

SUSTAINABLE CIVILIZATION: COHESION, CAPACITY, AND EXTERNAL CONTACTS

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Abstract: Human civilizations cover the Earth. In the last several thousand years, many civilizations have been created. Several still exist. Over the next few hundred years, they will change. The most likely scenarios are:

- ▶ All current civilizations come to a quick end in conflict with each other. After several hundred years, new civilizations arise. Many have values and policies strongly contrasting with those of today's civilizations.
- ▶ A new civilization is formed from a combination of today's, which then collapses in civil disorder. After a few hundred years, new civilizations arise, many with values and policies strongly contrasting with those of the world's current civilizations.
- ▶ Today's existing civilizations coexist peacefully until they, in turn then together, dissolve in civil unrest. After a few hundred years, new civilizations arise, many with values and policies strongly contrasting with those of the world's current civilizations.
- ▶ Today's existing civilizations change their values, over the course of a few decades, to embrace values of sufficiency and sustainability. They coexist peacefully until, in a few hundred years, the coalesce into a new civilization.

This paper describes a model to simulate the characteristic behavior modes of one civilization's extent and intensity, and how it relates to a second civilization. These modes include externally generated pressure collapse; internal loss of cohesion and resource shortage collapse modes; and a mode of sustainable civilization.

Problem Statement

People are everywhere. For ten thousand years and more, people have increased in number and organization. The increases have not been uniform or evenly distributed, but the long term trend has been overwhelming. In the last twenty-five years, there has been a growing cry in Western civilization that human population growth cannot continue indefinitely.

Arnold Toynbee defined a civilization as "an endeavor to create a state of society in which the whole of Mankind will be able to live together in harmony, as members of a single all-inclusive family. This is, I believe, the goal at which all civilizations so far have been aiming unconsciously, if not consciously" (p. 44). "A civilization can be defined as 'an intelligible field of study'; as being the common ground between the respective individual fields of a number of different people; and as being representative of a particular species of society" (p. 45). He further categorizes (and subcategorizes) civilizations as independent (unrelated to others; unaffiliated to others; and affiliated to others); satellite;

and abortive. He says any listing "cannot be conclusive and is subject to ... various ... reservations" (p.72). Here are some examples: Andean (independent, unrelated); Sinic (independent, unaffiliated); Western, Islamic (both independent, affiliated to both Syriac and Hellenic); Tibetan (satellite); and Nestorian Christian (abortive, eclipsed by Islamic).

There is a commonality and a cohesion to a civilization that transcends states and nation. Religion, language, art, and science; politics, custom, architecture and literature are all variations on a theme within a civilization, by comparison with other themes carried in other civilizations. The variation within Europe or within China in space and time in these areas is seldom if ever as great as the variations between Europe and China. Our prospects for future are the same.

In *Beyond the Limits*, Meadows, Meadows, and Randers have succinctly stated the case in systemic terms:

- ▶ With current values and policies, a smooth approach to limits will not happen. Nonrenewable resource limitations or pollution effects will erode the planet's carrying capacity, causing a population collapse.
- ▶ Family planning, population control, and the pursuit of "sufficient" income rather than "more" -- a change of values where everyone wants no more than two children and a moderate income -- are by themselves an insufficient to change the outcome of the first scenario.
- ▶ Value changes and emphasis shifting can, in combination, provide a relatively smooth transition to a sustainable population level -- if the desired standard of living is not too high, and if the changes are relatively soon in coming. But these levels are only sustainable for a few centuries at most. Eventually a way of life dependent on nonrenewable resources must wane as the resources wane. Nonrenewable resources are a bridge to get us to a renewable future -- or the end of life as we know it.

Scattered through their work are references to what economists call 'externalities'. They refer to erosive feedback loops, "most notably social erosion, in which a breakdown in social order feeds upon itself to create further breakdown." (p. 130). "World3 has no explicit war, no labor strikes, no corruption, no trade barriers, and its simulated population does its best to solve perceived problems, undistracted by struggles over political power" (p. 117). One clue indicating overshoot is that "[c]onflicts increase, especially conflicts over sources or sinks. There is less social solidarity, more hoarding, [and] greater gaps between haves and have-nots" (p. 139). "We have to remember too that the World3 model has no military sector to drain capital and resources from the productive economy. It has no war to kill people, destroy capital, waste land, or generate pollution. It has no civil strife ... floods, earthquakes, volcanic eruptions, Chernobyls, AIDS epidemics, or surprising environmental failures. In these senses it is wildly optimistic. The model could be representing the uppermost possibilities for the 'real world'" (p. 178).

Michael Mann categorizes social power into four principle sources: economic, ideological, military, and political. Economic sources are stocks like population, land, capital, and knowledge -- lessened by pollution. Ideological sources are oriented towards values and goal selection. They provide meaning, behavioral norms, and aesthetic and ritual practices. "Ideological organization comes in two main types.... It develops a powerful autonomous role when emergent properties of social life create the possibility of

greater cooperation of exploitation that transcend the organizational reach of secular authorities ... The second configuration is ideology as immanent *morale*, as intensifying the cohesion, the confidence, and, therefore, the power of an already established group" (pp. 23-24). Political sources formulate and administer policies. Military sources are special forms of economic sources applied against other civilization. These various sources have nonuniform extents and intensities in time and space, and constitute the infrastructure of a civilization.

The genesis of a civilization is in a time and place where competition is fragmented, experimentation is common, and a variety of protocivilizations compete. They might be just beyond the reach of an existing civilization, or in the ruins of a dead civilization. By trial and error, through confrontation and cooperation, a protocivilization establishes itself as first among equals. Its genesis may be quick or slow, and may or may not be affected by neighboring full civilizations. Once a decisive competitive advantage is established, it quickly grows to the limits of its infrastructure to support and advantage to sustain. The expansion is either conducted by military means or diffused by economic or ideological means.

Once established, the civilization has an ebb and flow to it, as ideological, economic, political, and military changes occur separately and together. If pressure from other civilizations is relatively modest and the carrying capacity is great, as in China or India (Mongols and Timurids notwithstanding), the civilization may endure for millennia. If pressure is great, as it was for ancient Egypt, or carrying capacity modest, the civilization may be overwhelmed and absorbed, at least in part, into successors.

These pressures vary with the relative strengths of adjoining civilizations economically, politically, ideologically, and militarily. The longer the contact, the more likely the pressures are to be released through trade, conquest, or proselytization. In the last two millennia, western Eurasia has seen its civilization count stay constant at two, but neither of the civilizations of 2,000 years ago have survived. Several changes have come and gone to turn Greco/Roman and Iranian civilizations into Western and Islamic, respectively. Greco/Roman was changed by Germanic and Slavic inclusions and reformulations; Iranian by Arabic and Turkic. China and India in contrast have been bowed but unbroken by encounters with other civilizations and have had much greater continuity, even though they also have undergone great changes. China in particular had an interesting dynamic with Manchuria and Mongolia, in which Mongolia periodically flooded China without abruptly changing its nature at any time yet transplanting the seeds of renewal from their Manchurian nursery. [Barfield]

Quite apart from external pressures, civilizations depend upon the ability of their land and resources to carry them. Large parts of the Mediterranean countries, Middle East, Africa, and India no longer support the populations they once did. In places like Easter Island, the Yucatan, and the American Southwest, civilization was rendered impossible until recent times by erosive overuse of land and other nonrenewable resources. In these cases the declining resources themselves were the ultimate but not the proximate cause of the local civilization collapse. A loss of cohesion as demonstrated by increased warfare, civil disorder, and (where possible) emigration released the internal tension and incidentally ended civilization in the affected area.

The late 20th century world has five major genera of civilizations -- African, Western, Islamic, Indian, and Chinese -- with several species in each. They interact increasingly with each other. Unlike 2,000 years ago, they have no 'uncivilized barbarians' beyond their collective boundaries. For the last 500 years, the interactions among the various civilizations have become more important than relations beyond them. A new global civilization is forming from the compost of the old, watered by the torrents of trade, travel, and communications flooding the world.

Under enough stress, individuals as well as entire civilizations will cross into irrational behavior. We have a choice, in setting values and policies, what our collective path is these next 200 years. The economic and military paths will be consequences of those choices. There are many possible outcomes: cascading civil strife from place to place, increasing in violence and frequency; escalating warfare, also increasing in violence and frequency; or a coalescent world civilization living within sustainable limits. This list is neither exhaustive nor conclusive.

Model Structure

The model built to analyze a civilization has nine state variables: internal population; land; nonrenewable resources; military effectiveness; the fraction of the military in garrisons; the mobile fraction of the military; cohesion; and the effectiveness of the secondary civilization's military. The model is generalizable enough to include capital, knowledge, and more civilizations, which will be addressed in a subsequent paper.

Population is increased by births and decreased by deaths. The net birth rate is a function of population and the current land utilization capacity. Land use is driven by consumption needs. Land acquisition is done by the military. In this model, land fertility is assumed to be constant. Nonrenewable resources are reduced by depletion. At low levels, resource availability constrains consumption.

The military's size is a function of the population free from production duties. It also has a level of effectiveness, increased by cohesion and knowledge, and dual conquest and garrison roles. These roles are shifted over a period of 25 years, depending on how much territory there is to garrison and how much territory is beyond the frontier. **Mobilization** is one of five structural levers used in the simulations. If there is no frontier, all the troops will be on garrison duty. Frontiers arise when a civilization cannot, typically for logistic or economic reasons, extend itself over all lands adjacent to it. **Logistic limits** are the second of the structural levers in the simulations. If there is little territory to garrison, most of the military will be mobile. In the absence of conflict, strength differentials diffuse across the frontier, eventually disappearing. The outer 1/8 of a civilization's environment is difficult to access and rule, with the frontier being only half as accessible as the inner 7/8.

The development of competitive **innovations** is the third lever used in simulation - a 10% (mostly military in the simulation) advantage in year 10 for the primary civilization, a 1% advantage once in each 500 years for the secondary civilization. **Cohesion** affects, among many other things, the stiffness of military resistance. It is built over time by the sheer size of a civilization, and is the fourth lever used in simulation. The changing strength of civilization A is compared to the fixed strength of civilization B, and land changes hand accordingly. **Non-renewable resource limits** restrict a civilization's ability

Parallel Program

to sustain and defend itself, and directly undermine its cohesion. For civilizations that depend on them, their absence is a terminal shortcoming.

Simulations

The model was put through several dozen simulations. Four types of response were seen:

- Finite lifetime, with growth, life, then collapse under external stress, and finally replacement:

Logistic Limits	Cohesion	Mobilization	Secondary Innovations	Resource Limitations	<i>Success occupying available land</i>
yes	yes	yes	yes	no	<25% @ 60 years; 40% @ 110 50% @ 620 60% @ 710 70% @ 740 95% @ 780
yes	yes	yes	no	no	<25% @ 60 years; 40% @ 110 50% @ 900 60% @ 1220 70% @ 1250 95% @ 1300
no	yes	yes	no	no	<25% @ 60 years; 40% @ 115 50% @ 900 60% @ 1220 70% @ 1250 95% @ 1300

This mode illustrates the growth of a civilization to its effective limit, followed by the diffusion of its knowledge beyond the frontier. It also illustrates the military shift from building to maintaining. The pressure it was able to generate in growth is greater than it can generate in maintenance. Eventually another civilization, if given the opportunity and resources, will overcome it. All scenarios in this mode have cohesion, military mobilization/demobilization, and no resource constraints.

At the beginning of a civilization, a community develops a competitive advantage with respect to nearby protocivilizations. This advantage, once applied, begins a rapid growth phase. In the case of Rome, logistic and economic factors left it with a substantial frontier - both in the east with Persia, and in the north with the Germans. Once their hegemony was established and the frontiers drawn, their competitive advantage was institutionalized. Subsequent innovations were greatly slowed, and the army shifted from regular combat to garrison duty. Soldiers at retirement were given grants of land. Their descendants, while

nominally obligated to serve in the legions, were as a practical matter difficult to mobilize, especially outside their province. The long life of the empire was characterized by three processes that ultimately brought the civilization to an end: numerous people outside the empire; a slowing of innovation; and a shift of the military from mobile to sedentary. Although these were the ultimate causes, the coup de grace was made possible by the loss of cohesion, not as a proximate result of those three causes. Cohesion and demobilization are dual keys to dominant success. They also are the seeds of its failure.

► Indefinite lifetime as the only civilization:

Logistic Limits	Cohesion	Mobilization	Secondary Innovations	Resource Limitations	Success occupying available land
no	no	no	no	no	>95% @ 160 years
yes	yes	no	no	no	>95% @ 50 years; 99% @ 80 years
no	yes	no	no	no	>99% @ 60 years
no	no	no	yes	no	>99.9% @ 260 years

Without resource limitations and with a permanent mobile military, a civilization can build and sustain itself indefinitely. New competitors are quickly extinguished. Cohesion makes a quick victory more likely than it would otherwise be. The first of these scenarios is like the last. In the absence of the other levers, an innovative advantage will enable a civilization to prevail over its rivals.

► Indefinite lifetime in coexistence with another civilization:

Logistic Limits	Cohesion	Mobilization	Secondary Innovations	Resource Limitations	Success occupying available land
yes	no	no	no	no	stable 12.5% @ 350
yes	no	yes	no	no	stable 50% @ 500
yes	no	yes	yes	no	stable 50% at 370
no	no	yes	no	no	stable 50% at 300

Cohesion provides a positive feedback loop between initial success and later power and momentum in further head-to-head competition. Without it, the exchange of information in proximity makes a peer relationship inevitable. The scenario with just logistic limits activated exists because the capabilities of the dominant civilization are diminished at the great distance of the secondary civilization.

► Finite lifetime, with growth, life, then collapse under external stress, without replacement:

Logistic Limits	Cohesion	Mobilization	Secondary Innovations	Resource Limitations	Success occupying available land
any	any	any	any	yes	varies, but limited

A civilization depending on nonrenewable resources will eventually run out of them. Any future civilizations in that place will have only renewable resources to work with, and so will have a much harder time starting than its predecessor did. The retreat caused by

resource limitations becomes a route in the face of enemies. In their absence, the sheer momentum of retreat undermines the cohesion that makes civilization possible. Logistic limits may provide relatively convenient respites, but once essential resources are in critical supply, the unraveling of a civilization is all but assured.

Conclusion

Many disciplines have important knowledge to contribute to humanity's ability to survive the next few years, decades, and centuries. Historians in particular have received insufficient attention in the growing concern for our planet's future. People have been in many past situations that, if better known, would help us with our todays and our tomorrows.

Beyond the Limits, even in its most optimistic scenarios, outlines a slow decline over several centuries as nonrenewable resources are exhausted. Our knowledge, our care, and our actions are the most important renewable resources we can draw on to ensure the future of civilization on Earth.

Barfield, Thomas J. 1989. *The Perilous Frontier*. Blackwell Publishers

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Meadows, Meadows, and Randers 1992. *Beyond the Limits*. Chelsea Green Publishing.

Toynbee, Arnold 1972. *A Study of History*. Oxford University Press.

- ☐ Barbarian_Military
 - ☒ Init_Barbarian_Military
 - ☒ +dt*(Barbarian_Military_Learning)
- ☐ Builder_Fraction
 - ☒ Initial_Army
 - ☒ -dt*(Settlement_Rate)
- ☐ Cohesion
 - ☒ Init_Cohesion
 - ☒ +dt*(Bonding)
- ☐ Cohesive_Force
 - ☒ I_Cohesive_Force
 - ☒ +dt*(Building_rate)
- ☐ Land
 - ☒ Total_Area/2
 - ☒ +dt*(Expansion_Rate)
- ☐ Maintainer_Fraction
 - ☒ Total_Army-Initial_Army
 - ☒ +dt*(Settlement_Rate)
- ☐ Military_Effectiveness
 - ☒ Barbarian_Effectiveness
 - ☒ +dt*(Civilization_Military_Learning)
- ☐ Population
 - ☒ Init_Population
 - ☒ +dt*(Flow_rate)
- ☐ Resources
 - ☒ Init_Resources
 - ☒ +dt*(Acquisition_Rate)
 - ☒ -dt*(Depletion)
- ☒ Acquisition_Rate
 - = IF(Resources < 0, 0, Expansion_Rate*Resource_Density)
- ☒ Barbarian_Military_Learning
 - = 0+MAX(-Military_Learning,0)+PULSE(Barbarian_Improvement, 100, 100)
- ☒ Bonding
 - = (I_Cohesion-Cohesion)/TA_Cohesion
- ☒ Building_rate
 - = (I_Cohesive_Force-Cohesive_Force)/TA_Cohesive_Force
- ☒ Civilization_Military_Learning
 - = MAX(0,(Military_Learning))+PULSE(Military_Improvement, 10, 2000)
- ☒ Depletion
 - = MIN(Desired_Depletion,Max_Depletion)
- ☒ Expansion_Rate
 - = (Max_Area-Land)/TA_Area
- ☒ Flow_rate
 - = (I_Population-Population)/TA_Population
- ☒ Settlement_Rate
 - = (D_Maintainers-Maintainer_Fraction)/TA_Army_Fractions
- ☐ All_Land
 - = Total_Area
- ☐ Barbarian_Area
 - = Total_Area-Land
- ☐ Barbarian_Effectiveness
 - = Barbarian_Military
- ☐ Barbarian_Power
 - = Barbarian_Area*Barbarian_Effectiveness*Barbarian_Military_Fraction
- ☐ D_Maintainers
 - = Total_Army*Home_Land/All_Land
- ☐ Desired_Depletion
 - = Population*Desired_Depletion_per_Capita_per_year

Parallel Program

```

() E_Expansion_on_Diffusion
= IF(ABS(Expansion_Rate) > .01, 0, 1)
() E_of_Shortages
= MIN(1, Max_Depletion/Desired_Depletion)
() I_Cohesion
= ABS(DELAYINF(Expansion_Rate, 100000)) + Land/INIT(Land) * INIT(Init_Cohesion)*E_of_Shortages
() I_Cohesive_Force
= Cohesion*Population
() I_Military
= Military_Fraction*Population
() I_Population
= Land*Carrying_Capacity
() Logistic_Limits
= GRAPH(Land/Total_Area,0,0.125,[1,1,1,1,1,1,1,1,1,1"Min:0;Max:1"])
() Max_Area
= Total_Area*(Military_Power/(Military_Power+Barbarian_Power))
() Max_Depletion
= MAX(Resources, 0)/Min_Time_to_Deplete
() Military_Fraction
= IF(Mobilization_Switch=1,Buider_Fraction,.1)
() Military_Learning
= (Barbarian_Military-Military_Effectiveness)/TA_Military_Learning*E_Expansion_on_Diffusion
() Military_Power
= I_Military*Military_Effectiveness*Logistic_Limits*IF(Cohesive_Switch = 1, Cohesion, 1)
◇ Barbarian_Improvement
= 0
◇ Barbarian_Military_Fraction
= .1
◇ Carrying_Capacity
= 1
◇ Cohesive_Switch
= 0
◇ Desired_Depletion_per_Capita_per_year
= 1
◇ Home_Land
= 100
◇ Init_Barbarian_Military
= 10
◇ Init_Cohesion
= 1
◇ Init_Population
= INIT(I_Population)
◇ Init_Resources
= 240000
◇ Initial_Army
= .1
◇ Military_Improvement
= 1
◇ Min_Time_to_Deplete
= 25
◇ Mobilization_Switch
= 0
◇ Resource_Density
= 1
◇ TA_Area
= 3

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◇ TA_Army_Fractions
= 10
◇ TA_Cohesion
= 10
◇ TA_Cohesive_Force
= 10
◇ TA_Military_Learning
= 10
◇ TA_Population
= 10
◇ Total_Area
= 100
◇ Total_Army
= .2