SUSTAINABILITY

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ABSTRACT

Theoretical considerations and observations of vegetation dynamics are used to examine constraints to population growth and sustainability.

Introduction

The concept of sustainability has become fashionable largely replacing conservation as the Holy Grail for land use and management. There is therefore merit in considering what sustainability is and whether it can be achieved.

What is sustainability?

Something that is sustainable can be continued in perpetuity. For organisms and natural biological systems this means they must be innately self sustaining and self perpetuating. For systems incorporating human inputs it requires that the inputs can be maintained.

The basic requirement for the perpetuation of organisms is simply that the gains must exceed the losses. For plants this means that the carbohydrate expenditures associated with living must be less than gained through photosynthesis. There must be a profit. The same applies with animals as the gains in energy must exceed the energy needed for the maintenance of life.

This basic requirement whereby sustainability depends on making a profit applies to any land use and business as it does to biological organisms. Organisms die and systems collapse where the return is less than the expenditures.

There is notionally a situation whereby the gains could exactly balance the losses but for this to be viable the system would have to operate at 100% efficiency. As 100% efficiency is not achievable sustainability depends on the returns being greater than expenditures.

Sustainability involves growth through making a profit.

Can it be achieved?

The notion that a system can continue to grow runs contrary to the second law of thermodynamics. Systems must degrade with time hence inputs are required to achieve growth. The growth of organisms produces a decline in the system and the greater the rate of growth the greater the rate of decline of the total system. This is a fundamental paradox of life, that success is ultimately counterproductive. The more we exploit the environment the greater the rate of decline of conditions needed for survival. This applies as much to business as to biological systems.

In seeking sustainability we are seeking the unachievable. The best that can be done is to string things out as long as possible. The main approach adopted up to the current century, and most noticeably in the 20th century, was to increase our capacity to access new resources. Growth has always been enhanced by increasing the extent to which we exploit our environment with developments directed at identifying new resources.

Some now consider that there is a finite limit to our capacity to exploit resources but no one is in a position to know what that limit is. Discoveries have continued to raise the bar and the new horizons extend to planets other than earth. There has been no abatement in our seeking to exploit new resources as this has been an effective means of achieving sustainability.

The alternate means of stringing things out are to reduce the rate of resource exploitation and to increase the efficiency of utilisation. Recycling and reuse are central to increasing efficiency. They involve slowing the rate of decline of resources and thereby the rate of decline of the entire system.

Reducing the rate of exploitation means each individual making do with less and/or reducing the number of individuals. Both of these are diametrically opposed to basic biological drives to reproduce and to appropriate as much resource as possible. Reproduction is as central to human society as to other biological populations. Reducing appropriation reduces viability and hence is diametrically opposed to biological needs and drives for survival.

One assumed difference between humans and other organisms is the conscious awareness of potential long term consequences of our actions. We can consider alternate scenarios and draw conclusions as to what might be in our best interests. However, we have great difficulty in escaping our basic biology hence we continue to breed while complaining about the level of utilisation of resource.

What is a sustainable population?

Businesses built on consumers advocate large populations as that promotes the sustainability of the business. This includes most religions. It does not, however, promote the sustainability of the society. It means spreading the limited resource across a very large number of individuals where this weakens the society. It degrades rather than promotes the sustainability of the community.

Educated societies having well defined limits to development have opted for high levels of individual resource utilisation but limited numbers of people. Breeding rates are low and sometimes below replacement. This is a viable option as it limits the rate of resource utilisation and maintains the capacity to develop means of exploiting new resources. It is socially acceptable as it addresses the innate biological needs for sex and acquisition of resource. It has been possible because technology has removed the nexus between sex and reproduction.

There can be no single answer as to the sustainable level of population because of different views as to acceptable living standards. My answer has always been about half and that cryptic response is as good as any. At a basic level it addresses the circumstance that most estimates are unduly optimistic and fail to take adequate account of factors such as climate variability and disease. However, it also takes account of observations on native vegetation.

The most general ecological rule is that organisms tend to expand to occupy the available space, and hence tend to maximise their utilisation of resource. However, they cannot occupy all of the space, particularly for all of the time. A strategy of occupying all of the space is unsustainable if only because fluctuations in resource availability would cause the system to collapse at some time. For a eucalypt community studied the maximum level of sustainable tree development is around 60% of a theoretical maximum. Also, even taking account of shrubs and grasses, it is necessary to identify a component of bare ground, or unutilised resource, to account for the observed dynamics of the system.

While the maximum realised level of development of the eucalypt community is around 60% of the maximum, the average level is considerably less at around 40%. This arises because of the life cycles of plants and episodic recruitment. Existing individuals control the resource and effectively prevent the recruitment of new individuals. This suppression of competition continues until the existing individuals have declined to a low level at around 20% of the maximum. Theoretically the environment can support more vegetation than is ever present but the community has evolved to a fluctuating sustainable level that is well below the maximum.

Maximising sustainability ultimately involves being conservative. There is no theoretical or practical difference between conservative and sustainable approaches to land use provided conservation is interpreted correctly and not equated with preservation. Addressing sustainability does, however, highlight the essential need for profit.

Build up of Communities

Nature of change

Reference to a build up identifies a need to determine what is increasing. Basic options include:

- Number of individuals.
- Total biomass.
- Rate of reproduction.

The basic options represent different measures of the abundance of organisms. For complex communities the number of individuals provides limited information because of the large differences in the sizes of different forms of organisms. The total biomass identifies the amount of organic material but the contribution of different components can vary considerably. For example, within individuals such as trees the biomass of different components does not identify their relative significance. While all parts of an organism are generally essential for its survival some contribute more to production than others, as with leaves versus the trunks of trees.

The rate of production provides a measure of the level of system function. Together with the total biomass it provides a measure of turnover.

Higher level but potentially more diffuse options include:

- Level of organisation.
- System complexity.
- Level of energy consumption.
- Level of material controlled by individual organisms.

The higher level indicators attempt to better account for the effectiveness of the organic material as well as abundance. For example, most human effort is now expended in increasing the amount of resources used and/or controlled by an individual or society that is not incorporated into organic material. This controlled resource that is not incorporated into individuals is manifest as material possessions. The returns from this effort do not show in the total biomass, population numbers, or the rate of production of organic matter.

The level of organisation and system complexity are abstract notions that can be difficult to quantify. Indicators can be developed but their relevance is difficult if not impossible to determine.

The levels of energy consumption and control of resources are tangible and measurable. They can therefore potentially be useful measures for evaluating the development of individuals and communities.

The key difference between the basic and higher level indicators relates to production and utilisation. The basic indicators address production while the higher level indicators address utilisation. The difference between production and utilisation could be used as an objective and measurable indicator of the level of system development or complexity.

The ratio of production to utilisation is generally taken as a measure of efficiency. The higher the production per unit utilisation the higher the efficiency. However, the effectiveness of an organism can be inversely related to efficiency. An organism is most effective when it can control maximum resource with a minimum level of organic development. In evolution effectiveness can be inversely related to efficiency.

The main uncertainty in this effectiveness measure of complexity relates to the differences between an individual and a community. Optimisation of some form can be assumed to occur with individuals but this does not necessarily translate into optimisation for the community. Gains for one component of a community do not necessarily translate into gains for the community as a whole.

Change

Long Term

The general successional change is given as being from lower to higher organisms and then from lower to higher life forms. An indicative sequence on bare rock would be bacteria, fungi, lichens, mosses, ferns and then flowering plants. With flowering plants the sequence is generally given as being given from grasses and forbs through shrubs to trees.

With each of these progressions there is an increase in:

- The size of the largest life form.
- The total amount of organic material
- The level of production of organic matter.
- The level of energy consumption.
- The level of material controlled by organisms.

All indicators exhibit a pronounced increase with the development of the community.

The key limitation of such an analysis is that the observations are directed at identifying the build up of the community over time. Axiomatically build up only occurs where the gains exceed the losses. The observations do not extend sufficiently in time to observe a decline.

The increase in these indicators over time largely derives from the constraints imposed on the range of observations by the explicit desire to observe a build up.

Long term observations identify that, while biological systems show an initial build up to an apparent plateau at the maximum, there is subsequent decline. The duration of this decline is considerably longer than the combined development and plateau phases.

This pattern of build up and decline can be observed with the development of plant communities and occurs in generalised representations of the evolutionary patterns of the numbers of species in Orders of animals. This pattern is an inevitable consequence of the mode of functioning of biological organisms within the existing constraints.

The observed patterns of development and decline can be schematically derived by assuming that development occurs as exponential growth within a defined upper limit where this is represented by the sigmoidal growth curve. A constant rate of loss is the simplest form of decline where this assumes that the numbers lost depend solely on the numbers present. A constant rate of loss produces an exponential decline in numbers when there is no replacement. Logically, the rate of growth has to be greater than the rate of decline for development to occur.

The existence and common occurrence of the sigmoidal growth pattern has been well established experimentally. The occurrence of exponential decline in populations has similarly been well demonstrated for plant populations, and is usually referred to as reflecting density independent loss.

Combining the sigmoidal growth curve with the exponential decline produces a characteristic growth and decay curve for biological systems commencing with sigmoidal growth to a maximum followed by gradual exponential decay. The interaction between the asymptotic approach to a maximum and the exponential decay produces a plateau around the maximum. As decay commences when development first begins, the maximum observed level of development is always less than the maximum level of potential development.

What Does It Mean for Human Populations?

The theoretically expected patterns are readily observable within societies in the great disparity in the use of resources. Those doing best are effective in appropriating most resource while those that are efficient typically live a hand to mouth existence.

The solution generally proposed as a means of rectifying this socially inequitable situation is to achieve uniform distribution of resources when this does not provide benefits. It does, however, produce detriments as it limits the development of new options. Those struggling to survive in a hand to mouth existence do not have the resources to expend on developing new options where the provision of new capabilities is essential for future societies to survive. With a uniform spread of resources no one has the capacity to develop new capabilities. The stagnation deriving from degrading all to the lowest common denominator serves only to promote decline.

Progress in evolution has involved increased use of resources by individuals. As that approach provides and effective solution it logically should be adopted by human populations. That is, the objective is not to maximise the human population to achieve some notional maximal level but to control numbers so that many or most retain a capacity to develop.

Overall, the notion that there is some level of sustainable human population is erroneous. Even if populations can be raised to some high level that level cannot be sustained. Given the absence of catastrophes the population would decline exponentially. Given catastrophic change the population would collapse dramatically at some time.

As humans are a highly invasive species the occurrence of catastrophic collapse is essentially inevitable. Indeed, catastrophic collapse has occurred historically with civilisations such as the Mayan, and recurrently in North Africa. Until now such collapses have been localised so when one society collapses others elsewhere can grow. However, with global warming the trigger for the collapses, the lack of food, will become synchronised globally thereby increasing the magnitude and extent of the collapse.

Any suggestion that there is no simple solution serves no purpose other than to placate readers. The requirements are to reduce the overall use of resources while maintaining the concentrated use of resources needed to achieve developments. This requirement can only be met by reducing the size of the human population to well below its current level.

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