

Measuring Sustainability: Deriving Metrics from Objective

ICOSSE 09

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Architect/Planner
-Application

sustain – from Latin *sustinēre*: *sub-* from below
+ *tenēre-* to hold

= to keep in existence

A low-angle photograph of a nuclear power plant. Two large, white, hyperboloid cooling towers dominate the foreground, rising towards a sky filled with large, billowing white clouds. To the left of the towers, dark industrial structures with pipes and smaller smokestacks are visible, with some steam or smoke rising from them. The lighting suggests a bright day, with the sun low on the horizon, casting a warm glow on the clouds and the towers. The overall scene conveys a sense of industrial scale and environmental impact.

Indicators: UN Commission on Sustainable Development

- Percent of population living below poverty line (4.3.1 Equity)*
- Nutritional status of children (4.3.2 Health)*
- Emissions of Greenhouse Gases (4.3.7 Atmosphere)*

WORKABLE, WEARABLE, WASHABLE, VULNERABLE, VIEWABLE, VIABLE
VARIABLE, VALUABLE, USABLE, UPGRADABLE, TREATABLE, TRANSFERABLE
TESTABLE, TEMPTABLE, TENABLE, SWIMMABLE, **SUSTAINABLE**, SURVIVABLE
SUITABLE, STOPPABLE, SPREADABLE, SINGABLE, SHIPPABLE, SEPARABLE
RIDEABLE, REWARDABLE, REVOKABLE, REPUTABLE, REPEATABLE
REMOVABLE, RELIABLE, REIMBURSABLE, REINFORCEABLE, REGRETTABLE
REFUNDABLE, REFILLABLE, RECYCLABLE, RECOVERABLE, RECORDABLE
RECOGNIZABLE, RECLOSABLE, READABLE, QUOTABLE, QUESTIONABLE
QUANTIFIABLE, PUNISHABLE, PRONOUNCABLE, PROFITABLE, PROBABLE
PRINTABLE, PREVENTABLE, PRESENTABLE, PREFERABLE, PRACTICABLE
POURABLE, POTABLE, PLIABLE, PLEASURABLE, PLAYABLE, PERSUADABLE
PEACEABLE, PAYABLE, PATENTABLE, PALPABLE, PALATABLE, OPERABLE
OPENABLE, OBTAINABLE, OBSERVABLE, OBJECTIONABLE, NUMERABLE
NOTABLE, NEGOTIABLE, NAVIGABLE, NAMABLE, MOVABLE, MIXABLE
MENTIONABLE, MENSURABLE, MEASURABLE, MENTORABLE, MALIABLE
point 1: SUSTAIN-ABLE is a measure
LOVEABLE, LIVABLE, LIKABLE, LAUGHABLE, LAUDABLE, LAMENTABLE
KNOWLEDGABLE, JUSTIFIABLE, ISOLATABLE, IRRITABLE, IRREVOCABLE
IRRESOLVABLE, HUGGABLE, HOSPITABLE, HELPABLE, HANDLEABLE
GULLABLE, GUIDABLE GRASPABLE, FRIABLE, FORMIDABLE, FORMABLE
FORGIVABLE, FORESEEABLE, FORDABLE, FLOATABLE, FIXABLE, FAVORABLE
FATHOMABLE, FASHIONABLE, EXTRUDABLE, EXTINGUISHABLE, EXPENDABLE
EXECUTABLE, EXCUSABLE, EVOLVABLE, ERASABLE, EQUITABLE, ENVIABLE
ENJOYABLE, ENDURABLE, EATABLE, DURABLE, DIVIDABLE, DOABLE
DETECTABLE, DELIVERABLE, DEGRADABLE, DEFINABLE, CULPABLE
CURABLE, CREDITABLE, CONSIDERABLE, CONNECTABLE, CONCEIVABLE
COMPUTABLE, COMPARABLE, COLLECTABLE, CLOSABLE, CHEWABLE
CHARGEABLE, CHANGEABLE, CAUSABLE, CAPABLE, BUILDABLE BREAKABLE
BONDABLE, BENDABLE, AVOIDABLE, AVAILABLE, ATTAINABLE, ASSUMABLE
ASSESSABLE, APPROACHABLE, AMICABLE, AMIABLE, AMENABLE
ALLOWABLE, ADORABLE, ADJUSTABLE, ACHIEVABLE, ABSTRACTABLE
ACTABLE, ACCEPTABLE, ABSORBABLE, ACCOUNTABLE, AFFORDABLE, ABLE



point 2: **sustain+able** – a measure of:

Environment w-r-t Humanity

Can the environment be sustained?

Human activities w-r-t Env.

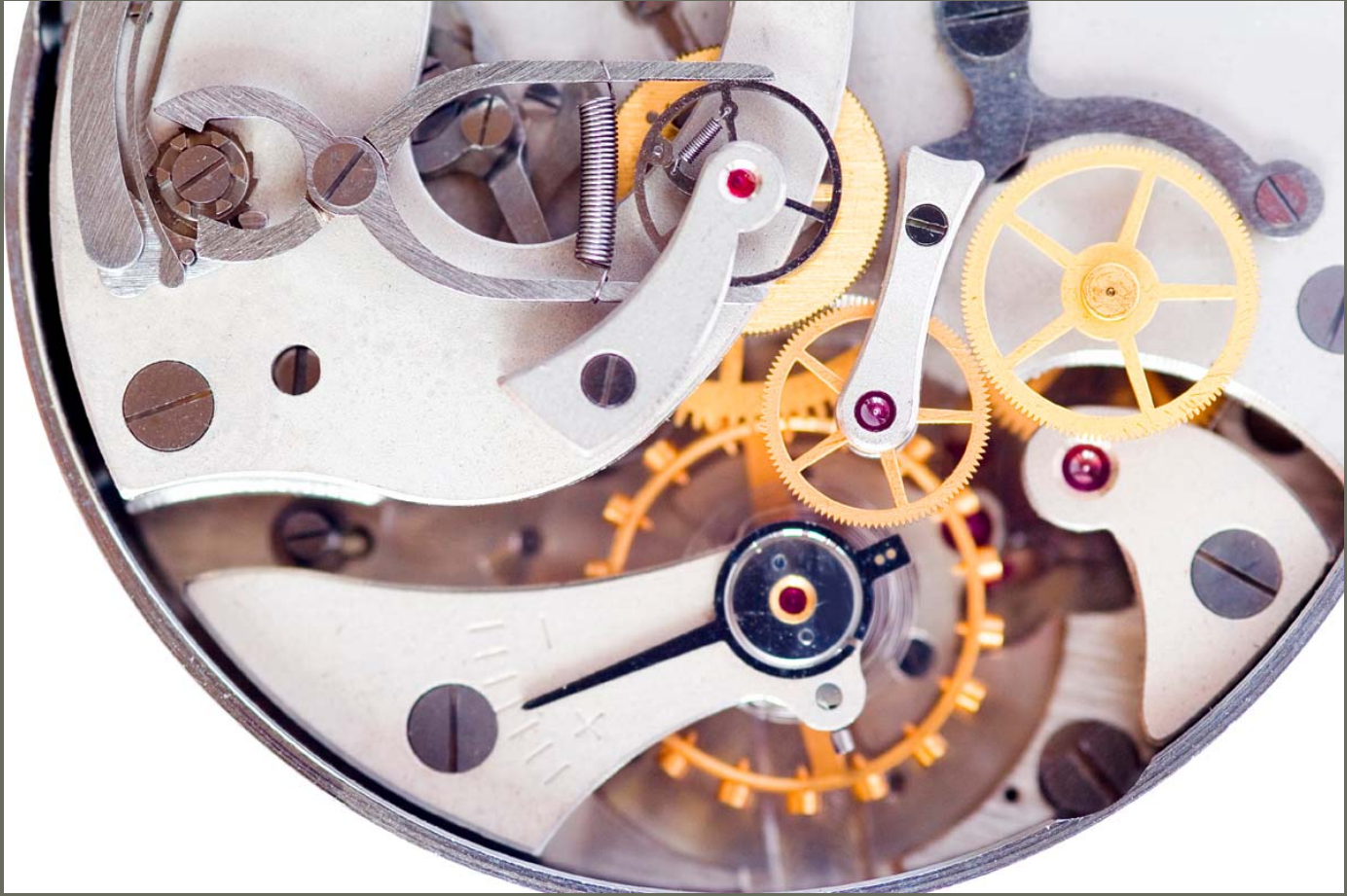
Can the environment sustain activity?

objectives

“... development that meets the needs of the present generation **without compromising** the ability of future generations to meet their own needs.” (WCED 1987)

-

conditions of meeting
objectives



conditions of function

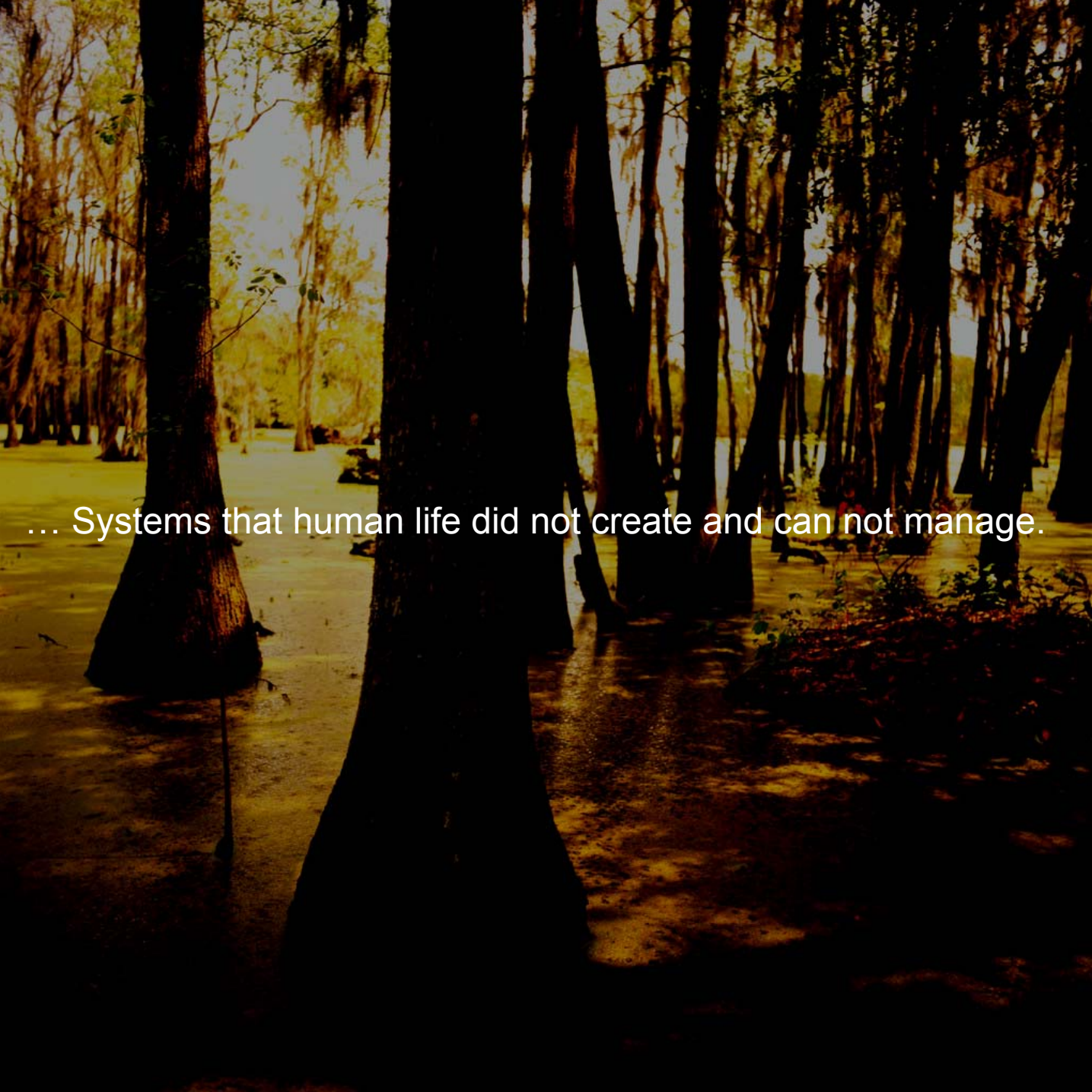


conditions of value



Assurance

Natural Systems are essential to human life...

A photograph of a dense forest, likely a swamp or wetland, featuring tall, slender trees with Spanish moss hanging from their branches. The ground is covered in water and fallen leaves, creating a reflective surface. The lighting is warm and golden, suggesting a sunset or sunrise. The text is overlaid in the center of the image.

... Systems that human life did not create and can not manage.



A photograph of a forest path. The path is made of dirt and small stones, winding through a dense forest. On the left, a large rock is covered in thick green moss and ferns. The forest floor is also covered in moss and various types of ferns. Tall, straight tree trunks are visible in the background, and the overall atmosphere is moist and verdant.

Premise: Natural systems did and would **manage** without us.

Hypothesis: Natural systems would **manage** with us
AS-LONG-AS essential attributes of NS remain intact.





Measure 1: Is Earth able to manage itself?



Measure 2: Are human activities managed with regard to self-managing natural systems?





Measure 3: Is human use of natural capital always within capacities of ecosystems to regenerate?

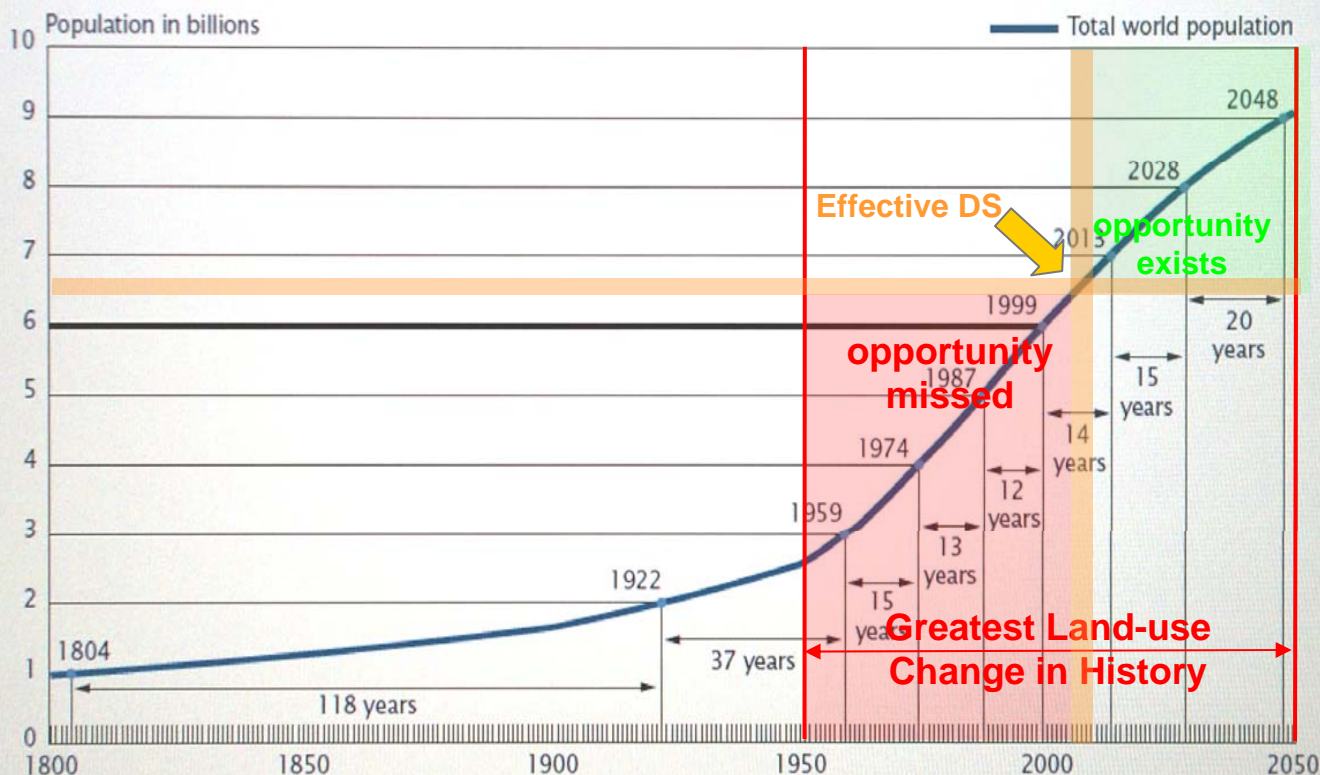


Measure 4: Does adequate decision support exist to align human land-use decisions with ecosystem integrity today?

Figure 1.

Time to Successive Billions in World Population: 1800-2050

The sixth billion accrues to world population in record time!



Source: United Nations (1995b); U.S. Census Bureau, International Programs Center, International Data Base and unpublished tables.

Measure 5: Are all effects of land-use change on natural systems counteracted?



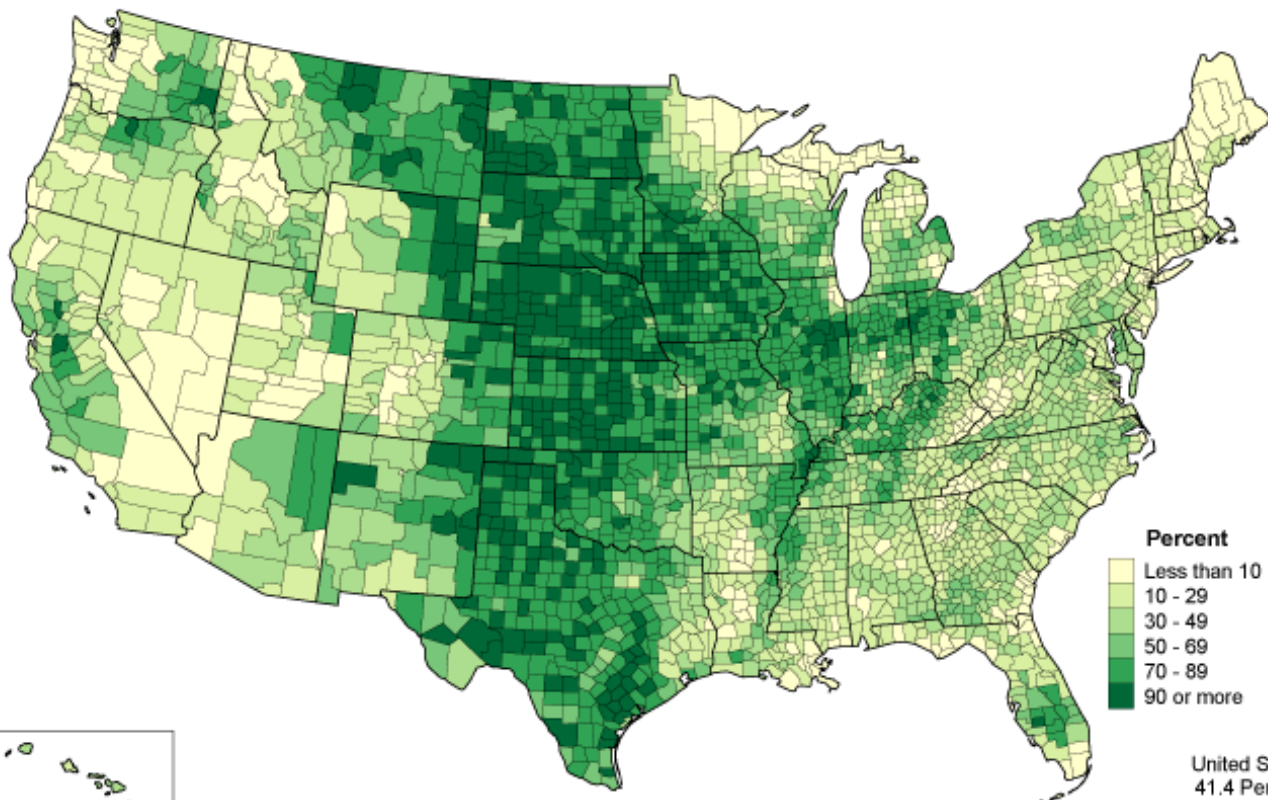


Measure 6: Are ecosystem services intact?

Provisioning
Regulating
Cultural
Supporting



**Acres of Land in Farms
as Percent of Land Area in Acres: 2002**



Percent

- Less than 10
- 10 - 29
- 30 - 49
- 50 - 69
- 70 - 89
- 90 or more

United States
41.4 Percent

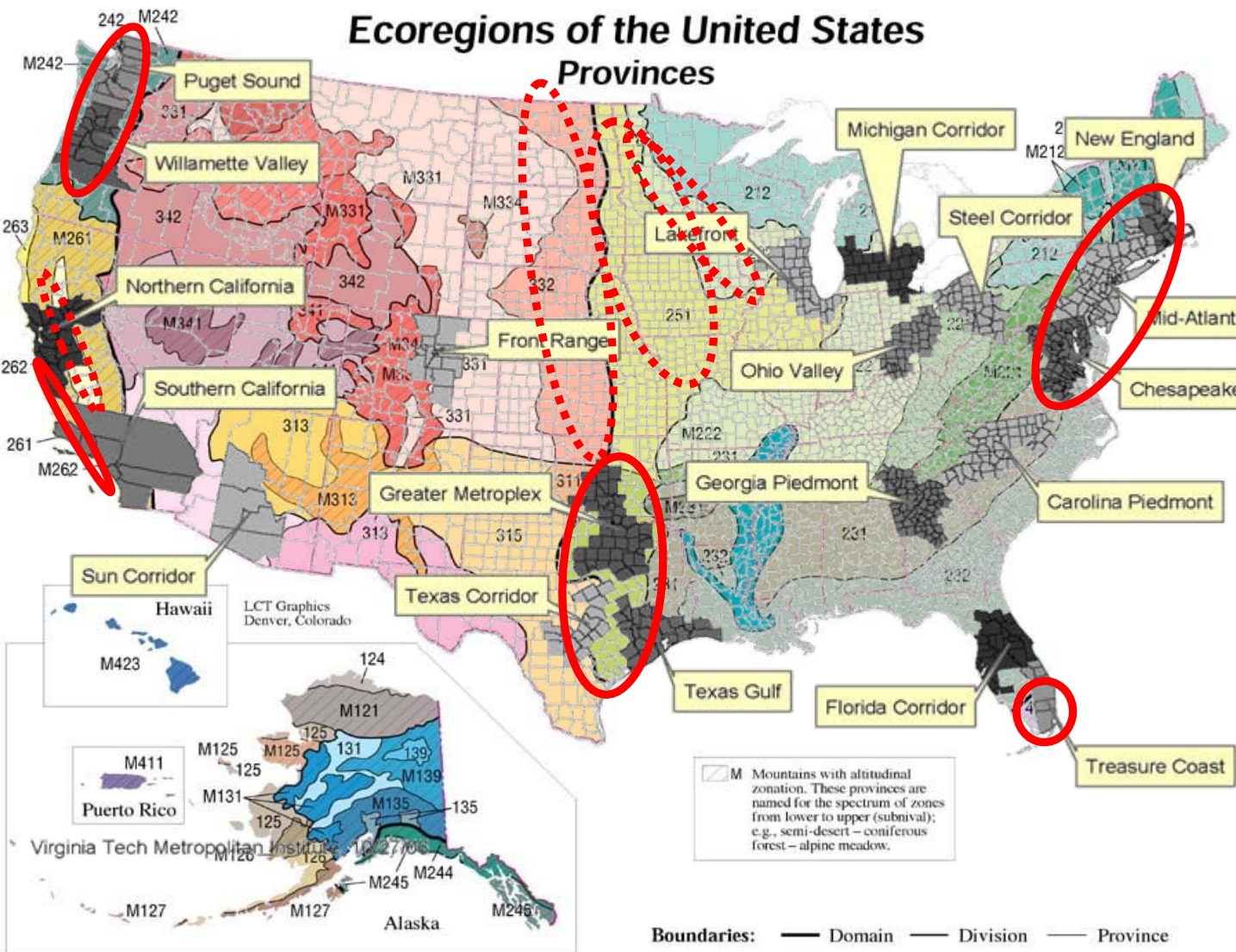
02-M078

U.S. Department of Agriculture, National Agricultural Statistics Service



Ecoregions of the United States

Provinces

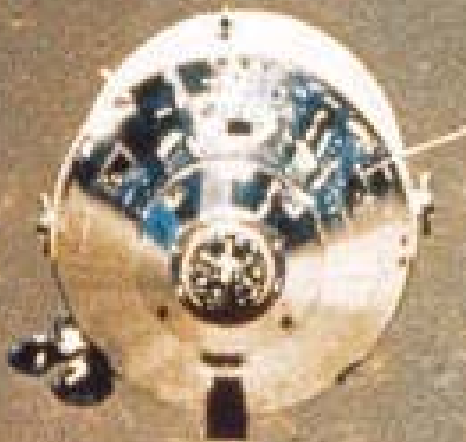


Used with permission of Robert Bailey, US Forest Service
 Used with permission of Robert Lang, Virginia Tech Metropolitan Institute

Measure 7: Does each person that affects land-use change at the site level have the means to participate in counteracting the off-site effects of land-use change?

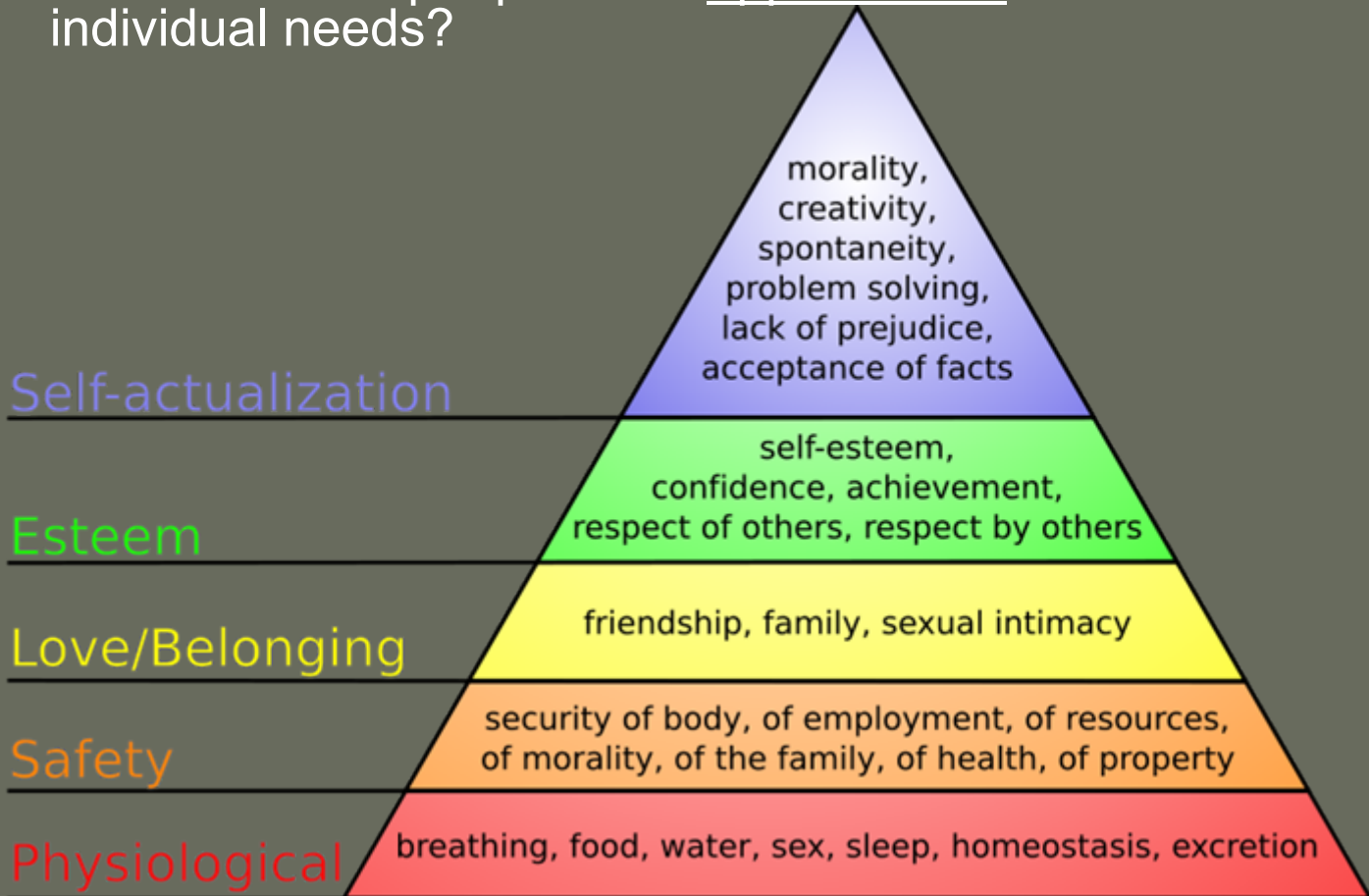






Measure 8: Do fail-safe systems exist?

Measure 9: Do people have opportunities to meet individual needs?



Measure 10: Are we able to remain, adapt in-place?



Part 2 - Sustain-able re: Environment

Natural systems

Social systems

Economic systems



What are the **conditions**? -

- of environment being sustained?

- of environment being able to sustain human life?

Examples of conditions -

- Birth \geq mortality **ala** $\text{Capacity}_{\text{Earth}} \geq \text{Demands}_{\text{Population}}$
- H₂O renewal \geq depletion/degradation
- Soil renewal \geq depletion/degradation
- Fish renewal \geq depletion
- Energy available \geq demand
- Habitat availability \geq needs of E & V population

System Component	No	Precondition of Intact Natural System
Productivity	1	Productive biomass of any land area is at near-natural levels.
	2	Native plants predominate the ecosystem
	3	Growing trees and plants bring nutrients from deep soils to form cellulose at the surface where they decompose.
	4	Native coastal mangroves, wetlands, seagrass beds, and coral reefs are intact.
	5	Water chemistry of sea-water is sufficient to maintain photosynthesizing plankton.
Biodiversity	6	Genetic diversity exists.
	7	Native and non-native species are isolated from each other.
	8	Fragments of truly native environments remain intact.
	9	Natural disturbance regimes exist or are simulated when they can not exist.
	10	Distribution of redundant species is maintained across multiple time and space scales.
	11	Habitats exist in configurations, sizes, and quality that meet physiological and behavioral needs of native populations and communities.
	12	Habitats are refreshed/renewed with clean water.
	13	Native spawning/birthing/hatching sites continue to exist in useful condition.
	14	Connectivity between spawning/birthing/hatching sites and maturation areas and return is open and accessible (including migration).
	15	Individual species and communities are widely dispersed beyond the range of any disturbance regime.
Soils	16	Connectivity between habitats is redundant and grain is appropriate for native species.
	17	Unique environments remain intact.
	18	Soil minerals are renewed.
	19	Adequate moisture exists to make nutrients soluble.
	20	Soil chemistry and ph sustains native soil bacteria, microorganisms, and plants.
Water	21	Organic natural wastes are abundant.
	22	Ground water recharge < withdrawals.
	23	Surface water recharge < all combined water uses.
	24	Wetlands exist to purify waters.
	25	Avenues for groundwater recharge are clean.
	26	Air and water must be clean enough for autotrophs to live.
	27	Water quantity and speed of surface flows meet historic cycles, durations, and intensities.
	28	Soil compaction/impermeability and soil cover do not increase runoff above near-natural levels.
Air/Atmosphere	29	Trees/plants break the force of falling rain and loosen soil to allow absorption and slow runoff.
	30	Sufficient forests exist to generate Hydroxyl radicals to process pollutant levels in the atmosphere.
	31	New deciduous forests and crops exist in higher latitudes and old forests exist to consume CO ₂ .
Energy	32	Forests exist in sufficient contiguous sizes to translate and moderate energy influx.

System Component	No	Prerequisite of Intact Social System
Social	33	A history and progression of how people faced problems is evident and transparent.
	34	Places that provoke spiritual feelings remain intact.
	35	Plant and animal taxonomy is documented.
	36	People are able to freely interact and share ideas, labor, and resources.
	37	Individuals have a voice in matters that affect them.
	38	Risks to human life/health are known.
	39	Human life is isolated from stochastic events.
	40	Institutions exist to serve collective society.
	41	Health risks are monitored and potential risks are made public.

System Component	No	Prerequisite of Intact Economic System
Economic	42	Materials are efficiently used and reused as much as possible.
	43	Waste is attenuated by environmental processes.
	44	Resource use is linked with investment in resource renewal.
	45	Qualitative community resources are improved.
	46	Net economic effects > costs incurred to natural systems.
	47	Net economic effects > costs incurred to social systems.
	48	Consumption of natural resources is counted as a cost.
	49	All costs are calculated before being incurred.
	50	Financial resources are sufficient to maintain community infrastructures, institutions, and services.



Application -- Metrics provide:

- a way to make decisions
- a way to test decisions
- a way to modify decisions



Sustainability Metrics:

Aligns what we do to this planet with
what we need from this planet?

Is the process of change

exploitation of resources

direction of investments

orientation of technology

made consistent with

future +

present needs?



THANK YOU!

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