HLP, general ability to detect political deception, is far more influential than the other, so this is the preferred HLP. Pushing there with the right solution elements will solve the change resistance subproblem.

This is the heart of the model. Constant true meme size always equals one. False meme size equals one or more. If it's set to 1.1, the two HLPs are set to zero, and the model is run, Figure 7 shows the result:

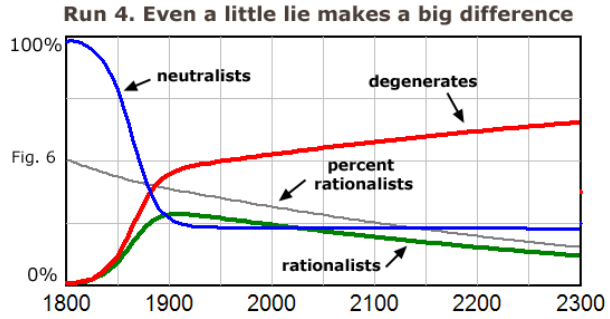


Figure 7 – In this run false meme size is set to 1.1. This is only a tiny bit bigger than the opposition. It would seem that itsy bitsy lies wouldn't make much difference, but no—they make a huge difference over a long period of time. As the graph shows, the good guys get wiped out. After 500 years they are down to about 20%.

Next let's change repulsion to corruption to 20% and general ability to detect political deception to 80%. This represents pushing on the right high leverage point with solution elements. Testing shows the optimum strategy for those managing deception in the race to the bottom is a false meme size of 4.7. Figure 8 shows the result:

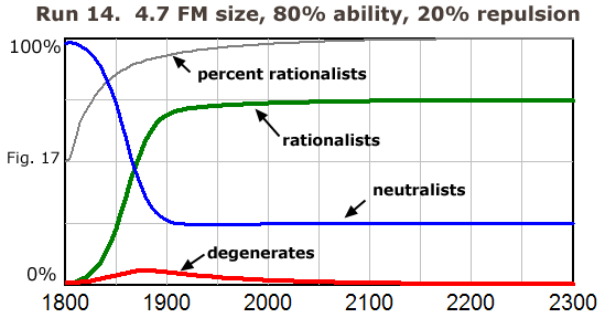


Figure 8 – This run represents what it will take to solve the change resistance subproblem. By pushing on the right high leverage point with sufficient force, the race to the bottom collapses, as its supporters flee for their lives to the race to the top. That loops goes dominant and stays dominant indefinitely, which is exactly what's required to solve the sustainability problem since **sustainability** is defined as the ability to continue a defined behavior indefinitely.

That's how the root cause of subproblem A works.

In Figure 5, the main line of force directly causing the environmental sustainability problem is the extra heavy arrows. The root causes of A and B work together to cause the **Race to the Bottom among Politicians** to be dominant most of the time. This causes successful opposition to passing proposed laws for solving the sustainability problem, as well as other problems that run against the interests of corporations. That in turn causes large for-profit corporations to successfully and destructively dominate political decision making of all kinds. Following the extra heavy arrow, this cascades over to the symptoms of the environmental sustainability problem.

The last two nodes in that line of force are the Intermediate Cause Dominant Loops of D and Symptoms of D nodes. These nodes are all most people working on the environmental sustainability problem can see clearly. The rest lie hidden in the fog of problem complexity. This is analogous to military analyst Carl von Clausewitz's famous fog of war:

> The great uncertainty of all data in war is a peculiar difficulty, because all action must, to a certain extent, be planned in a mere twilight, which in addition not infrequently — like the effect of a fog or moonlight — gives to things exaggerated dimensions and unnatural appearance. (Clausewitz, 1832, Book 2, Chapter 2, Paragraph 24)

The closer you get to the root causes the thicker the fog. By the time you try to trace the forces causing the sustainability problem all the way back to their real causes, *the smothering thickness of the fog stops you at the intermediate causes of Table 1.* These are so plausible and so full of common sense they must be the real causes, so that's what activists have been lobbing popular solutions at for the last forty years. As Clausewitz explains, "uncertainty ...like the effect of fog ...gives to things exaggerated dimensions and unnatural appearances." This causes activists to exaggerate the importance of intermediate causes and erroneously assume they are the root causes. That error, in war as well as in activism, is often fatal.

An interesting property of Figure 5 is that if any single root cause can be resolved the environmental sustainability problem would be solved:

A & B. A dominant **Race to the Bottom among Politicians** loop requires two preconditions: root causes A and B. Resolve either one and the race to the bottom cannot stay dominant over the race to the top. Resolving root cause A or B would thus eliminate the symptoms of A and B, which would eliminate the forces causing environmental unsustainability.

C. If root cause C was resolved, solutions to problems like sustainability would be fixed. Problems would be mostly solved proactively, when it's easiest to solve them, or they would be solved reactively.

D. If root cause D was resolved, the environmental sustainability problem is directly solved.

What makes the Broken Political System Problem so historically difficult to solve is not only its well-hidden-in-the-fog root causes. There's also the **Corporate Dominance** growth feedback loop. All that destructive dominance of political decisions leads to accumulation of a mountain of incremental changes that favor *Corporatis profitis* over *Homo sapiens*. This causes all four root causes to grow worse, especially root causes A and B:

A. The ability of *Corporatis profitis* to use high political deception effectiveness to fool voters into voting against their best interests strengthens. Examples are the growing personhood rights of corporations and the weakening of laws designed to make television news a reasonable approximation of the objective truth.

B. The goal of *Corporatis profitis* drifts further away from the goal of *Homo sapiens*. It's now so far away the two goals are disastrously impossible to achieve simultaneously in the same niche, the biosphere. One life form will win and one will lose. It has become painfully obvious which is winning.

Perhaps something else has by now become obvious: *Only by clearly seeing the fundamental forces of a difficult complex system problem can the problem be solved.* This holds for all complex system problems, whether they are questions of planetary motion, how matter behaves at the quantum level, or how the human system behaves at the global level. If you can clearly see the fundamental forces involved, problems like these just about solve themselves.

There's another loop making the problem even harder to solve: the **Solution Sabotage** loop. The root cause of C, low quality of political decisions, leads to failure to correct solutions when they start failing, the symptoms of C. That causes all four root causes to grow worse. One is the root cause of C, so we have a reinforcing feedback loop that grows stronger over time. Examples of deliberate **Solution Sabotage** are deregulation, weakening and rollback of existing laws, refusal to support paying United Nations dues, and pro-business appointees in public positions.

There is some evidence these are the root causes:

A & B. The Dueling Loops model explains why the left-right political spectrum exists, why mass political deception exists and why it is used by the right, why the right wins most of the time despite democracy being designed for the common good, why political systems tend to drift to the right and then to the left (they are cyclic), why activists are unable to solve the sustainability problem, and why that problem occurs in the first place. This gives substantial support to the hypothesis of root causes A and B.

C. Adding the **Intelligent Adaptation** loop to the Dueling Loops model explains why subproblem C occurs at the root cause level. It's because memetic life forms (like corporations) can adapt faster than genetic life forms (like people). This intermediate force leads to the fundament force (the root cause) of excessive model drift: low quality of political decisions, since that benefits *Corporatis profitis*.

D. Support for root cause D is presented later, culminating in the quote from (Dahlman, 1979).

So where do we start? How do we use our understanding of the fundamental forces to solve the sustainability problem?

Resolving the Root Causes

As Clausewitz would advise, the key to solving the problem is to strike where the enemy is weakest. More than anything else the enemy is dependent on the **Corporate Dominance** loop. Destroy its effectiveness and the battle is won. [5]

A frontal assault on directly solving root cause B is impossible because we can't walk up to the eight million pound gorilla of *Corporatis profitis* and ask him to change his goal to one that aligns with that of humans. That won't work because it would reduce his competitive advantage. No independent life form will willingly reduce its competitive advantage because all independent life forms are engaged in a continual battle for survival of the fittest. Instead, we can knock out the **Corporate Dominance** loop by resolving root cause A.

Resolving the root cause of subproblem A is the crux of the problem. Once change resistance is over-

come the system will "want" to solve the problem just as strongly as it doesn't want to solve it now.

However, in the fundamental forces diagram the force arrow leading into root cause A is strong. That means we also cannot make a fully successful frontal assault on directly resolving that root cause. Table 1 has nine solution elements for resolving root cause A. This will help some. But it will probably not be enough or work fast enough due to the well entrenched position of the enemy as measured by the strength of the forces feeding into root causes A and B. However, we can overcome the power of mass deception by sneaking around to the back side of the castle and starting at root cause D, which has a weak force feeding into it. *That weak force indicates where the enemy is weakest*.

Root cause D is weak because it's not on a feedback loop and is therefore not self-reinforcing. When we strike at the root that's where we must begin. Ultimately striking there will allow us to later strike at the crux of the problem, root cause A.

The Root Cause of Subproblem D

Let's explain root cause D.

Table 1 says subproblem D, the environmental sustainability problem, has the intermediate cause of "externalized costs of environmental impact." That's the cause popular (superficial) solutions address. There are "two main groups of solutions at the system level: prescriptive regulations and market-based, such as carbon taxes and tradable permits. At the agent level the main solution is the three Rs" of reduce, reuse, recycle. The latest trend is finding more efficient ways of internalizing costs, which has led to market-based instruments as the preferred solution at the systems level:

> Over the past two decades, the superiority of market-based instruments has developed into a virtual orthodoxy. … Indeed, the presumption seems to have shifted toward using market instruments unless one can show they are somehow deficient. (Freeman and Kolstad, 2007, p4-5)

Why, despite only two decades of use, have market-based instruments (MBI) become so favored?

> In theory, *if properly designed and implemented*, market-based instruments allow any desired level of pollution cleanup to be realized at *the lowest overall cost to society*, by providing incentives for the greatest reductions in pollution by those firms that can achieve the reduction most cheaply. … In addition, market-based instruments have the potential to *bring down abatement costs over time* (that is, to be dynamically cost effective) by providing incentives for companies to adopt cheaper and better pollution-control technologies. (Freeman and Kolstad, 2007, p20, in a chapter by Robert Stavins, italics added.)

Thus the current consensus is that MBI are the lowest cost solution. "If properly designed and implemented," MBI will internalize the presently externalized costs of environmental impact, which will solve the sustainability problem.

But do MBI really offer, as Stavins argues, "the lowest overall cost to society"? Will they really "bring down abatement costs over time" to the high efficiency level needed to rapidly solve the sustainability problem in time to prevent collapse?

No. MBI are command-and-control in disguise because the problem solver for each environmental problem is government rather than firms. Nor can MBI offer high economic efficiency because they are not property rights based. The clue for why this is so lies in the work of Ronald Coase.

Coase (1937) defined **transaction costs** as "the cost of using the price mechanism" or "the cost of carrying out a transaction by means of an exchange on the open market." Transaction costs are not the cost of creating technology, performing research, and other productive actions themselves, but the costs of arranging for their acquisition via markets. Examples of transaction costs to buy a product are the cost of finding out where to get it, the cost of specifying and determining the quality of the product, the cost of bargaining, the cost of contracting, and the cost of payment. The transaction costs associated with production of most modern goods and services are prohibitive if not done within a firm.

Next we derive the economic root cause by use of transaction cost theory and the close parallel between private and common property.

What are we mostly transacting in today's world? The rights to private property. How well is that working? Extremely well. Why? Because transaction costs for firms managing the production of private property

goods and services are low, which encourages the needed firms to appear.

Common property is any shared natural resource for which it is difficult to exclude potential users, such as the air we breathe, the water we drink, and the many shared ecosystem services we rely on to survive. What is the environmental sustainability problem most concerned with? Management of common property. How well is society doing that? Poorly. Why? Because transaction costs for managing common property are high, so high that unlike private property it's nearly impossible for sustainability advocates to create firms for managing the sustainable production of ecosystem services. Because the needed firms rarely appear, government has stepped in to fill the void, first with command-and-control regulations and then with market-based solutions. *Therefore the economic root cause of the environmental sustainability problem is "high transaction costs for managing common property sustainably."*

That externalities are generally not the economic root cause and high transaction costs are was pointed out over thirty years ago:

> One may enquire why market transactors are unable to make the emittor of an externality internalize the cost of his action. The only reason why wealth-maximizing economic agents do not undertake these transactions must be that the cost of carrying out the actual transaction is greater than the expected benefit.
>
> Ultimately, the relevance of externalities must lie in the fact that they indicate the presence of some transaction costs. For *if there were no costs of transacting,* then the potential Pareto improvement would be realized by costless bargaining between self-interested economic agents. Transaction costs are therefore a necessary condition for the persistence of unwanted effects from externalities, for with zero transaction costs side effects will be internalized and will not negatively affect resource allocation. The conclusion is thus unambiguous: in the theory of externalities, transaction costs are the *root of all evil.*
>
> *... It is a very strange feature of modern welfare policy prescriptions that they propose to do away with externalities, which are only one of the symptoms of an imperfect world, rather than with transaction costs*, which are the *heart of the matter* of what prevents Pareto optimal bliss from ruling sublime. (Dahlman, 1979, italics added):

"Root of all evil" and "heart of the matter" mean root cause. But that's not where attention is presently focused: "...policy prescriptions ...propose to do away with externalities ...rather than with transaction costs."

The High Leverage Point of Subproblem D

Next we find the high leverage point for resolving this root cause.

In *The Nature of the Firm* Ronald Coase (1937) posed a question no one had seriously asked before. Why do firms appear? In theory the price mechanism should work equally well for organizations or individuals. But:

> ...why is such organization necessary? Why are there these "islands of power"? Outside the firm, price movements direct production, which is coordinated through a series of exchange transactions on the market. Within a firm these market transactions are eliminated, and in place of the complicated market structure with exchange transactions is substituted the entrepreneur-coordinator, who directs production.

Coase showed that firms appear because "Within a firm these market transactions are eliminated." This increases economic efficiency, which allows a firm to sell its output at a lower price and still be profitable. This opportunity attracts entrepreneurs and investors. From this arises the principle that *firms appear when there is a profitable opportunity to lower transaction costs.*

Firms have appeared by the millions to manage private property. But they have not appeared to manage common property, except in sporadic cases such as case-by-case contracts to manage a renewable resource sustainably. As a result, in most cases either no one or the government plays that role. Therefore society needs to *"allow firms to easily appear to lower the transaction costs"* for managing common property sustainably. That is the high leverage point. Pushing on it would reduce the "friction" of the billions of daily transactions needed to manage the planet's many sustainability problems. This friction would fall to such a low level that the total problem would quickly be solved as the

needed firms suddenly appeared—just as they did two hundred years ago at the dawn of the Industrial Revolution.

Common Property Rights as the Solution for Subproblem D

Finally we find the solution element for pushing on the high leverage point.

The high leverage point is "allow firms to easily appear to lower the transaction costs for managing common property sustainably." Candidate solutions thus hinge on two key factors: how to design those firms and how to allow them to appear. There are millions of ways those factors could be designed. How are we going to search that large solution space efficiently and get our solution right the first time?

We don't have to search it. Evolution already has. The forces of memetic evolution have produced a system for managing private property that's so miraculously productive we take it for granted. This is *Private* Property Rights. So why not take what can be learned from that system and create another system called *Common* Property Rights? That's the key insight.

Examine Figure 9. This models the solution.

By viewing private and common property in terms of their management needs rather than their physical forms, the planet's property management system can be conceptually divided into two symmetrical halves sharing a central backbone. The existing Private Property Rights system, once extracted from the portion of the system that can be shared, forms a template for creating the proposed Common Property Rights system. Each is the mirror image of the other because of high reuse of existing infrastructure. The Common Property Rights system thus designs itself. Its essential components pop out of thin air as the fundamental generic components that form the Private Property Rights system are identified. Each system contains the same symmetrical seven key components.

Common Property Rights is a comprehensive system for sustainable management of ecosystem services whose use is shared in common. It's generic, efficient, and self-replicating because it's the mirror image of Private Property Rights, which has proven to be so generic, efficient, and self-replicating it has swept the earth.

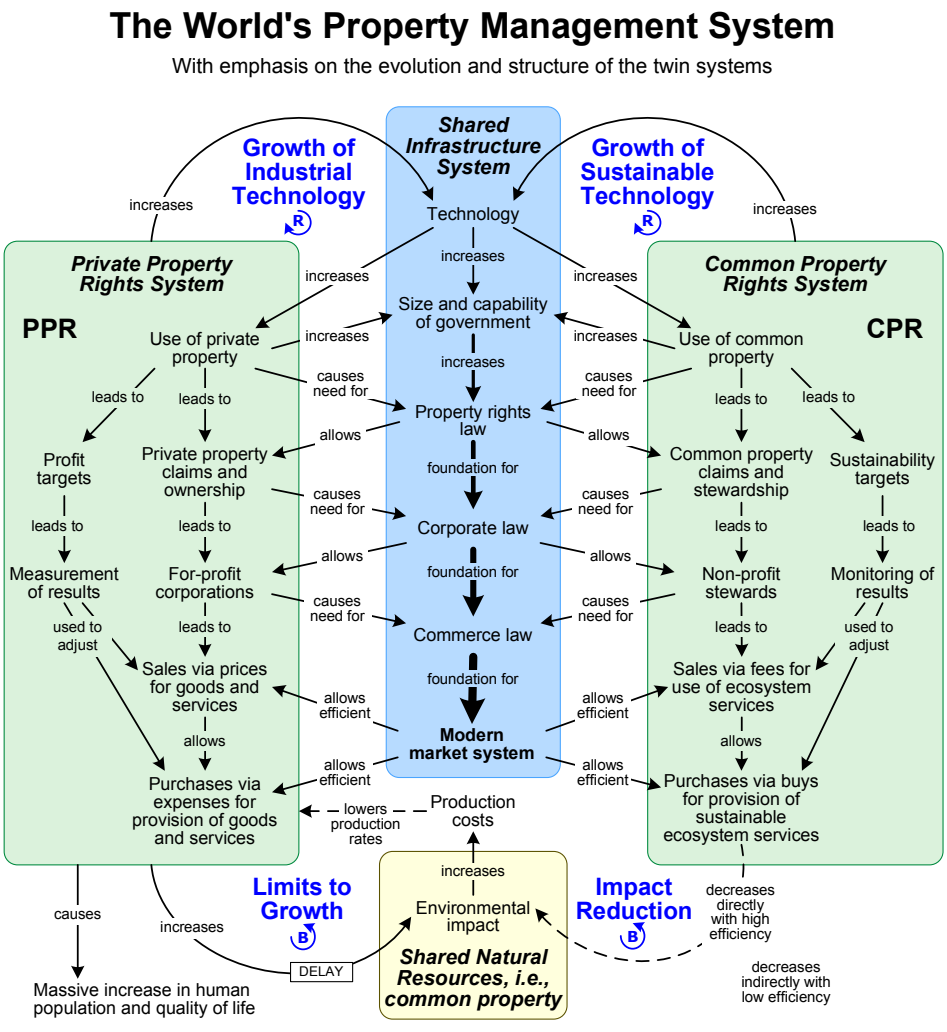


Figure 9 - Note the shared infrastructure system. This forms the bulk of the management system and is easily shared with the proposed system on the right. The feedback loops show how the left system is causing the environmental sustainability problem and how the right system can solve it. Because of high reuse of proven mechanisms, the solution on the right should achieve the same high efficiency we have long enjoyed from the solution on the left. We are essentially reusing an old system rather than designing a new one from scratch.

Legend: R for reinforcing loop, B for balancing loop. Solid arrows indicate direct relationships. Dashed arrows indicate inverse relationships.

Common Property Rights employs the seven main components described in Table 2. Like the way Private Property Rights revolves around corporations, Common Property Rights revolves around stewards. The world's environmental NGOs are acting as *de facto* stewards. As *bona fide* stewards they will have a sound business model at last. No more fund raising nightmares!

The only significant difference between the two systems is one manages private and the other manages common property. They share the same infrastructure and high level system design.

Society can thus expect that once a global Common Property Rights system something like the one shown in Figure 9 is implemented, the environmental sustainability problem will be solved. The Sustainability Revolution will begin. Its effects will be just as rapid, beneficial, and unpredictable as its twin, the Industrial Revolution, because both are based on the same conceptual structure.

Private Property Rights System	Common Property Rights System	
1. Enabling legislation	Enabling legislation	Defines the system by defining its components and how they interact. This can be simple because so much of private property law is reusable. It's easily applied to common property. All that need be specified is the differences between Private and Common Property Rights.
2. Corporations	**Stewards**	Stewardship corporations are formed. Stewards must be non-profit to avoid a conflict of interest. Each has the chartered goal of performing a specific service for the good of humanity. Stewards are trusted public servants who work for the common good rather than for themselves.
3. Claims	Claims	Stewards file claims on any unclaimed common properties needing wise stewardship. Claims allow the solution to spread naturally and efficiently, and to thus eventually solve the entire problem. This is identical to how all land was claimed long ago. Once a claim is accepted the steward doesn't own the property. It owns the right to manage it for the long term good of all. Thus Common Property Rights could more accurately be called Common Property Management Rights.
4. Goals	Targets	After a claim is approved the government and the steward set the targets for that common property, such as allowable levels of pollution. The objective is to meet the sustainability targets with the lowest fees possible. Just as prices on new products come down to the lowest possible level over time, fees will do the same.
5. Prices	Fees	Stewards charge fees for use of their common property. This is a "user fee" per unit of ecosystem service use, such as one dollar per pound of a pollutant or ten cents per codfish caught. A fee is not a tax. Psychologically and legally, fees are the price of providing a sustainable ecosystem service. Fees will start out low to avoid shocking the system, and then will be gradually raised to the level required to meet the targets.
6. Expenses	Buys	Fees are spent on buys, as the steward "buys" the health of its common property back. Buys are the expenses of providing a sustainable ecosystem service, such as education, R&D, implementation cost assistance, and cost of monitoring. Special care will be taken to minimize transition hardships. The more efficiently buys are spent, the lower future fees will be.
7. Monitor results	Monitor results	Stewards monitor the health of their common property to adjust fees up or down and to adjust how buys are spent. The idea is to raise fees just high enough to meet the targets.

Table 2 - The Common Property Rights system revolves around stewards so they are bolded. Stewards around the world cooperate in areas like R&D and constructively compete to see who can offer the lowest fees while meeting their targets, in order to keep their claims. This global race to the top drives the system toward "the lowest overall cost to society" because the system is complete and every component is strong.

Implementing Common Property Rights

How are we going to implement Common Property Rights? In activism and in war, the answer is always the same: strike where the enemy is weakest. In the parlance of the System Improvement Process that means seeking out pockets of low change resistance and striking there.

Common Property Rights revolves around stewards. Once the world has enough stewards the sustainability problem is solved. Our challenge is to quickly startup as many stewards as possible, get their number to the critical mass needed for self-replication, and then stand back and watch them cover the globe.

Stewardship startups can't work everywhere at first since Common Property Rights is so different from what lawmakers are used to. This forces us to carefully look around for places where the solution could work.

The four key requirements for a successful stewardship startup appear to be:

1. A pocket of low change resistance such as a county, city, or state. *This is the key requirement*. The local political system must be ready to change. Otherwise the all-important enabling legislation will not be passed. The local legislature must be open to the idea of allowing stewards to file claims on unclaimed common properties needing wise stewardship and if the claim is accepted, to charge fees per unit of ecosystem service use. *The enabling legislation can start small with a test pilot project using non-generic legislation for a single*

steward for a limited period of time. Later the law can be upgraded to be generic.

An example of a pocket of low change resistance may be found in Vermont, US. The Vermont project, along with many similar efforts, is naturally evolving toward the equivalent of Common Property Rights. As (Farley, Costanza, and Flomenhof, 2012) describe it: (Italics added)

> ...the Vermont legislature is considering the creation of a Vermont Common Assets Trust (VCAT) that would make the state's atmosphere, aquifers and other resources created by nature or by society as a whole the *common property* of all Vermonters, present and future. ...users of those common assets may be assessed *fees* that would be deposited into a common assets trust fund, which would be managed so as to protect those assets and serve the interests of present and future people of the state. ...
>
> Common ownership through a CAT can not only avoid the tragedy of open access resources but can also overcome the numerous other market failures described above. In fact, for many resources, sustainable, just and efficient allocation may require *common property rights*. ... Creating *common property rights* to open access resources is fairly straightforward, as it does not take away existing property rights.

The differences between solutions like VCAT and Common Property Rights stem from their design impetus. VCAT's origins lie in study of the *superficial layer* of the sustainability problem using comparative analysis, intuition, expert opinion, and study of the literature. It thus lacks individual stewards, claims, and commitment of 100% of fees to a steward's buys.

The origin of Common Property Rights lies in study of the *fundamental layer* using the System Improvement Process. The result is solutions like VCAT are designed to resolve intermediate causes (especially externalized costs) while Common Property Rights is like a rifle shot. It's focused on one thing: resolving the root cause of high transaction costs for managing common property sustainably. If that root cause is correct then the solution can't miss. It's like aiming at a bullseye that's only ten feet away.

VCAT is close to the bullseye. It has enabling legislation, targets, monitoring, and fees. But it lacks enough of the seven components of Common Property Rights to hit the bullseye. In particular it lacks individual stewards, claims, and commitment of 100% of fees to a steward's buys. This will cause VCAT to be significantly less generic, efficient, and self-replicating. This difference is easily corrected by adding the missing components.

2. A legal NGO is ready to help change the law. An interested, well established non-governmental organization (NGO) specializing in using "The Power of the Law" to promote environmental causes must exist. This is required to get the pilot enabling legislation passed and later the full non-generic legislation. Examples are the Southern Environmental Law Center (SELC) and GreenLaw.[6] Using SELC's phrasing, legal NGO's use "The Power of the Law" to get offenders to behave more sustainably. But that can only solve a small fraction of the total environmental sustainability problem because The Power of the Law only applies to existing law. We need so many new laws that what's really needed is a single generic new law that covers all environmental problems. That's what the enabling legislation does and is why Common Property Rights should be very appealing to legal NGOs.

3. A *de facto* steward already exists. There must be a well established environmental NGO who is already behaving as a steward. Their goal is to solve a well defined environmental problem. They have already made notable progress and have a good network of supporters. They are probably working with one or more legal NGOs to handle the legal aspects of their work.

An excellent example of a *de facto* steward is Upper Chattahoochee Riverkeeper in Georgia, US.[7] Their "mission is to advocate and secure the protection and *stewardship* of the Chattahoochee River, its tributaries and watershed...." They're a member of the Waterkeeper Alliance, who has nearly 200 *de facto* steward members. Very few *de facto* stewards are fully achieving their mission due to lack of the necessary income and favorable law, which is why Common Property Rights should be very appealing to environmental NGOs.

4. Realization that what we're trying now is not working. Both the legal and environmental NGOs must be expressing strong dissatisfaction (an expression of pain) with progress on solving the sustainability problem or they will not be receptive to a solution as novel as Common Property Rights. This means they are seeing high change resistance and are acknowledging that present approaches are not working. They have taken the first (and hardest) step toward paradigm change. They will thus be more receptive to considering something new.

Here's an outstanding example of expression of pain from the Southern Environmental Law Center: [8]

> In the new Congress, we are encountering a severe backlash against essential environmental safeguards. Under the guise of reining in federal spending, anti-environmental forces are attempting to gut the enforcement of federal protections and to put the brakes on EPA just as it was beginning to make real progress on pressing issues, such as regulating global warming pollution and placing strict limits on toxic emissions from burning coal. Big polluters can only be amazed at their sudden good luck. The same thing is happening in several of our states. We will not let these *forces* get the upper hand. (Note the use of "forces.")

All we need is the first successful steward. Steward number one is the catalyst that initiates the chain reaction of self-replication. To accelerate it several "first stewards" would be better. Once there's one successful steward, other *de facto* stewards will hear about it and want to become *de jure* stewards themselves.

Here's a high level plan for how to do a startup and how that leads to stewards covering the planet:

1. Find a spot on the planet that satisfies the above four requirements.
2. Change resistance is the crux so focus on that. The real hurdle is getting the temporary non-generic enabling legislation passed. This applies only to the test steward for a period of 5 or 10 years or so.
3. Explain to your elected representatives how Common Property Rights works. Show them how it's a better mousetrap. Explain why it can solve the sustainability problem and other solutions cannot. What you'd like to do is run an experiment. There's little to lose and a lot to gain.
4. Get the temporary enabling legislation passed.
5. Incorporate a stewardship corporation, file a claim, and get the claim accepted.
6. Get fee based stewardship of your common property running smoothly. This will take a few years.
7. As you go, collect data demonstrating how well Common Property Rights can or can't work. Use this to continuously improve Common Property Rights.
8. If things go well, use experimental results to get the temporary non-generic enabling legislation upgraded to permanent generic legislation. The first time this happens will be the actual birth of Common Property Rights as a comprehensive solution. This would be a historic occasion worth celebrating.
9. That political unit is now open for claims. Dozens to hundreds of *de facto* stewards will incorporate as real stewards and start filing claims.
10. Those stewards will spread the solution to other political units.
11. More and more enabling legislation will be passed. Mongolian hordes of stewards will materialize as if out of nowhere, due to the pent up desires of hundreds of thousands of *de facto* stewards around the planet.
12. The solution will self-replicate until stewards cover the Earth and manage every common property needing wise stewardship, at which point the environmental sustainability problem is solved.

This is not a preposterous as it may sound. It's happened before. In 1800 at the beginning of the Industrial Revolution the population of *Corporatis profitis* was minuscule. That life form came out of nowhere and covered the globe in two centuries, as graphed in Figure 10 for multinational corporations (Gabel and Bruner, 2003, p3). This suggests it can happen again. And it can happen an order of magnitude faster because we can intelligently accelerate the population growth of stewardship corporations. We can do it in twenty years instead of two hundred. This leads to:

The Prolific Stewards Hypothesis

The prolific stewards hypothesis is that **once the first few successful Common Property Rights stewards are released into the largely unfilled niche of sustainable ecosystem services management, the life form will self-replicate and cover the globe in as little as twenty years.** [9]

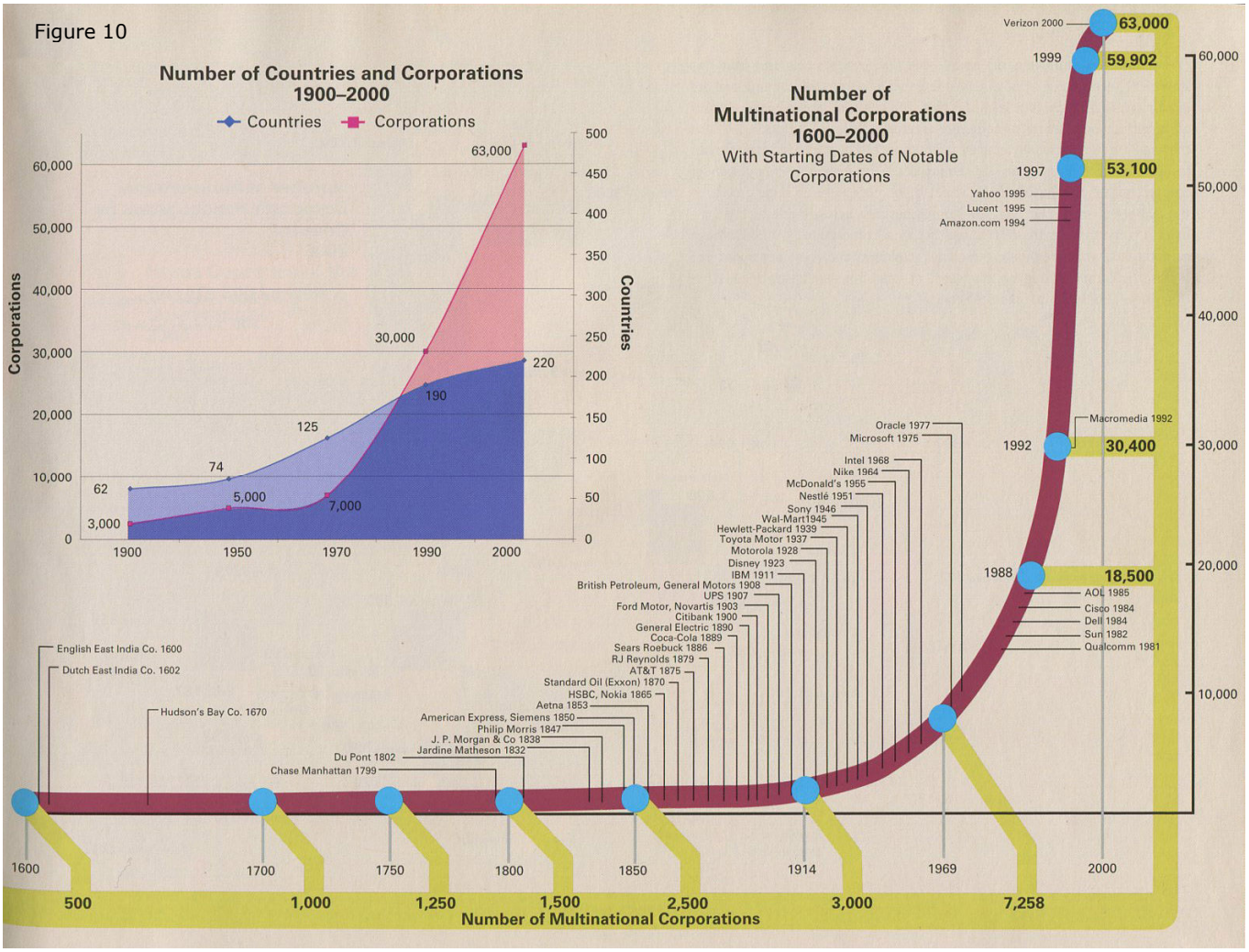
We have arrived at the logical outcome of the solvability hypothesis stated at the beginning of this paper. We are essentially proposing an epic solvability experiment: release a few well groomed stewards into the wild and then watch as they multiply until they fill the Petri dish of the planet.

The newly hatched life form needs a brain. There would be some group of meta-stewards to coordinate the evolution, population growth, collaboration, and quality of stewards as a whole. Their goal would be to maximize the speed of successful solution element implementation.

How will the spread of stewards overcome change resistance? How will it break the power of the **Corporate Dominance** loop? Exactly how is described in the *Common Property Rights* book. See the material dealing with "A Leverage Chain Perspective of How to Solve the *Complete* Sustainability Problem." This describes a carefully orchestrated sequence of pushes on the four high leverage points. Only the first push takes much effort. Most of that effort is not the push itself but overcoming paradigm change resistance from problem solvers so they can be persuaded to try something as radically different as root cause analysis in order to penetrate to the fundamental layer of the problem. Ironically, **radical** means "of or going to the root or origin; fundamental: *a radical difference*." [10]

The remaining pushes require only small amounts of assistance from problem solvers because the relieved fundamental forces of the system (such as those hordes of new stewards, newly enlightened citizens, and the first 2.0 corporations) do most of the pushing as the chain reaction proceeds. Once the final push succeeds the Broken Political System Problem will be solved, along with its chief symptom: that pesky little problem

Figure 10



called environmental sustainability.

The first push is the one described above: the first few stewards. The success of the first push makes subsequent pushes possible because it begins to reduce mass deception. By witnessing the success of stewards in tackling seemingly insolvable problems and doing so in a supremely helpful-to-people manner, citizens will see with their own eyes that certain gigantic "truths" are not actually true.

The biggest of these is the universal fallacious paradigm that *Growth Is Good* and *Corporations Are Good*. As described in (Harich, 2010) "These are the fundamental axioms behind the dominant paradigm of our age: that free markets, driven by the invisible hand of corporate competition, offer citizens the best of all possible material worlds, regardless of whether a nation is democratic, theocratic, or socialist."

Yet both axioms are false. Endless GDP growth is not good because ignoring limits leads to overshoot and collapse. Large for-profit corporations as presently designed are not good because they pursue their goals over the goals of their creators, the people. This has devastating side effects.

Seeing these explosive new truths will precipitate an intellectual awakening as potentially game changing as the Enlightenment. The result is the people (starting in some areas of the world and spreading to the rest) will demand a transition from Corporation 1.0 to 2.0 because the proof it is needed and will work is all around them. They can see with eye popping clarity that stewards are not for-profit corporations but yet are doing a better job of providing critical goods and services than for-profit corporations. That stunning proof will cause the scales to fall from their eyes, as they awaken to the new truths that *Unsustainable Economic Growth Is Not Good* and *1.0 Corporations Are Not Good*.

Underneath these new truths hides an even bigger one. Presently the implicit goal of the human system is the goal of its dominant life form, *Corporatis profitis*. The goal is maximization of short term profits. Once the root cause of the Life Form Proper Coupling subproblem is resolved the new goal of the system will be the goal of *Homo sapiens*: optimization of long term quality of life for those living and their descendents.

New truths lead to new worlds. Won't this one be a delight to live in?

Summary and Implications

All problems arise from their root causes. Root causes are the fundamental forces causing a system to behave the way it does. Once a problem's root causes are found and resolved, those forces change to entirely different ones, causing the system to shift into an entirely new mode.

This suggests that once the root causes of the sustainability problem are resolved, the human system will shift gears into a new mode that is inherently sustainable. This can happen amazingly fast because if the correct root causes are found, there is no long transition mode. There are only the two main modes of unsustainable and sustainable. The system can flip instantaneously from one mode to another, just as a car shifts in seconds from reverse to forward gear.

So how can we find those root causes, those fundamental forces?

To fill that gap Thwink.org has developed a formal problem solving process specifically for this type of problem. The System Improvement Process (SIP) was designed, applied, and iteratively improved over a period of seven years. SIP differs radically from conventional approaches so it has reached several **novel conclusions**. These include:

1. The sustainability problem cannot be solved unless it is first decomposed into the right smaller subproblems. At one stroke this changes the problem from insolvable to solvable.
2. Four main root causes were found, one for each subproblem. Popular solutions address none of these root causes. This explains why, despite over forty years of often brilliant and heroic effort, environmentalism has been unable to solve the sustainability problem.
3. The sustainability problem is itself a symptom of an even deeper, bigger problem: the Broken Political System Problem. *That is the real problem to solve.*
4. Analysis shows the root causes of the Broken Political System Problem cannot be resolved by a direct frontal assault. It appears they can, however, be resolved indirectly by striking where the enemy (*Corporatis profitis*) is weakest with Common Property Rights.
5. Once the first few successful Common Property Rights stewards begin to thrive, the life form will self-replicate and cover the globe in as little as

twenty years. In other words it appears that the sustainability problem can be solved in as little as about twenty years.

New types of problems require new tools. Newton had to invent calculus to crack the problem of why types of motion occur. Galileo had to build his own telescope to see with his own eyes what was up there in the heavens before he could make the observations that led to eventual acceptance of the heliocentric theory and the founding of modern physics. Following in this tradition, this paper has attempted to sketch what the **key new tools** needed to crack the sustainability problem might be. These are:

1. Root Cause Analysis
2. Problem Driven Problem Solving
3. Model Based Analysis

These tools are not for everyone. They require some serious finesse and training, as well as a whole new way of thinking. But once you've made the switch everything changes, just as it did for Newton and Galileo. You can SEE what could not be seen before. You can EXPLAIN what could not be explained before. Your work is no longer work. Instead, it's more like a playful romp on the beach because now your insights emerge from systematic inspection of the fundamental layer of the problem. Gone is the endless drudgery and frustration of being stuck in the mud of the superficial layer.

This has happened before. It's why Sir Isaac Newton, looking back on his own discoveries, wrote this:

> I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.

In that great ocean of truth lie the root causes of the sustainability problem.

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Endnotes

[1] The classic example of "similar solution wish lists" is the United Nation's Agenda 21. Adopted by 178 governments at the first Earth Summit in Rio de Janeiro in 1992, Agenda 21 contains long lists of "activities" to promote sustainable development. These actions have not been implemented on anything more than a token basis. Solution failure is widespread but only weakly acknowledged, such as by titling the 2012 version of Agenda 21 *The Future We Want*. More realistic would be a new document titled *The Analysis We Need*. It would sell the idea that only a proper root cause analysis can solve the problem. Wish lists can't.

Ironically, "root causes" appears six times in the 1992 version of Agenda 21. For example, section 2.20 states "Such regulations should address the **root causes** of environmental degradation…." This is a mere platitude, however, since the document makes no effort whatsoever to perform or promote root cause analysis.

Twenty years later in Rio + 20, little has changed: "The official discussions will focus on two main themes: How to build a green economy… and how to improve international coordination for sustainable development." The single theme should center on root cause analysis. (Quote from www.un.org/en/sustainablefuture/pdf/conf_brochure.pdf)

[2] Earlier work at Thwink.org uses the term "social proper coupling" rather than "life form proper coupling." We are changing to the latter to avoid confusion with "social sustainability," one of the three pillars of sustainability.

[3] Regarding: "Then we'd have all three pillars of sustainability represented. Subproblems E and F could also be added to Table 1." – If this is done we must remember that subproblems D, E, and F are symptoms of the Broken Political System Problem embodied in subproblems A, B, and C. Solution strategies for D, E, and F will not work unless they are part of a larger plan to resolve the root causes of A, B, and C. The Common Property Rights solution element is part of such a plan.

[4] Regarding: "The implicit goal of the human system is maximization of the short term value of profits." – The most obvious proof is the universal prominence given stock market indexes. These appear on the front page of the world's most influential newspaper, The New York Times, as well as many more. All news on the front page changes daily, except market indexes. The same holds for many television news shows. The indexes are always there, because those dependent on that information and/or driving the wheels of the system don't want to take their eyes off the road. They want those indexes on the dashboard all the time because that's what they need to tell how well they are driving.

Stock market indexes are composites of the market's consensus on what the net present value of profits are. They are the world's best measure of how well *Corporatis profitis* is maximizing short term profits.

[5] The metaphor of war and the enemy is employed only to dramatize our points and allow use of Clausewitz's body of theory. It is not meant to demonize large for-profit corporations, corporate managers, or corporate proxies. Each is a single social agent taking its behavior cues from the system it lives within. To change their behavior one must change the system.

[6] For information on the Southern Environmental Law Center (SELC) and GreenLaw see their websites at: southernenvironment.org and greenlaw.org.

[7] See chattahoochee.org/mission-and-history.php.

[8] Quoted text retrieved June 11, 2012 from southernenvironment.org/about/from_our_president.

[9] Twenty years may sound impossibly fast, but consider that Common Property Rights is like a new technology. People consistently underestimate how far new technologies will go in twenty years. Examples are the early Industrial Revolution, conversion to electricity, the personal computer, the internet, and social media like Facebook and Twitter. All these and more totally transformed some aspect of society in a single generation or less, though when the change started it looked like it would take much longer. "We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten." (Bill Gates, unsourced)

[10] Definition of radical from dictionary.reference.com/browse/radical, accessed June 13, 2012.