GROWTH, SUSTAINABILITY, AND THE POWER OF SCALE

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Summary

This work examines the relationship between growth and sustainability over the past 50 000 years of human cultural development. The dual objective is to identify the causes and consequences of growth in the scale of sociocultural systems. Sustainability is treated here as the universal human problem of how to maintain viable cultural systems within the scale limits imposed by particular social power arrangements, technologies, and environments. This broadly-based approach places tribal cultures, ancient agrarian civilizations, and globally integrated commercial cultures within a single explanatory framework involving culture scale, cultural processes, and human decision-makers. There are three crucial assumptions: 1) Larger scale social systems are inherently less sustainable than smaller systems, because of diminishing returns to social and material costs; 2) Growth will ultimately prove unsustainable; and 3) Perpetual growth is neither natural, nor inevitable. A simple mathematical model of cultural development is used to demonstrate that scale increases can be expected to concentrate power and reduce sustainability. The anthropological evidence suggests that growth beyond the level of small-scale, domestically organized societies is an *elite-directed* cultural process that occurs because it concentrates social power in direct proportion to increases in scale. More importantly, elite-directed growth may reduce sustainability by disproportionately impoverishing more people than it enriches.

Growth over the past 10 000 years increased the scale of local, regional, and global populations, and accelerated the intensity of resource use. Larger scale cultural systems became less democratic, less just, and consequently less sustainable, simply because they grew larger under elite direction. It will be shown that larger scale systems can remain democratic, just, and sustainable, but this is likely to occur only with very intentional democratically-based development planning that emphasizes broad social objectives rather than narrow economic goals. Sustainability is an issue of household well-being and a resource allocation, rather than an economic production problem. The fundamental insight of scale theory is that the growth process will be intrinsically inequitable in the absence of deliberate and powerful democratic countermeasures. With social power more equitably distributed, destabilizing growth would cease, and truly sustainable societies could be created.

1. Why Scale Matters

It is important at the outset to distinguish between growth and development. These are closely related concepts and are often treated as synonymous, but growth can occur without development, and vice versa. Growth is the increase in some quantitative measure such as the number of people in a given society, the amount of material wealth, or the standard of living. Continuous growth leads naturally to changes in the scale, or magnitude of a given quantity, until it reaches natural limits that may only be overcome by qualitative change. Development refers to qualitative changes that occur through time. Cultural development may involve organizational or technological changes that allow a society to grow larger, increase wealth, or help people maintain themselves in the face of environmental changes that may reduce the natural resource base. Thus, development can be a means to maintain growth, and/or it can be a means to maintain a given set of culturally defined values within desirable parameters, including human well-being. In the contemporary world dominated by commerce and capital, the members of elite institutions almost universally regard growth to be a desirable goal, whether growth of markets, national economies, aggregate consumption levels, stock prices, or business sales and profits. Indeed, the most widely distributed and therefore dominant idea is that unlimited economic growth measured as wealth production or capital accumulation is the defining feature of capitalism. The prevailing assumption is that economic growth benefits society as a whole. However, close inspection shows that the social outcome of growth is paradoxical, because order of magnitude changes in the scale of societies or capital can be expected to concentrate social power. This is because the size of things in nature, including household wealth and income, is empirically related to their rank frequency distribution, such that larger things are less common than smaller. Growth amplifies these natural differences.

Social power can be defined as whatever means people use to achieve their goals. When social power becomes more concentrated in a society, households ranked lower on the power scale may have difficulty meeting basic needs. Power imbalances can make cultural systems less sustainable. In this section the power concentrating effect of growth will be explored as a “natural” expression of mathematical power laws using a simple model of cultural evolutionary development. The effects of scale change will be simulated by first ranking cultures in six order of magnitude population levels in the following development sequence:

1. tribal bands and villages (500);
2. chiefdoms (5000);
3. city-states (50,000);
4. agrarian empires (5 million);
5. commercial nations (50 million);
6. global culture (5 billion).

These six scale ranks represent the most crucial organizational turning points in the previous 50 000 years of cultural development, but as will be shown later, these scale levels are not always isomorphic with other key technological or cultural changes. Social power is uniformly measured in the simulation model as the number of arbitrary production units representing the subsistence equivalent of a bushel of wheat, that individual households control. The amplification effects of technological change are removed in the development model by treating per capita production as a constant 50 grain-equivalent units (1 unit = 1 bushel of wheat, approximately 27 kilograms), based on an estimate for the general effectiveness of pre-industrial technology. The distribution of power is modeled on a household basis, assuming an average household size of 5 persons throughout. The growth model also assumes that social power is unequally distributed to households according to a constant pattern, in order to better isolate the pure effects of scale change. The measures of social power generated in the model do not pretend to great precision. They are intended to suggest the general magnitude of scale effects, given the model's theoretical assumptions.

It is remarkable that in many modern commercially organized societies the size distribution of household income, taken as one measure of the distribution of social power, empirically resembles the rank frequency distributions of animal species, earthquakes, and avalanches. Like many things in nature, households with large amounts of social power are naturally less common than households with little social power. This inverse relationship between size and frequency follows logarithmic power laws, such that size increases and frequency declines by powers of ten. These distinctive power law distributions are skewed far to the right of the arithmetic mean, and are not bell-curve normal distributions around the arithmetic mean. Rather, they are lognormal distributions that display a normal distribution around the geometric mean, and approximate straight, down-sloped lines on double log.

Social theorists have been aware of the presence of these law-like mathematical relationships in human affairs for many years. Regular relationships have been shown between rank and frequency in many aspects of human life from words to cities, that can be described by the simple equation ($y = c / x$) for an equilateral hyperbola. At the end of the eighteenth century, Italian economist Vilfredo Pareto found that the proportion of people receiving personal incomes of given sizes at upper income ranks was virtually a statistical cross-national constant. He attributed income concentration to innate differences between people. However, these patterns are far more unequal than normally distributed individual differences, and thus must reflect other natural and cultural dynamics. Other researchers have shown that increases in either wealth or population can push any social system toward greater inequality in the absence of cultural regulations to regulate the otherwise natural distribution of power.

The present model (see Table 1) arbitrarily selects a constant lognormal income distribution based on a coefficient of inequality of G=0. 59 (based on the Gini coefficient). This is on a scale in which 0 represents complete equality with every household receiving the same income, and 1 represents complete inequality, where one household receives all the income. Income distributions are commonly graphed on a Lorenz Curve where the cumulative proportions of households and income are ranked from bottom to top. The Lorenz Curve for the 0.59 distribution used in the present model shows that the bottom 10 percent of households has 1 percent of income, the bottom 20 percent has 2 percent, and the bottom 90 has 55 percent (see Figure. 1). Conversely, measured from the top down, the top 10 has 45 percent. The 0.59 distribution is skewed somewhat toward inequality, but is not an extreme form of inequality, and may actually approximate a "natural" rate of inequality based on differences in natural ability of household heads, experience, luck, and stage of domestic cycle. It approximates the distribution of wealth in real estate in the United States in 1798, and is far less than the 0.85 inequality in property ownership that existed in Europe at the same time. It is likely that real ancient city-states and agrarian empires showed much higher inequality than the 0.59 rate used in the present model. Thus, this first version of the model is very conservative and can be used to demonstrate the power concentrating effects of pure scale.

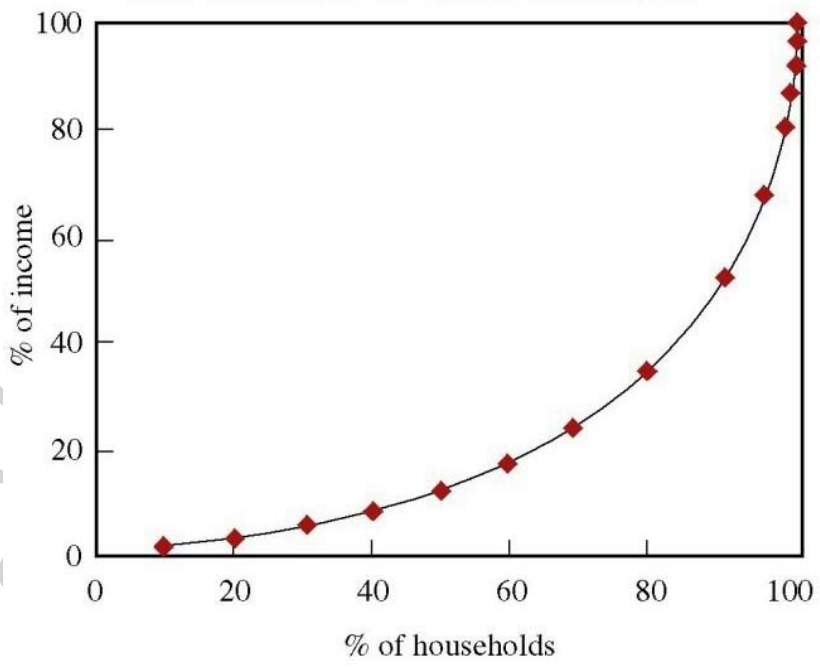

Figure 1. Lorenz Curve of Income Model, G=0.59

Rank	Lognormal Rates		Cumulative Distributions		Rank Distributions	
	Households	**Power**	**Households**	**Power**	**Households**	**Power**
	Hr	Pr	Hr*1000	Pr*250 000		
1	0.0001	0.005	0.10	$1250	0.10	$1250
2	0.0002	0.009	0.20	$2250	0.10	$1000
3	0.0005	0.017	0.50	$4250	0.30	$2000

4	0.001	0.027	1.00	$6750	0.50	$2500
5	0.002	0.043	2.00	$10750	1.00	$4000
6	0.005	0.079	5.00	$19750	3.00	$9000
7	0.01	0.12	10.00	$30000	5.00	$10250
8	0.02	0.19	20.00	$47500	10.00	$17500
9	0.05	0.32	50.00	$80000	30.00	$32500
10	0.1	0.45	100.00	$112500	50.00	$32500
11	0.2	0.63	200.00	$157500	100.00	$45000
12	0.3	0.74	300.00	$185000	100.00	$27500
13	0.4	0.82	400.00	$205000	100.00	$20000
14	0.5	0.88	500.00	$220000	100.00	$15000
15	0.6	0.92	600.00	$230000	100.00	$10000
16	0.7	0.95	700.00	$237500	100.00	$7500
17	0.8	0.98	800.00	$245000	100.00	$7500
18	0.9	0.99	900.00	$247500	100.00	$2500
19	**1**	**1**	**1000.00**	**$250000**	100.00	$2500
					1000.00	**$250000**

Average Social Power

Top 1	$6,750	1st Quintile	$788
Top 5	$3,950	2nd Quintile	$238
Top 50	$1,600	3rd Quintile	$125
Top 5%	$1,600	4th Quintile	$75
Top 10%	$1,125	5th Quintile	$25

$1 unit of social power = 1 bushel (27 kilograms) of wheat
productive technology = $50 per capita, household = 5 persons

Table 1. The Simulated Distribution of Social Power in a Model Chiefdom, 5000 People, 1000 Households, Gini Coefficient = .59

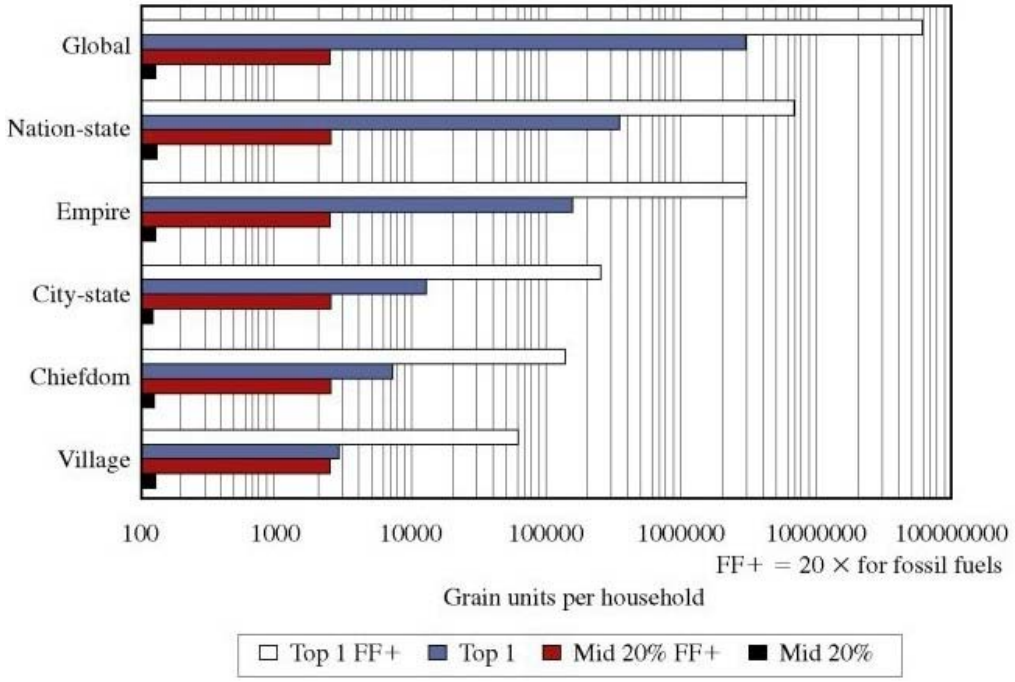

Figure . 2. Average Household Incomes by Social Scale, Household Rank, & Energy Base, G=0.59

Given a constant proportional distribution of social power among households, scale increase will have no apparent effect on household well-being. Even given the arbitrary inequality rate of 0.59 used in the present model, the top 20 percent will always receive the same share in a tribe of 500 as it does in a city-state of 50 000 (Figure 2 and Table 1). Theoretically, if the proportional distribution remains constant, only unequally distributed technological, or organizational changes in production will raise or lower the absolute social power and material well-being of particular households. However, scale change will concentrate social power whenever there are cultural limits on the number of ranked positions in a social power hierarchy. Elites are here defined as those individuals occupying specific ranked positions, such as the top 1, top 5, top 50 individuals, and so on. In all societies except domestically organized tribal societies, there is always a single top political office, although it is possible for separate hierarchies to exist in different areas of society and culture. There may for example be a separate hierarchy of religious power, or economic power, in addition to political power. In any culture that ranks individual households by wealth, there will always be a number one wealthiest household. Whenever social power is unequally distributed, scale increase will give a disproportionate share to the top ranked elites counted as a fixed number, as the top 1, top 5, etc. In contrast, the membership of proportionally defined groups such as the top 2 percent, top 5 percent, will by definition increase proportionately with growth in scale, and their relative share of power will remain the same. Although other power-related factors may make it possible for proportionately defined elites to also gain disproportionate power.

It is important to stress that the concentration of elite power considered here affects only the few elites at the very top, and may not produce obvious changes in the overall measures of inequality. When elites are counted as a constant number they will become

a smaller proportion of the population as growth occurs, and they will necessarily receive a disproportionately larger share, even if the rules for the overall distribution of power remain the same. Of course, it can be predicted that elites will seek to use their concentrated power to change the distribution rules to their advantage.

The simulated effects of scale change in the first trial run of the cultural development model are striking. In this test only "natural" inequality is assumed and technology remains at a constant pre-industrial level, nevertheless the concentration of elite power is disproportionate to the magnitude of scale increase. The 10 million-fold increase in population from a tribal society to the global society theoretically produces a 1000-fold increase in social power for the world's top ranked household. A ten-fold increase in the scale of society such as occurs between the tribal village and the chiefdom is matched by a 2.25-fold increase in the power of the highest ranking elite. The 100-fold increase in population from city-state to empire produces a 12-fold power gain for the top elite. These increases in elite social power may seem relatively modest, but they are apparently enough to provide power-seekers with a "natural" incentive to promote further scale increase.

To more accurately model the actual course of cultural development it is necessary to consider how elite-directed cultural changes, beyond the mere mathematical increase in population, further amplify the effects of scale change. In reality, important cultural organizational changes must occur in order for the scale of society to increase. Two crucial variables can be examined at the outset: the technology of production and the distribution of the *social surplus*. The social surplus is defined as the proportion of per capita production in a particular society that is above minimum per capita subsistence needs. Minimum subsistence needs represent the biological minimum of nutrients and shelter that individuals need to receive for a household to successfully maintain itself and reproduce. Nutritionally people need an average of approximately 2000 calories and 50 grams of protein daily. In addition to this amount, different cultures will recognize different, often ranked, materially defined living standards. Based on a generous interpretation of the ancient Roman annual grain ration, the model assumes that 40 grain-equivalent units (bushels) per capita are required to maintain minimum subsistence. Thus, even with no changes in technology, assuming a per-capita production figure of 50 units, 10 units (20 percent of production) remain as a potential per capita surplus that could be socially extracted to support non-food producing elites and their retainers (Table 1).

To make a link between the concentration of power and cultural sustainability it is necessary to consider the significance of the "natural" inequality that we have assumed in the first trial run of the present model. In the model tribal society, approximately half of the households would be expected to receive less than a subsistence share. This is an unrealistically high rate of inequality for cultures in which there are no commodities, territory is communally controlled, and everyone has access to the tools and natural resources needed for subsistence. Furthermore, such inequality is meaningless in this case, because in a tribal society ties of kinship and marriage connect everyone, and reciprocal exchanges guarantee that all receive their minimum needs. Any natural inequalities, whatever their actual rate or cause, are *culturally* reduced, such that crucial shortfalls are effectively eliminated. In a very real sense the primary objective of

domestically organized cultures is meeting the basic needs of all households. Potential surplus production above the 40 unit per capita subsistence requirement is converted to leisure, and remains only as a strategic reserve available to every household in case of emergency. The effect of these cultural arrangements is that the village headman, the top elite, can realize few, and only temporary, personal benefits from any disproportionate share of production that he might receive. There would not be enough elites to form an effective interest group and no accepted cultural means for them to protect their privileges. This also means that there is no cultural incentive for tribal elites to promote system growth, although clearly they might have personal incentives for growth. This absence of growth incentives makes domestic scale cultures inherently more sustainable than any other form of culture.

1.1. Chiefdom Organization: Simple Political Scale Systems

The situation is very different in a chiefdom in which a number of villages are politically and economically dependent on a central head. The top elite, now the chief, can employ whatever natural inequality he might enjoy to sustain a personal retinue. Given the increased scale of the system there will be enough wealth and enough people in the combined households of the top 50 elites to maintain distinct descent lines of "noble" lineages, and this group along with their retinue of dependent beneficiaries will constitute a powerful interest group. Chiefdoms are culturally more complex systems that require a politically directed economy operating above the household level. The political economy must mobilize and direct subsistence resources to sustain its activities, and it must see to the production and distribution of wealth or status objects to secure the loyalty of lower level elites. *Tribute* is an appropriation of domestic-level surplus production above the subsistence level of tribute-paying households. The immediate effect of surplus extraction is that to maintain their previous material level, households must intensify their productive output by working harder and adopting more labor-intensive technology. If the chief, as the top administrator, is able to direct the use of all extractible surpluses his personal power gains can be enormous. In the model chiefdom of 5000 people the advantages for the elite of tribute extraction are clear. The chief's social power would theoretically increase more than 8-fold from 6750 units to 56 250, which would be enough to support a retinue of 280 households at the minimum subsistence level.

The increased sustainability costs of chiefdom organization are also clear. Chiefdoms are relatively high-density societies because they depend on the chief's ability to personally lead, and under pre-industrial technology this means that he can only control several villages within a half-day's travel on foot. Thus, villages under chiefly control must necessarily be relatively large, permanent, and close together. Because of their greater population density and because households must produce an extractable surplus, chiefdoms require more intensive subsistence systems than domestically-organized villages, which means that increased human effort and technology will be needed to increase the rate of food production from a given area of land. More intensive production systems often rely on monocrops, and are inherently more difficult to sustain, because they require permanent cropping, plows, terracing, fertilizer, and irrigation, and place more demands on soil, water, and nutrients. More intensive production systems are also more vulnerable to weather, disease, weed invasion, and

pests, and are thus more likely to collapse. In comparison, domestically directed production systems are low density, extensive systems that can rely heavily on natural processes, and can thus use relatively simple technology and minimal human effort. Smaller-scale productive systems are more resilient and have the reserve capacity to deal with natural fluctuations such as adverse weather conditions, because their full production potential is rarely exploited.

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Biographical Sketch

John H. Bodley is Professor of Anthropology at Washington State University, where he served as department chair from 1992–1996. His BA 1965, MA 1967, and Ph.D. 1970, are from the University of Oregon. He has worked as a field zoologist in Mexico from 1961-1962 for the University of Kansas, and conducted anthropological fieldwork with indigenous groups in the Peruvian Amazon during 1966–1969, and 1976–1977, supported by research grants from the National Science Foundation. He was a visiting researcher at the International Work Group in 1980, and a visiting lecturer at the University of Uppsala in 1985, and the University of Vermont in 2000. He was a member of the American Association for the Advancement of Science Committee on Scientific Freedom and Responsibility in 1991–1994. His principal publications include *Victims of Progress* (1975, 1982, 1990, 1999), *Anthropology and Contemporary Human Problems* (1976, 1985, 1996), *Cultural Anthropology: Tribes, States, and the Global System* (1994, 1997, 2000), and *Cultural Ecology of Amazonian Palms* (with Foley C. Benson, 1979).