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## **Design for Sustainable Community**: Goals and Limits in an Optimum Development Plan for the Palouse Ecosystem

### I. Introduction

Our local communities are proud to attract more people and larger industries, but do so thoughtlessly, without regard for the limits of population size or the rate of energy use, without sufficient consideration of the effects on the quality of our lives or on the quality of the environment. Although we make plans for people and their activities, the plans are reactions to growth and change. The formal development from planning results in a complex of problems, from pollution to ugliness.

We have always tried to exceed the physical and biological limits1 rather than recognize them and be guided by them. This paper suggests an approach to comprehensive planning based on the biohistory of an ecosystem, the cultural values of the people, and knowledge of the limits for sustainable development. This approach makes the limits explicit and set sustainable goals within the limits. A synthetic framework provides for the health of the ecological system, as well as the health of its human inhabitants.

### A. Central Planning

At first a means of controlling people through zoning, central planning has expanded its reasons to include sanitation, economics, and aesthetics as well. Although planning grants some consideration to support areas and aesthetic factors, cultural traditions and the natural environment are not primary concerns.

Planning means deciding on goals to be achieved in specific situations. The goals are usually small and not comprehensive, such as the rate of emission of sulfur oxide, and usually end up being a compromise in cost-benefit analysis. Planning tends to neglect or dismiss the distribution of negative,uncertain, or nonmonetary effects. Furthermore, we have no mechanism for developing long-range plans. Certainly, there seems to be no way to deal with long-term, slow catastrophes, from erosion to change of climate. We have not developed qualitative indicators on ecological health or quantitative measures of social, mush less an ecocentric view that would value preserves of nature for itself.

Most plans address *problems*, from waste water treatment to air pollution monitoring. Unfortunately, everything else, from employment to pests, is also considered as a problem, and not a direct effect of the cultural implementation of a technology. Most plans seem to be extremely good at compiling area data, from topographic to climactic. These plans are concerned with determining the adequacy of the infrastructure (utilities, streets, sewers) to support actual and projected population growth. Development plans (water, power) are comprehensive in the sense of seeking to meet all needs of public, health, agriculture, and industry. But they fall prey to all the assumptions of the industrial culture. They tend to be multipurpose with the aim of providing maximum net benefits through management of watersheds, fish and wildlife, and flood control. But both multipurpose and maximum benefits are misunderstandings. Multipurpose in practice means human use; and maximum benefits are dangerous. Modern resource management strives for maximum sustainable yield, based on partial knowledge of population size and great ignorance of population flows. Direct observation and traditional knowledge yield far more "information" about animals than autopsies and mathematical models.

Development plans also tend to call for the eventual development of *all* resources in an area; Brazil's Plan 2010, which would develop all of the Amazon with 136 high dams, is a good example. A one-world planned economy is an even greater threat. It is based on unlimited industrial production, unlimited commodity consumption, increased exploitation of nature, and the free flow of resources and labor. This kind of planning requires the abandonment of local controls on development, trade, or lifestyles. All countries would be expected to open their markets to outside investment, eliminate tariff barriers, reduce government spending (especially to the poor), convert small-scale, self-sufficient farming to agribusiness, and open all land to resource gathering. Planning is characterized by a utilitarian globalism that denies value to the systems that support it.

As a result of central planning, the patterns of life have become the products of market forces and stylish transportation operating in a sterile abstract order. In America we are criticized for having a "frivolous" culture based on "savage" capitalism. Capitalism increases the pressure for uniformity, a single pattern of existence. Formal development is more concerned with an assembly-line model, simple, isolated, efficient, and easy to maintain. We become remote from, and indifferent to, the system that supports us. We then acquire unrealistic images of the world and harmful values and then make bad decisions based upon them.

B. Ecological Planning

A number of proposed plans to heal the earth and improve human communities have been presented in popular books. Unfortunately, many of them are too philosophical and general, suggesting that we could change values without showing how or urging us to alleviate some of the symptoms without addressing the disease. Other plans, such as the Limits to *Growth* (Meadows et al.), are too global. And still others, such as *Design with Nature* (McHarg), are less concerned with limits than with conservation. Laszlo offers a similar compendium of global goals that can essentially be summarized to be health and freedom for people in a healthy environment. Many of these plans offer admirable models, but little in the way of goals or paths.

A plan should consider the whole system and design communities for an optimal fit within the limits of the system. Ecological planning considers an optimum population within one ecosystem, although it is connected to others by trade for some necessities or luxuries. This kind of planning is a conscious adaptation of the benefits of technology to the traditional idea of physical, not cultural, limits. Using the Palouse ecoregion (or bioregion) in the Northwest United States as an example, we can outline a comprehensive plan to deal with some of the implications, as well as question them.

1. Identify our place within its natural boundaries. The Palouse is a uniquely identifiable ecosystem, with recognizable boundaries and a unique history and character.

2. Calculate the optimum amount of wilderness to preserve the natural cycles indefinitely. If the current area is less than our calculations, restore the difference and set it aside as a reserve.

3. In the remaining area, zone areas for appropriate use, including conservation, preservation, and artificial areas (with historical, cultural, and functional importance).

4. Identify the resources needed for human use, including raw materials and the productivity of the areas. This productivity can be used to calculate a base line population.

5. Apply cultural modes—in style, values, and technology—to set limits on technology and population. Preserve the cultural values. Renewable resources will sustain a population longer than energy capital like oil or gas.

As part of the formulation of a plan, we have to examine the natural and cultural histories of the Palouse. We need to understand interactions in the ecosystem, as it was with no humans, as it was lightly settled, and as it is now, dominated by humanity.

II. Biohistory

A. The Palouse Ecosystem

The Palouse is a dry, intermountain grassland of approximately 6 million hectares located within the Columbia Basin in the Pacific Northwest. Its origin, topography, and soil composition are unique. The geological foundation of the area is basalt, from lava flows that occurred 15 million years ago. Lighter deposits of volcanic ash fell from Glacier Peak (12,000 years ago) and Mt. Mazama (6,000 years ago). The eruption of Mt. St. Helens (in 1980) added a 2-8 centimeter deposit to much of the Palouse. Heavy depositions of loess, originating in arid lands to the west continuously since the early Pleistocene (300,000-500,000 years ago), resulted in fertile soils of loam and silt loam texture, which developed in a semiarid Mediterranean climate. The landscape has moderate to high relief; elevations range from 180 to 1,200 meters. Annual precipitation varies from 200 to 800 millimeters. A high proportion (45-65 percent) of this precipitation falls during the winter months. Maximum temperatures coincide with minimum precipitation during late summer, producing intense drought.

The Palouse has 40 habitat types in 9 zones. The primeval vegetation was composed of dense stands of perennial bunch-grasses (caespitose grasses, such as Idaho Fescue, Bluebunch Wheatgrass and June Grass) and shrubs (including Snowberry and Wild Rose). (A habitat type is a particular environment inhabited by organisms; a zone is a clearly-delineated division of vegetation.) The ecotones separating habitat types are relatively sharp.

Palouse vegetation is determined primarily by climate, sometimes by soil and topography; unlike most other grasslands, it developed without significant grazing or regular fires. Fire plays a minor role in these habitats, since the perennial species sprout from underground parts—in fact, fire kills native Artemesia species. In its natural state, grazing did not significantly affect the composition of the grassland, although deer were present.

Archaeological history indicates that there were small populations of Bison and Pronghorn Antelope as recently as 2,000 years ago, but no permanent populations have established themselves since, possibly due to the larger snow depth west of the Rocky Mountains, which inhibits crossings. The native grassland is relatively rich in species, 93 mammalian species representing 58 genera. Birds and insects are also well represented. There are at least 25 mosses and 9 lichens. (And there are at least 10 sensitive or threatened species in the province.)

Ecosystems result from the interaction of all living and nonliving factors of the environment. These systems are profoundly affected by both random and purposive physical and biological factors. As a result, habitats change and organisms adapt. By modifying their habitats in the process of living, organisms change the characteristics of the system and force further adaptation. For example, mammals alter their habitats through chewing, digging, and burrowing. Rodents can dislodge earth at a tremendous rate (18—120 cubic meters/ha/yr). In many cases these activities improve the conditions for growth of vegetation. Mammalian grazing promotes regrowth and the movement of seeds. Bison and prairie dogs were responsible for much of the character of the American plains. Rodent caches may account for 15 percent of Ponderosa seedlings. Beavers and other rodents create microsystems that other animals depend on. Caribou and elk transfer energy between systems. Shrews consume major portions of larch sawfly larval populations. More important, organisms are limited by the productivity of the system in varying degrees, and the productivity is limited by light (and heat) and water (see Table 1).

Human populations inhabit specific ecosystems and are parts of them. They are adapted to and limited by the productivity of ecosystems. Like other mammals, humans change their habitats to suit themselves. Humans have modified animal and plant associations in a different way, simplifying patterns of energy and chemical exchange, solidifying themselves at the end of many food chains.

The total amount of biomass or energy produced by populations through growth and reproduction is the productivity of the system. An ecosystem has various kinds of productivity. Gross Primary Productivity (GPP) is the rate of energy storage by photosynthesis (equal to photosynthetic efficiency) in autotrophs (plants). The maintenance and reproduction of plants is paid for by the energy expenditure of Respiration (R). The amount of energy stored as organic matter after respiration is identified as Net Primary Production (NPP), which equals plant growth efficiency. The calculation of NPP is shown by: NPP = GPP - R. The NPP accumulates through the history of a system as plant biomass expressed as kilocalories per square meter (Kcal/m2). The biomass minus the decomposition in a system is the standing crop biomass of that system. The kilocalorie is used as a unit of energy flow and production; it is a useful common denominator for these calculations. The problem of confusing production (amounts) with productivity (rates) is avoided by considering all values per unit area (square meters or hectares) over the entire year. The energy stored in consumers, or heterotrophs, is referred to as secondary production (SP) or assimilation. The storage of energy or organic matter not used by heterotrophs is the Net Community Production (NCP).

In a Mature (balanced) ecosystem, the net primary productivity (NPP) equals respiration; in an accumulating system, NPP usually exceeds respiration by 1-10 percent. Although stable ecosystems tend to produce a maximum gross primary productivity (GPP), species, biomass, and the production to respiration ratio (P/R) continue to change long after the maximum has been achieved. In fact, as the GPP approaches an asymtote, respiration increases. In a mature system, temperate rain forests for instance, net community productivity (NCP) approaches zero, as adapted heterotrophs become more efficient at using production. In accumulating systems, such as grasslands, NCP can range from 20—70 percent, although 30 percent is a good average for the Palouse. A balanced system is integrated and self-perpetuating, where production (the photosynthetic fixture of carbon) is balanced by respiration (the oxidation of carbon). As a system becomes balanced, the pressure of selection of organisms shifts; the capacity to live in crowded circumstances with limited resources is favored (usually with regard to animal populations, although perhaps it applies to humans).

B. Human Cultures

The Palouse has supported several groups of people with unique cultures for over 12,000 years, according to archaeological evidence. A number of prehistoric living sites have been found in caves, shelters, and camps. These archaic peoples caught salmon, steelhead trout, and other fish in the Columbia and its tributaries. They hunted rodents, jackrabbits, deer, antelope, and elk, and possibly mountain sheep and bison. They trapped migratory birds nesting along streams, and sharp-tailed grouse and sage grouse.

About 5,000 years ago, as the area became more densely settled, people depended more on wild plants, such as roots and berries. Settlements became more permanent, especially in winter. Groups tended to disperse in temporary camps in the summer, when getting food was easier.

Tribes developed unique identities, as Spokane and Columbia-Sinkiuse in the north, Coeur d'AlIne and Nez PercÈ in the east, Palus, Walla Walla, Umatilla, Yakima, and Wanapam in the central and south, and Klickitat, Wishham, Kittitas, and Wenatchi in the west. Although their languages are different, many of their beliefs and customs are similar. Neighboring tribes would maintain ties through trade, marriage, and sharing resources (hunting and gathering grounds).

In late winter, the many varieties of salmon (chinook, silver, sockeye, chum) traveled upstream to spawning grounds. A leader or shaman determined when the Indians could begin their catches; this allowed many salmon to get upstream and reproduce. To catch the salmon, as well as trout, sturgeon, and lampreys, they used a variety of tools, from two-pronged harpoons to leisters, gaffs, spears, weirs, and nets. After the fishing dwindled, groups would move to root-digging grounds, where the women would use hardwood sticks to collect over 20 varieties of roots, including bitterroot and camas. Men hunted deer, elk, sheep, goats, bear, and wolves.  Food was stored in different kinds of woven baskets, made from bear grass, wild hemp, and cedar and spruce roots.

Traditional clothing was made from sagebrush, shredded cedar, and willow bark. Tanned deer hides were used for ceremonial clothes, although after trading with Plains Indians, styles began to change towards buckskin clothing and moccasins; breechcloths, leggings, and shirts for men and dresses for women. They also traded for buffalo robes.

Palouse Indians had very few large settlements. A village rarely exceeded 200 people. The earliest Yakima lodges, for instance, were pit houses, covered by up to 3 feet of earth over grass mats on a frame of wooden poles, with a central opening for smoke. After the Indians acquired horses, and became more mobile, the shape of their buildings changed. Mats on wooden-pole frames were easier to dismantle and move. In the summer, mat or deerhide lean-tos were used on hunting trips. Later, they favored deerskin tipis. The Coeur d'AlIne had a circular arrangement of tipis; location in the circle corresponded to the location of homeland. Sometimes tipi placement was irregular or determined by social relationships.

Although inhabitants of a village (or a band) recognized a certain amount of the land surrounding as their territory, they shared most of the hunting and gathering grounds with people from neighboring villages. Each village might contain from 5 to 15 lodges, a lodge being the household of an extended family, usually three generations. Clubs and societies promoted bonds between nonfamily members. Many social ceremonies reinforced the cohesion of a group. Gatherings were regular, to celebrate the first fish or last crop of berries, as well as social ties. They visited, traded, played sports, and gambled. Some of the exchange items included furs, skins, dried roots, berries, fish, baskets, feathers, horses, and slaves. European objects were first acquired through trade with other Indians. These included metal knives and hatchets, copper kettles, glass beads, and copper bracelets. Trade with the British added tobacco, alcohol, and blankets.

Indian peoples were able to use the area without changing it fundamentally. They were able to work out appropriate solutions in harmony with their environment. Traditional forms of restraint, such as prescriptions for marriages and births or restrictions on hunts, ensured that tribes would not interfere with local animal and plant populations, much less with ecosystem cycles. Population density was controlled by the traditional approaches to resources. Cooperation and consensus, as opposed to competition and individual exhaltation, permitted planning to remain informal. Cultural beliefs made planning for the indefinite future more inclusive; life was a continuity in form (from bear to human, for instance) as well as in state (from unborn to person to ancestor).

The peoples were able to convert animal and vegetable resources into all their needs for food, shelter, and clothing. When other items were available, such as horses and metal knives, they were able to trade, fish, berries, baskets, and roots for them. In the 1700s, probably no more than 40-60,000 Indians lived in the Palouse; this number could probably be supported indefinitely by the Net Community Productivity (NCP)—that is, using only that amount of ecosystem productivity that is not used by the plants and animals. Indian contributions to agriculture, architecture, government, and planning have rarely been acknowledged.

Peoples of European descent traveled through in the 1800s, first to trade and then to run cattle, which thrived on the bunchgrass. The first wave of travelers was aiming for Oregon and did not consider the plateau to be prime farming country. The Indians, meanwhile, had started herding cattle and cultivating gardens, while continuing to fish and gather. About the time of the first homesteaders (after 1860), the Indians also expanded their ranching and farming.

Agricultural development was the first intensive use of the region. In the last 100 years, dry-land farming has almost completely replaced the original vegetation, although fragments can be found in fence corners, right-of-ways, cemeteries, and inaccessible slopes. As agricultural technology became more advanced and the demand for crops increased, less desirable segments of the prairie were tilled. Smaller islands of native vegetation, regarded as waste places, were left for livestock grazing, since the native vegetation was palatable and nutritious. However, native vegetation was easily injured by close cropping and unable to compete with introduced exotics on disturbed sites. Even the few remaining natural stands, on the steepest slopes and boundaries, have been influenced by fertilizer and herbicide drift. Since the 1880s, alien grasses, chiefly cheatgrass and Kentucky bluegrass, have pioneered most disturbed sites.

The Palouse has become more populated, with hundreds of thousands in urban locations. Agriculture has produced monumental yields, but only at the cost of tremendous erosion and great subsidies of fertilizers and pesticides. Dams have been built all along the Columbia, altering the river and fishing grounds. Changes have been made without regard to the long-term impact on the ecosystem or on its human population. We have simply dominated the entire ecosystem.

Humanity is a pandominant species. (A dominant is a species with greater influence than any other in its biotic community, changing the lives of other species and the character of the habitat.) As pandominant, humanity reclaims, overgrazes, clears, depletes, and wastes at a level that threatens the stability and existence of many systems. One of the ecological consequences of human activity is the degradation of wild habitats for human developments (food, housing, and recreation) and the introduction of novel elements into the biosphere—elements that have not been harmoniously worked in over time. The biomass, or demomass, of the human species probably far exceeds the biomass of any nondomestic species, and that biomass is supplemented by the tremendous biomass of domestic animals, which is four times greater.(Borgstrom, 1975). This biomass forms an equivalent population that consumes much of the same food, such as milk, fish, and grain. The domination of humanity is related to other characteristics as well: A large biomass ($6 \times 10^{14}$ Kcal), a large annual increase (2 percent), our high structural organization (information, matter), and our high energy use (globally, 13 times mammal equivalents).

This dominance has major effects on ecosystems: transient perturbations in energy relations (from oil spills, burning); chronic changes/shifts of systems (from dams, irrigation, chemical wastes); species manipulation (from the import and export of exotics); and, interference competition with wild species, as opposed to exploitative competition, which can be stabilizing). None of these effects are exclusive to humans as a species, but they are excessive, rapid, compounded, and large-scale. With a comprehensive, ecological, long-term plan, we can direct or anticipate changes and impacts.

III. A Plan for the Palouse

In planning for an optimum human presence within ecosystem restraints, few have considered minimum wilderness preservation, air and water quality, genetic minima, nonrenewable resources, appropriate technological innovation, the importance of cultural frameworks, adventure, research, beauty, uniqueness, and other intangible experiences. This thought experiment is a deductive, synthetic, conceptual model based on data generated from research on biological productivity, the rates of resource use, and cultural valuation. A deductive approach is necessary because accurate measurements of productivities in most ecosystems are lacking and exactness in values is misleading. A synthetic approach is necessary to integrate quantitative and qualitative data. In combining measures of qualitative and quantitative, it is simpler to set aside the first and then to calculate the second. The model must be conceptual because of the inherent fuzziness[2] of the systems.

The central planning system is designed to take full advantage of computer applications and find a base unit of measurement. But a computerized information model is only partial; what cannot be quantified, such as feelings or relationships, is often ignored. Computers cannot handle personal observations, sensory impressions, or historical contexts or mythical relationships—just those things used by primary cultures to manage their resources. Although this model quantifies many things that seem nonquantifiable, it is essentially a verbal description.

This model has a small theoretical basis, but it is a plan as well as an appeal to action. This plan is in harmony with strategies for sustainable ecosystems, the conservation of biological diversity, and aspects of global change. This model attempts to work out plans and policies for long-term environmental stability. The plan describes an architecture of physical and social institutions, that is, of buildings as well as of politics. This model should be transtemporal and transspecies. Should use the focus/frame metaphor for stability and planning. Contrast unconscious growth with conscious planning. The goal of planning is to enhance life—all life, not just human life.

The human population energy of the Palouse is related to land area, productivity, technology, and culture in one algebraic expression (Figure ?)

P is population, a general number which is calculated by adding the total annual agricultural productivity (in Kcal) to the total annual resources (in Kcal), multiplying that sum by a technological and cultural modifier fraction, and dividing that by the annual per capita requirements for food and resources. A is available area, the minuend $A_0$ is the total land area, and the subtrahends $A_1$, $A_2$, and $A_n$ are wilderness areas, conservation areas, and other areas to be reserved. N is the net usable productivity, which is calculated by subtracting the the total unavailable productivity (M) from the net primary productivity (NPP); M includes percentages for below-ground productivity, various wastes, and inedibility. H is a factor $E_n$ is an energy values for a resources, water power or zinc, for instance. The exponent T is a technological modifier, based on the use of technology in extending or contracting the food or mineral productivity. The exponent C is a cultural modifier, based on the application of cultural values in determining area and productivity. Total area (A), NPP, and $E_n$ are known quantities, while the remaining factors must be evaluated in a mathematically fuzzy way. U is the sum of annual food requirements ($R_f$) and annual resource requirements ($R_r$) per capita.

For the total figures for all essentials—food, shelter, clothing, transportation—energy is converted to Kilocalories and placed on an annual budget (and averaged over 1, 10, or 100 years). These calculations are used for the purpose of illustration; they are not conclusive or binding. The entire equation is expanded in the following discussion.

A. Wilderness Reserve

In spite of the uniqueness of the Palouse, there has been no successful attempt to save more than patches of the original vegetation. In the 1960s the Idaho Association of Soil and Water Conservation called for the expansion of the Great Plains Conservation Program to include the Northwest prairie. This, and later resolutions, were defeated for regional or financial reasons. Small research natural areas (RNAs of 10-15 ha) have been saved by Washington State University as research areas, but no large stands of native grasses remain. Most of the communities, such as Bluebunch wheatgrass/Idaho fescue, in the Zonal Meadow Steppe Association are only partially represented.

Ecosystem preservation protects entire biotic communities: genes, populations, species, habitats, associated traditional human cultures, and all the processes and interactions. Most conservation strategies are completely anthropocentric, from saving hunting grounds in the middle ages or resources this year. The most important ecocentric argument is autological—ultrahuman species need nonhuman places. To keep the essential services of nature, from atmospheric cleaning to soil-formation, we need large reserves. Reserves are critical elements in global element cycles; they provide a natural base line for management reference and a unique opportunity for scientific research. Large reserves would increase representation of species and save viable mammalian populations, that is, maintain the integrity of wild gene pools. Such reserves would permit natural processes to occur without human interference. We also need large reserves to derive further benefits from understanding natural processes and direct economic benefits from species. For aesthetic purposes: to see, to participate in nature (these being the basis of watching and tourism).

The desired size of the preserve is a complex function of the area's key species, quantity of suitable habitat, and minimum viable numbers of species. Large-bodied vertebrate species tend to have lower population densities, thus a reserve with self-sustaining large-bodied vertebrate populations will likely be adequate for herbivores, insectivores, and primary producers. The key mammal species in the Palouse are coyote, badger, and mice, with white-tail Deer as regular visitors. Determining the minimum number of individuals in a population to guarantee a high probability of survival results in widely varying minimum areas, depending on the key species selected. Frankel and Soule calculate that a population of 500 is needed to maintain genetic viability of each animal species. Each animal requires a minimum area; for example, each coyote requires 700 ha (7-10 square km) for a home range. Since not all coyotes in a group breed—some become aunts or uncles and help care for pups—it is necessary to assume 3 coyotes per breeding unit. Using coyotes as the key species, the minimum area for the reserve becomes 1.05 million hectares (over 16 percent of the total area). With a home range of 250 ha (2.5 square km), the minimum area for deer would be 200,000 hectares. With a home range of 1-5 ha, the minimum area for mice would be 2,500 hectares. Using Idaho fescue (5000 individuals), the minimum area would be about 10 hectares. Usually, large carnivores are a sensitive indicator of the carrying capacity. In the Palouse, however, coyotes have taken over many predator niches formerly held by lions and bears, and coyotes have adapted fairly well to anthropogenic landscapes, so preserving their entire range may not be as critical. Minimum habitat protection is necessary for the protection of endangered or threatened invertebrates, which are responsible for maintaining basic ecological processes through predation, recycling, and pollination.

Although there have been debates over whether a single large reserve is better than several small ones, the shape and size of a Palouse Reserve is determined by habitat studies of the unique natural history and conditions. The key plant species to be protected are Idaho fescue and Snowberry, with all their ecological relationships to micro-organisms and arthropods. The large carnivores and herbivores (coyotes and deer) can adapt to more artificial conditions, so their needs may not be limiting factors. The size should be large enough so that species will not be vulnerable to "extinction vortices" caused by genetic or environmental stochasticity. In this reserve, disturbance from farming, grazing, or recreation would probably be the greatest threat.

The recommendation for a Palouse reserve is 1 large area, about 1.1 million hectares, buffered doubly by rehabilitated fields and then by fallow agricultural land (1.3 million hectares), 3 areas of 3,000-10,000 hectares, and 22 satellite areas of 8-25 hectares, which would probably not be buffered. Saving a million hectares might be economically or politically difficult under the current industrial monolith; 1 million hectares is about 17 percent of a region that profits immensely from growing grains and legumes. A 200,000 hectare figure is over 3 percent. As a starting percentage, this might be more likely; it would be less than a sales tax or an income tax percentage increase.

The large areas of the proposed reserve would be laid out on the SW/NE axis with large fingers extending to the NW and SE, to maximize the number of protected NE slopes. Since the winds are predominately from the SW, herbicide drift would be minimized. A range of elevations across areas would minimize the effects of climactic change— and the possibility of extreme change is rarely considered in wilderness design. Soils, drainage, and land-use history and ownership would also receive similar considerations. This would allow management for diversity on different scales. The reserve would extend into the ecotones separating grassland and forest provinces; the edge effect would benefit many species. Fence rows could limit access and might even encourage dispersal. For example, small mammals and birds use fence rows for travel and nesting; fences also create microsites for different communities. Daubenmire noted that slight differences in soil depth and moisture permitted different types of associations in the Palouse; this was especially true around fences, which caused greater dust and snow accumulations. Because local soil conditions result in a wide variety of habitat types in small areas, even small preserves would have a rich flora and fauna.

There is little information on the restoration or preservation of "near-natural" ecosystems— primarily native, not subject to major change. In the Palouse, there are probably very few near-natural areas; most are semi-natural (pastures as a consequence of human activity) or artificial (totally humanized with asphalt and exotic species). The Palouse could not be restored to its original state, since many species are extinct, but it could be rehabilitated. There are a number of methods (such as direct planting into de-sodded ground) that can be used to restore species-rich grasslands. The inner buffer zone, being rehabilitated, would be the most expensive to create. The outermost buffer would be managed by benign neglect (despite the fact that many do not list this as a management option). Natural processes, such as fire, wind, or species explosions, would be allowed to operate freely, even if they altered the functioning of the system.

The north-south finger-like shapes for the reserves would minimize the dangers from physical and climactic changes. The greenhouse effect could drastically alter the species distributions in reserves, with the loss of many species. Placing the reserves on heterogenous soil types and topographies increases the chances that the temperature and moisture requirements of species would be met.Simply maximizing the size and number of reserves would enhance long-term survival.

The cost of reserves would be high. Palouse land sells for 2,000 dollars (US) per hectare. The cost of a reserve, for restoration, has been estimated at 20-140,000 dollars per hectare, depending on the density of planting and the area. The costs of buying, rehabilitating, and managing 200,000 ha could cost 2—4 billion dollars (or 15 billion for 1 million hectares). By comparison, the Forest Service is spending 3 billions dollars to add 35,000 miles of roads in roadless areas throughout the western United States. Larger areas would reduce management costs; smaller reserves in general require more intensive management and habitat manipulation.

B. Resources

The Palouse is relatively rich in organic resources. Perhaps the most important one is the living land itself, the ecosystem. The single most important system factor is climate, especially in the Palouse, which is in the area of marginal rainfall (less than 20 inches) for modern agriculture. The fluctuation of the climate over 10,000 years should also be considered. The Columbia and Snake rivers, which drain the mountains to the East, bring water through the region. We depend on that water (and on acquifers) for drinking and irrigation.

Palouse has large percentage of arable land—about 40, while the global average is only 24 percent. We put our buildings and roads over that land. We dig up tons of gravel for roads. We fence off portions for range and plow other areas for crops (see Table 7). We depend on the plants, animals, resources, and energy we take from it.

1. Plants

The Palouse is a grassland, also called a shrub steppe. There are no stands of forest, although there are willows and hardwoods around rivers and streams and the decorative, fruit, and plantation trees that people have planted and maintained. There are relatively few lakes and wetlands; there are few high elevations.

We have converted all the arable lands to agricultural use. In general, according to Eyre, converting wild lands to agricultural use reduces the average above-ground annual NPP by 75 percent. Agricultural intensification also causes fallow cycles to be shortened; a shift from mixed crops to monocropping; and a shift from natural fertility to artificial fertilizers. (To buy pesticides and fertilizers and equipment for applying them, most farmers operate in a condition of chronic indebtedness to financial institutions.) The bunchgrasses and shrubs have been replaced with large expanses of single crops, such as wheat or barley (see Tables 3 and 4).

Much of the productivity of plants is not useable by humans. In lightly grazed short-grass prairies, over 75 percent of the production is underground (83 percent in ungrazed). For example, in the production of forests, 65 percent of above ground production is not used by most lumbering operations (litter, leaves, bark, twigs). Of a dry weight sample of wheat, only 40-45 percent is actually grain. (Of course, much of the straw and slash should be left so that the system can regenerate, and some of it can be used for paper, packaging, and press-board.) Possibly the representative average of unusable material is 50 percent. Taking most of the material is not desirable anyway because mineral nutrients are locked up in plants and are needed for new growth. Complete extraction of plants would result in removal of 30 to 70 percent of the potassium in the ecosystem. Although there is plenty of potassium locked in rock particles, this is released very slowly.

Agriculture is faced with very real limits. The amount of light reaching the earth's surface is a limit that probably cannot be increased safely. Most modern plant varieties have about the same photosynthetic efficiency, anyway, although some varieties have a superior leaf arrangement. Plants would be more efficient if the atmospheric composition were manipulated so that ambient carbon dioxide levels were concentrated; this might be done in greenhouses. Phosphorus is a limiting factor; modern agriculture squanders it, so that much of it ends up in rivers and then the ocean. Available water is also a limit. Many of these limits are not negotiable.

Successful agriculture depends on an artificial climax or sustained successional state. Large-scale farming has some advantages, but even it is more efficient when done by the owners. Small-scale residential ownership is best. The soils have been destroyed, and we may not have the knowledge to succeed at working them. Waste and manure need to be returned to the soil. Smaller farms have started to fertilize by crop rotation and manure. There are successful organic farms on the Palouse and successful small ones that use low-energy methods. Some of these keep many kinds of plants and animals, produce less surplus, use no chemicals, grow adapted crops, and have wild lands. These farmers are closer to ecological harmony: with gardens, fields, trees, bees, fish pond, pasture, forest, and natural vegetation.

Much of industrial agriculture can choose to become more labor intensive and multicrop, and to reduce hybridization and use natural pest control. Farmer education, especially history and ecology, should be stressed. The farmer should have a thorough knowledge of the physiography of the land—soils, crops, forests, pastures, mineral content, microclimate—and study the effects produced by flora and fauna. Sometimes in the Palouse, farmers venture into the ecotones and even into forest areas to grow crops, which ends up costing more.

Many agricultural products, from milk to forests, are subsidized by the government and would be noncompetitive in the market without the subsidy. How would we deal with agricultural supports? Do without? Let true value be charged (3.00 for a loaf of bread)? There are things we can do to make agriculture sustainable and successful:

1. Diversify crops, especially adding drought resistant varieties (the Palouse has drought conditions every summer, worse periodically). Grow wild lupine to combine with soybeans for food. Convert from intensive cattle raising to antelope farming. Grow more varieties of apples (reduce imports of apples from outside the area). Increase self-reliance

on most foods (except those that cannot be grown here (kiwi, oranges).

2. Develop new products from existing crops.

3. Use appropriate technology (solar power, field drilling, organic growing); import less energy, maybe export some. Stress low-input agriculture; low-fertilizer and low-pesticide may result in lower gross sales per area but in higher net revenue per area.

4. Process the crop (sell noodles as well as wheat).

5. Market it ourselves.

6. Form cooperatives, especially for specialized market or low volume products (beets for instance).

7. Create a land trust. How do we protect farm land from pressures of development? As market value as a nonfarm increases? Zoning? Land trust to equalize taxes to farmer? Land trust funded by property transfer tax. The land trust leases the development rights on farmland.

We depend on vegetation for far more than food: it makes up the content of much of our newsprint, construction, furniture, clothing, packaging. Furthermore, with shortages of minerals, many substitutes are expected to be organic. But, our monocrops are directed only to one market.

2. Animals

The original grassland supported good numbers of mammals, from mice and coyotes to deer, antelope, and elk. To some extent they have been replaced by domestic species: Dairy and beef cattle, swine, sheep, and poultry. Livestock in the Palouse numbers over a 1.3 million individuals, over twice the human population. Over 60 percent of the cropland production is devoted to feeding them, and over 30 percent of raw materials to housing and transporting them (for example, it takes 5 to 20 calories of fuel to produce 1 calorie of meat).

Although many animals, such as cattle and sheep are raised on ranges, they often spend months in feedlots being fattened with grain for human consumption. About 95% of this food goes for respiration or ends up as manure. The 95% loss is acceptable when an animal is raised on rough ground or with native populations, antelope for example. Harvesting some wild animals may be a better alternative than agriculture; this would be cheaper than improving the pasture degraded from overuse. Wild species might be more appropriate on marginal soils. Raising food animals may be acceptable using wastes and scraps that contain recoverable food, but it is not acceptable using whole grain crops or on free range. Many animal foods could come from sources unappetizing to humans, such as insects or algae. Harvesting algae directly for food is possible, but has high processing costs and poor flavor and low acceptance.

3. Energy

The Palouse has sunlight, water, and wind; it also has small amounts of coal, gas, and oil, but not nearly enough to provide energy to residences and industries. Hydroelectric power is well-developed. Wind and solar energy are very abundant but not very well-developed. Power is available from several nuclear power stations (see Table 5). The research and production of nuclear energy has resulted in over 20 hazardous waste sites being located in the Palouse. So far, over half of the energy production in the Palouse—that from water power—is intermediately renewable. The big difference between energy resources and energy use is the quantity of imported oil (172 trillion kilocalories).

Energy use is increasing 3 times faster than the human population. Much of this energy is used in food production. For instance, an estimated 1,250 liters of gasoline (equivalents) are used to feed one person per year. (If the known reserves of fuel were spent for the earth's population at this rate, they would be exhausted within 13 years, assuming no use for any other purposes.)

Agriculture requires excessive energy. Catering to our refined tastes for flawless Platonic-form fruits, industrial agriculture has invested more energy in growing, packaging, shipping, and marketing apples, for instance, than the energy we get out of eating them (the ratio is about 2 to 1—for grains like wheat the ratio is 1 to 4). For some crops, such as brussels sprouts, the amount of energy used exceeds the energy yield by over 30 percent. Other crops, such as dry beans and rice, use almost as much energy as they yield. Energy for crop production is of two kinds: that to increase yields (through hybrid seeds and fertilizer) and that to reduce human labor (using tractors and drying rigs). The latter needs to be reconsidered.Effective use of human power in the U.S. could produce the same high yields, but using only 25 percent of the energy employed.

Technologies require energy. To produce 1 kilogram of phosphorus takes 3,200 kilocalories, including mining and processing.To produce 1 liter of fuel takes 10,000 Kcal and to run a tractor for an hour uses 90,000 Kcal. To build the tractor takes far more. The industrial revolution increased the quantity of energy, but decreased the variety of energy resources.

Energy generation itself consumes the greatest percentage (36) of energy. The main uses of the remaining energy are motor traffic, manufacturing, and residential and commercial heating.  Manufacturing is a heavy consumer; it includes: pulp and paper; primary metals (cars); nonmetallic products (plastics, shoes); and chemicals. Some of the energy crisis could be avoided by using less consumptive settlement patterns and natural energy utilization.

The public service function of nature provides free services to humanity that are essential to civilization. But when the free services are overloaded and breakdown, we have to pay for the repair. Further increase in flows of energy through technology will significantly reduce the capacity of the earth to support humanity, even large-scale fusion techniques. The overuse of nonrenewable resources can destroy renewable ones.For example, if acid rain from burning fossil fuels continues in the west, the primary productivity of Idaho forests may be reduced by a net 10 percent due to rising soil pH. This is the equivalent loss of energy from power of 15 1,000 megawatt reactors.

An analysis of energy supply possibilities is needed to recognize the consequences of actions in terms of resources. Terrestrial energy is the stock, solar energy is the flow. There are asymmetries in energy balances, from relying on the stock. The future offers less stock. There is a far greater flow of solar energy than stock.

Technology could be developed to tap the flow. The stock should be kept for transitional changes, rather than being burned up mall-hopping (a favorite sport and occupation in the Palouse). In all processes in which energy is changed, some of it becomes unusable (diffused and very difficult to harness, according to the second law of thermodynamics). We should reestablish earlier energy patterns for the region, and use combined systems of wind, water, solar, organic, and fossil fuels for energy. Depending on water power for a time is acceptable, but even damssilt up. Singly, these sources may be inadequate, but as a mosaic they could meet decentralized needs. The energy pattern should be pieced together organically from the potentialities of a region. Consumption and production of energy must balance safely.

Energy demand has resulted in the use of high risk sources. With nuclear power, the burden of proof for safety is on the agencies themselves; its use in the absence of complete assurances of safety places unnecessary risk on future generations.Even with inefficiency, there is no need to use high risk energy generation. Buckminster Fuller claims that by using only proven energy resources, only proven technologies, and only at proven rates, within ten years all of humanity could enjoy an energy income equivalent to the United States in 1960, and nuclear and fossil fuel energy could be phased out during that time. With efficient homes and electric transport, all of the area's energy needs could be met by established water power, which is estimated to be half of the potential.

Passive solar heating would be adequate for individual buildings. Photovoltaic cells could provide electricity and power cars. Local energy projects using geothermal sources, winds, or the sun are preferable, since their operation does not introduce new material to local cycles. All of these sources would be characterized by a small scale.

Perfect activity leaves no track behind it. Energy production should leave as few tracks behind it as possible. Nuclear fission leaves burning, long-lasting tracks. Burning organic fuels leaves pollution and sickness. Even large scale solar projects, extraterrestrial or earth-based would shift large quantities of energy around with unknown consequences; the sophisticated equipment involved would also cover large areas. Any concentrated energy use for large human populations and manufacturing may be too much. Even wood-burning stoves are causing pollution. Small-scale, nonpolluting activities would leave the fewest tracks.

4. Minerals

Because the Palouse rests on large deposits of basalt, its mineral wealth is limited. The basalt itself is valuable and useful, however. It can be crushed as a component of asphalt, used as building stone, especially in a tree-poor area, used for landscaping, and extracted into fibers—which are strong and flexible and could be used for reinforcing concrete or substituting in pipes, insulation, and even vehicles. Research onto other uses should be well-supported.

Other rocks are present: sandstone, siltstone, granite, limestone, and diatomaceous earth. A number of metals can be found and extracted: gold, magnesium, and copper. A few others are accessible: lead, zinc, tungsten, manganese, iron, magnesium, and nickel. The most common are listed in Table 6. There is some oil and natural gas, but not enough to currently keep the region going for even a year.

Virtually 100 percent of aluminum and manganese used has to be imported from overseas. Cobalt, copper, platinum, tungsten, and zinc—minerals used in advanced or strategic technologies (in alloys, catalysts, magnets, and electronic devices), are absent in large quantities, and must be imported from other regions in the United States or from outside. If no substitutes are possible in electronic equipment, then these minerals have to be acquired through trade.

*Human Population*

Current Figures

The population of the Palouse is currently over 682,000 people (see Table 8 for a breakdown of the numbers). Most of these people live in cities, from Richland to Spokane. That does not seem like a large number of people when compared to the urban areas in London or Hong Kong, but it is far larger than the archaic population. Several trends are evident: A long-term trend to larger cities, and a more recent movement from cities to smaller towns and rural farming communities.

Calculated Goals

Is 682,000 too many? How many more could there be? Is this number above or below some maximum carrying capacity? There is a maximum carrying capacity for this region, as well as an optimum. The carrying capacity is the population sustainable on a long-term basis of renewable and nonrenewable resources. For humans, this capacity must include domesticates, as human equivalents, since many domesticates compete for protein consumption. Domestic animals can extend the carrying capacity somewhat, since many of them consume agricultural wastes or use lands marginal for agriculture, but they are not as efficient as wild populations. Technology can expand the carrying capacity to some extent, with higher yield crops and resource substitution, but also it reduces the capacity with unforeseen effects, from the use of pesticides, for example. War and social disorder would also reduce the ultimate capacity. Furthermore, the capacity decreases as the per capita use of energy and resources increases. Carrying capacity calculations often just consider food energy, but all needs—clothing, shelter, transportation, information generation, aesthetic satisfaction—must be included.

A number of assumptions are necessary to calculate an optimum. Calculating a population based on plant productivity is relatively simple. The Palouse could support probably a maximum of 2 million people. However, considering the need for resources and the ubiquitous Law of the Minimum, the maximum goes down rapidly. J. von Liebig's 1863 law of the minimum describes a critical minimum, under steady state conditions, of a chemical material needed for growth and reproduction. Economists have claimed that the minimum does not apply in a growing system; alas, our system has been growing through transformation and not real growth.

H. R. Hulet pointed out that a population as a function of wood production would only be 80 percent of that calculated from food production—and the Palouse has far less wood than the continental average. Furthermore, the population would be even smaller as a function of energy and fertilizer use rates. The rate of aluminum use would support only 40 percent as many (800,000). More importantly, these rates are not sustainable, being based on high American standards of consumption. A lack of some resources is not necessarily limiting, since we can trade with other areas that need wheat or peas.

The current high levels of population, at a high range of standards, can only be maintained through the constant takeover of natural habitats for arable land, or through the drawdown of fossil fuels, or by economically cheating the poor and powerless. Since the quantity of wild lands and fossil fuels is quite limited, either human populations must adjust to renewable resources or technology must provide substitutes, to avoid an eventual population crash.

Eugene Odum suggested using land area as a measure of human carrying capacity. The minimum per capita acreage requirements, with a temperate area like Georgia as a model for a quality environment, is just over two hectares (5 acres). The percentage of areas is broken down in Table 10. The natural areas are based on minimum space needs for watersheds, as estimated by land use surveys. Food-producing land includes acreage for domestic livestock. Using Odum's technique for the Palouse, assuming that wilderness area has been considered in the calculation of natural areas, and converting for the differences in productivity of ecosystems (the Palouse is only about 40 percent as productive), the population calculation comes to 1.5 million people. This figure, however, does not include trade land, that productivity needed to trade for necessities, such as metals.

Furthermore, the population of the Palouse depends on the limiting factors of the earth, those scarcities which could be traded between the regional populations, and each regional population having a percentage of that ultimate limiting factor (maybe phosphorus or manganese)—the percentage distribution to be determined by the regional productivity available for human consumption. Restated, the Palouse may have enough food for over a million people, but it does not have enough wood to build them houses or enough steel to build trains; therefore, we would have to trade food resources for mineral or timber resources, assuming that other regions are able to trade.

Samuel Eyre also devised a common denominator to consider organic and inorganic assets together. He assigned a nutrition equivalent unit to weights of metal, but this calculation depended on a dollar value for food and minerals. For example, assuming the daily standard adult human nutrition requirement of 3,000 kilocalories, money income from minerals can be expressed in terms of annual nutrition units. Assuming that wheat releases 4 kilocalories per gram and is 10 percent cellulose and 15 percent moisture, then 1 kilogram of wheat yields 3,000 kilocalories, conveniently equal to the daily food requirement of one human being. One metric ton of unmilled wheat is equivalent to the annual food requirement of 3 people.

Assuming that aluminum sells for $1122.00 per metric ton and wheat sells for $109.00 per metric ton, 1 ton of aluminum costs the same as 10 tons of wheat (see Table 13). If it takes 13,000 tons of aluminum to meet the needs of the current Palouse population of 682,000 (about 0.02 metric ton per person for cars, wiring, and cans), then we need to trade the monetary value of 130,000 tons of wheat to get it—enough to feed 390,000 people! And that is 390,000 fewer people than the area can support if we need to have aluminum things.

Population carrying capacity can be formulated using the net primary productivity (NPP) of the system (see Table 11). Following Odum, that only 30 percent of the area should be used for producing food, the maximum agricultural area is set at 1.8 million hectares (the current use in the Palouse is actually somewhat less). Following Lieth, but averaging over the entire ecosystem, we estimate the grassland productivity at 1,200 Kilocalories per square meter per year (or 12.5 million Kcal per hectare per year); for energy-subsidized cultivated land, we take a mean of 4,000 Kcal per square meter per year (or 40 million Kcal per hectare per year). And, of that productivity, 75 percent is unavailable for harvest (60 percent is underground, 5 percent taken by pests, 10 percent used for respiration and reproduction), 65 percent of the harvest is inedible, 80 percent of the edible is lost in process, and 25 percent of the processed food is not consumed—leaving only 10 percent of the original productivity to nourish people. Thus, the gross productivity for the Palouse is 36 trillion Kilocalories per year, but only 3.6 trillion are available as food energy. Since every adult human being requires 3,000 Kcal per day (or 1.1 million Kcal per year—see Table 9), the maximum number of human beings, assuming that all other needs are met, is 1.27 million. Of course, food is not enough. We need a large quantity of calories for trade and luxuries. Assuming that other surpluses and deficits cancel out, for instance excess energy from water power for cotton for clothes or basalt for lumber, and balancing only agricultural productivity and aluminum needs, we get a population of 880,000 people.

The advantage of primary production as wealth is that the wealth is sustainable—plants are renewable and minerals can be recycled. One disadvantage is that the net community production (NCP) is not considered; NCP takes all of the food chain into account—the millions of other species. Furthermore, dollars are used instead of human work units—using human work units, the number of hours of labor to produce a standard measure, would make wheat and aluminum much closer in price. Also, the technological production (in integrated greenhouses or algae farms) of food is not considered.

It is possible to calculate a sustainable population using NCP instead of NPP (see Table 12). For temperate grasslands, NCP may approach 60 percent of NPP, although 30 percent is much more likely and 25 percent is used for the Palouse. The population calculation for NCP results in 317,000. These population figures have been maximum for the productivities. Because the climate is variable, the ecosystem is ever-changing, and humans have unforeseen effects, we should strive for an optimum number, which we could arrive at through an arbitrary multiplier like .5 (Wittbecker, 1981). Assuming the multiplier is 50 percent, the optimum population becomes 159,000, obviously less than our current population. This multiplier is considered as part of the cultural factor.

Each way of calculating a population has become more comprehensive and cautious and has resulted in a smaller population. The target population for planning depends on how cautious we are. Should we gamble and go for more people? If we calculate the maximum wrong, we break the system, and we do not know how to repair it. On the other hand, we might approach some minimum. The likelihood of this possibility is low. The Indians did not approach it at 50,000. The minimum number for genetic health, for the entire species, could be 5,000 individuals. For a guarantee of fertility, 50,000, and for a minimum for social contact, again 50,000.

*Resource Use by Population*

Just as important as any calculation of the population in an area is the rate of resource use by that population. Grasslands were the basis of early civilizations, and few regions have been altered as thoroughly or as devastated by human occupation, by overcultivation and overgrazing. Using too many resources, such as water and timber, too fast can make deserts.

We are digging up metric tons of minerals per hectare. We are draining the aquifer for our irrigation; and the Palouse is in the top ten areas in the United States for amounts of irrigation. We are mining the soil for everything it has and letting the rest erode (see Table 14). The Palouse is subject to moderate and severe erosion, with from 25 to 75 percent of topsoil lost and over 75 percent in many areas. This percentage represents hundreds of million tons of top soil lost annually and thousands of hectares of agricultural land degraded through erosion annually.

We are using 10 to 30 times as many resources as the Indians did 200 years earlier. Are we 10 to 30 times as happy? Indigenous peoples did not use resources at an accelerating rate. They were limited by their technology, but more importantly by their wants, as taught in myths and stories. Our high rates are clearly unsustainable. The difference is in our technology and values.

### The Impact of Technology

Technology can be used to expand or contract resources. Technologies have the capability to minimize the use of resources, but they also have negative effects. Breeding, fertilizer, pesticides, and modern equipment have certainly increased agricultural production, but the negative impacts of genetic loss, soil degradation, erosion, and pollution decrease actual and potential productivity. When all factors are combined, and total energy cost is compared with energy production, the result is disappointing and does not compare well with traditional methods, using draft animals and human labor (Wittbecker, 1976).

In another instance, technology has greatly increased the kind and quality of materials used for buildings and machines, especially aluminum and other light metals and silicon constructs. Yet, the scale of technology produces pollution that reduces the productivity of natural and agricultural systems. Unbridled, unconscious technology has given us benefits, but only at the cost of irreplaceable stocks of energy and environmental degradation. Instead of expecting technology to triple or quadruple our wealth, it is more likely that it has barely had a positive effect. Making technology appropriate, responsive, and conscious may go a ways to increasing its positive impact. Two technological processes are especially important, substitution and recycling.

Substitution is one way to avoid shortages of resources. For instance, petroleum products have substituted for rubber from trees for many uses, including tires; aluminum, relatively abundant, is substituted for copper, even though its electrical properties are less desirable. Plastics, also from petroleum, are used to substitute for wood, leather, and metal in many industries. Some substitutions may temporarily ease pressures on biological systems, but they depend on the supplies of petroleum, a practically nonrenewable resource. Therefore, in considering substitution, we should concentrate on materials that are plentiful and local rather than scarce or remote. Basalt is a good example. Perhaps wheat chaff is also. There are not substitutes for everything, so there must be a minimum of irreplaceable stocks. Recycling is well-established in larger towns. Waste is still dumped in the many landfills throughout the region, although the quantity of waste per capita may be declining with awareness and recycling.

New technology has been a primary force for change for decades; but some technologies, like computing or genetic engineering, may lead to opposite effects from the intended ones. The use of new tools may have unexpected effects. For instance, mass-produced computers may lead to individual autonomy, as well as invasion of privacy. New energy technologies could have the same effect. Small-scale water power plants could lead to decentralized living; or energy-saving devices could result in more energy being used.

#### *Choosing Technologies*

We assume that improving human lives requires new materials, machines, and techniques. But, we do not have measures to judge whether technologies are beneficial or harmful. We could start questioning technology: who it benefits, what the negative side or cost is, how it fits in a network of technology, and how can it be reversed if necessary. We could assume that technological changes are always somewhat harmful and study them for a long time before implementing them. Technology is not neutral or value free; there are inherent social consequences.

Personal transportation, for instance, is problematical, especially cars. In a similar ratio to livestock, the number of vehicles in the Palouse exceeds the number of people, contributing disproportionately to air pollution, acid rain, and gases that contribute to ozone depletion and greenhouse effects. By allowing changes in distances and by forcing dispersed needs, the car becomes indispensable. Nor have we considered what changes in social mores and even physical health result from our embrace of the car. Trucks and planes have become romantic as well. Perhaps we should consider restoring and expanding rail transportation in the Palouse, then adding bicycle and walking paths. The number of paved surfaces, however, must be aligned with land use.

A favorite Indian pastime was the telling and retelling of stories. Television also has repetition, but not the same depth of involvement. Radio stimulates images in the way books do, because neither impose images, although neither of these forms may be as involving. We have assumed improvements in technology are improvements in human existence, but we must examine them constantly, if we are not to lose some of the characteristics, such as empathy, that we value most highly. Some communities may wish to examine cars, computers, and television, and eliminate them or modify their use.

Limits to Nature and Technology

The earth is finite and its resources are finite for human purposes It is very difficult to quantify the limits exactly. We do not know what the limit of productivity that can be taken over is or what the limit of energy use is before a system is disrupted. Nor do we know the limit of interference in an ecosystem to avoid collapse. The trend is towards increased disturbance of natural systems.

The Indians had limited energy sources, but were able to change or move to avoid declining marginal productivity—this was only temporary as the region is finite. Now we have fossil fuels, but have not learned the lesson of limits. Every case involving growth is only temporary.

Within unknown limits, we need to establish a pattern of use that is sustainable and flexible, leaving other possibilities open. Mineral resources, like aluminum and copper, although finite and nonrenewable, may have indefinite cycles of use. Resources are used more efficiently, but then there are fewer reserves or flexibility in allocation of resources.

Technological multipliers are efficiencies that allow a limited increase in the carrying capacity of the entire ecological system. The load on the system can be expressed as the resource demand multiplied by number of people. Trade diminishes some resource or food capital, but can be used to avoid some minimums. The Critical Minimum is a factor limiting carrying capacity. We do not know what it is. Assigning a multiplier to the effect of technology is difficult due to the contradictory impacts of technology; it is estimated at 1.2, which is to say that technology has an overall benefit.

*Cultural Values*

There have been two cultural patterns on the Palouse. An archaic one that offered tribal egalitarianism and limited impact and a technological one based on republican democracy and industrial consumption. The first could not compete against the second, but it has not been completely eliminated either. The monoculture of coke and cars tends to overwhelm the subtle adaptations of the Nez Perce, for instance. A coherent culture provides a secure platform for exploration and open-mindedness; it provides criteria to judge the 'special effects' like television. A conscious culture, perhaps with elements of native American and early American traditions, with appropriate technology and knowledge, could improve and guide the culture of the market place; television, as does telephone and radio, unites people through information, but a common culture is indispensable for uniting their hearts.

Athelstan Spilhaus suggests that a good index of the quality of life is the number of choices or alternatives a society provides for its individuals. Western culture has valued the pioneer life of the individual—independent, self-sufficient, free to choose different life styles—but with more people, the choices are being subtracted. The more we value open spaces, the fewer people the area can support and still have the open spaces.

It may be that the Indians of the Palouse require 10 times the space as rural settlers; and, it may be that these settlers require 10 times the space as their urban counterparts. Or, it may be that people would prefer to have more discretionary time and less work time, as was possible in archaic societies.

There are numerous advantages of way of life of Palouse Indians: fewer working hours (about 4 per day); more leisure to talk, sleep, engage in rituals; a diverse and healthy diet; deliberate underproduction, below the maximum levels; deliberate control of population growth below maximum levels; and deliberate under use of resources, resulting in small ratio of people to resources. Subsistence economics means simply that surpluses are not accumulated. This might make them more vulnerable to food shortages, although the ratio reduces the possibility; furthermore, industrial cultures have far higher incidences of starvation. Our industrial culture is approaching a form of subsistence now, in the sense of a source or minimum of necessities—we cannot leave after we have eroded the soil. Perhaps we will be less tempted to exploit the land for short-term profit, since we have to remain after the profit leaves.

The greatest happiness for the greatest number could be achieved by devising a measure of quality of life from the accumulated wisdom of nutritionists, medics, psychologists, and sociologists. It could yield an optimum quantity and quality of the commodities of life: how much space, how much food, how much air and water. But would that be enough? Indicators of the quality of life cannot all be expressed numerically; they are elusive. Quality depends more on the spirit of the society than a count of material possessions. Even orthodox ecological criteria are not adequate to evaluate the quality of a particular environment for human life. Nevertheless, we can try to assign a cultural multiplier to our aesthetic and support space needs; it is estimated at 0.83, which means that the industrial culture does not satisfy our frontier mentality.

*Summary for the Palouse Model*

Ultimately, our cities depend on agriculture, and agriculture depends on wilderness—for recycling, pest control, genetic diversity, soil-making, and water purification, among other things. Our cities depend on cultures for their vitality, and cultures depend on wilderness for their context and imagery. Therefore, we must preserve wilderness areas and cultural knowledge first.

The findings of the plan can be summarized as follows (refer to Table 15). Replacing the general numbers and evaluating for P gives 570,000 people, less than the current population. The optimum energy rate is about than half of the per capita current rate (about $1.0 \bullet 10^7$ Kcal); at the current rate, with its dependence on large quantities of imported oil, the Palouse could afford less than 300,000 on a sustainable basis.

The Palouse has adequate resources to feed and care for its current population—at a reasonable level. The rates of use of energy and some minerals are far too high. Our demands and values are not related closely enough to the particular beauties and limits of our home ecosystem. We have to fit our goals within the limits.

## Other Considerations

*Economic Things*

Economic Goals

An economics based on ecological understanding would have many different assumptions from our current economics. For instance, the capital of an ecosystem would be its physical environment and its gross primary productivity; interest would be the net ecosystem productivity. The production percentage would be the amount necessary to keep the ecosystem healthy. Cultural capital would be the wealth of human knowledge about environments, and cultural interest would be experimentation.

*Expanding Capital*. Traditional economics has a three capital model of human wealth. Land, labor, and manufactures. Clearly, this is not adequate; the definition of each kind of capital needs to be expanded. For instance, land is the entire ecological system, complete with other species and biogeochemical cycles, preserves, as well as agricultural areas, resources, and artificial modifications like dams. And labor depends on the traditional capital of a culture, the beliefs and myths and rules for behaving, the institutions. Manufactures themselves depend on culture and land (resources), as well as on technology.

*Diversifying Institutions*. The simplest economic transactions were between individuals who gathered food or made tools and then traded. With the increase in specialization and complexity, came individual traders, then guilds, and finally corporations.

The Palouse has several universities, many farms, numerous small businesses, e.g., clothing, food, and hardware stores, automotive repair, and lumber yards and construction companies. Many of the stores in the Palouse are owned by large national or international corporations, resulting in an outflow of money. Many universities and farms depend on money from external sources, including the federal government. We could implement ways to keep money circulating in the area; sometimes this can be done by simply buying locally, but more ambitious solutions, such as local barter "bucks," are also possible.

*Stressing the Development of Wealth Over Growth*. Economics has always been concerned with measuring wealth. Wealth once meant tangible things, land, ships, houses; then labor and production; it has come to mean negotiable symbols such as cash and stocks or unlimited information. Yet, no single description is adequate. The basis of wealth for a long-time will be land. Even more so because we do not know its complete value (as many native peoples have found out when coal or pharmaceutical plants were discovered on their lands).

The distribution of symbolic and real wealth is very inequitable as the result of historical trends, old economic rules, and cultural confusion. The inequity could be reduced in the Palouse with caps on top salaries, a minimum income (or negative tax), and a simplified 10 percent tax on income. The services provided to society by some groups, football players and veterinarians, for instance, are paid for disproportionately well compared to those of others, such as teachers or nurses. Recognizing that the market is not the best judge of social value, local government could set salary ranges.

Economics is distorted when reduced to quantity and technique; there is always a psychological and ethical dimension to be accounted for—motives, values, needs, and aspirations. Economics could be restructured to take this consciousness into account. The assessment of personal or cultural wealth, for instance, is mostly psychological; wealth may be measured by how many valuables one has, which may be physical, like feathers or salmon or gold or land, or by how by much status, which may be behavioral, such as enjoying deference or a good reputation.

We make trade-offs in social systems without assigning dollar values. We could do that with ecosystems. The valuation could be scientific or be based on human labor. New values of natural resources are being recognized now by economists, such as option value, that is, reserving a resource for future use or existence value or paying for something to exist that will not be used.

One thing business can do is put a price on nature. But, let us make it a real price, reflecting the real cost of replacement. Let us base the cost on human labor and technology, so that 1 gallon of oil is worth a million dollars, as Buckminster Fuller once calculated. Let us make all those prices high, too high rather than too low. A tax of $3.00 per gallon could finance the renewal of the transportation infrastructure in the Palouse (and the price of gas would still be cheaper than it is in Europe).

### Limits of Economics

Sustainable development requires recognition of the large number of limits. The ecological approach to development makes it irrelevant to discuss global limits to growth. Local limits are far more significant to a majority of people. The Palouse, for instance, faces very real limits in rainfall and minerals. Regardless of how much food exists, people will starve unless they can get it (as is happening so often, now, elsewhere). Every community is forced to accept some upper limit, beyond which it cannot grow any further. Further growth results in destruction or disruption of the community itself and the natural communities on which it depends.

Complex societies depend on production from resources. Increased complexity requires more information processing and more integration of disparate parts. The costs of communication increase. Complex societies need control and specialization. Yet, investment in complexity yields declining marginal returns because of the increasing size of bureaucracies, increasing taxation, and costs of internal control. If complexity can be restrained, the society may be healthier.

### *Political Things*

The Palouse Indian nations governed their areas of the Palouse independently. Their political principles were similar: all land is communally owned by the tribe, although household goods may be personally held; all decisions were made by consensus in which everyone participated; chiefs were not coercive rulers, but teachers and leaders with specific duties limited to their realm—medicine, war, or ceremonies for example.

When the Europeans settled the area, they brought their centralized, representational government. The original goal of the American republic, according to Jefferson, was to make each person a participator in the everyday affairs of government. But the government (state or federal) has become gigantic, managing the area from remote locations of power, and participation has dwindled. Despite recent emphasis on personal responsibility and international cooperation, our political institutions have not responded.

Political institutions are not givens or timeless. Taking from the strengths of these earlier forms, it might be possible to modify government to be more effective. The first step would be to form an independent regional government for the Palouse.

The Palouse is a good candidate to be an independent political unit. It is a governable size, with over half a million people in 6 million hectares. It has clearly defined boundaries, as an ecosystem, that is the ecological community including humans, and not a state or county whose boundaries have been determined by rectangular grids for convenience. The Palouse has a history of democratic representation.

### Goals of Politics

The government of a community is a framework to maintain the people. For the original archaic peoples, tribal teachers were adequate. The adequacy seems less in our representational republic.

*Expressing the Purposes of Government*. Central government has lost sight of its own purpose, which is not the sum of special interests or its own perpetuation. Government has always had other reasons for existing.

1. A vision of the common good, where common means common to all beings in the ecological community as well, and where there is a balance of public and private interests.

2. Coordination of the means to satisfy the long-term needs of the community, by balancing freedom and regulation. This means controlling resources and land use—in essence determining the physical shape and size of the community.

3. Regulation of the community. Determining the closure and openness of the community; rates of increase or decrease, through births, deaths, or immigration. Encouraging some forms of technology or trade. Provide work opportunities to members.

4. Protection of the community from internal and external threats: natural disasters, criminal elements, and other communities. Most of these threats are unavoidable; some are long-term and rare; others are constant and of low intensity. Some are part of the human condition; others the result of historical imbalances. We need to be aware of them

and minimize their impact.

*Increasing Participation*. Citizenship is too complex for television or even electronic global villages; it must be in the community, in person, in place, where individuals learn about each other in context. Government by local meeting assumes the common sense and wisdom of the common person in an open exchange of belief and need. It requires trust and esteem.

Often this kind of involvement takes more time than just voting annually or having one official decide. The effect of presenting a problem before an Indian council was to slow down response by passing it to the entire constituency and getting a consensus; this ensured due consideration.

We must encourage the participation necessary for effective democracy, by soliciting public opinion and by offering real power to an involved public. We might look to Montana or Vermont for examples of how to change local participation.

*Taking and Yielding Powers.* Central government should shrink so that local government can expand, perhaps as much as 80 percent. Some things should be done at the Palouse level, such as the protection of watersheds, rivers, and the atmosphere (some protection must be done at the national and international level, of course).

Following the federal model, some delegated powers could go to the regional level, the Palouse, and reserved powers to the communities. A Palouse government could handle internal and external security, maintain law and order, and set ground rules on local economic exchange to ensure fairness. The most important responsibility of a government is to set standards for itself and its institutions.

The Palouse could have an administrative department to handle taxation, budgeting, and purchasing. It may wish to coin local money, perhaps on the model of the Local Employment and Trade System—LETS—on Vancouver Island in Canada, which records credits and debits on a computer, which can then only be used locally. There may be a department to protect the civil rights and liberties of the people and a department to protect the environment. Environmental disputes could be resolved by mediation (as was developed in Seattle in 1980s).

Spending on education, roads, welfare could be done at local level. There is some risk, especially with education or wilderness restoration, but the breakdowns and errors would not be devastating as with centralized planning. Citizens would need to do the work of government as well as make the decisions. They could have total control over some things. The judgments of the people are more important than the efficiency of those judgments. It may not be necessary to have many separate authorities or committees; it might be better to integrate policy making bodies so they are not too specialized (highways, schools, and waste, for instance, are related).

As Palouse cities become more sustainable their forms would change. They would be more compact, with more multiple-use streets, as a focus for human activity (less for cars); buildings could use solar power, efficient heating, perhaps integrate roof-top crops in an urban agriculture; older buildings could be integrated into new groupings to integrate services, play, and work with living; local public spaces and services could be developed; derelict land could be regenerated, either as green area or croplands.

Preconditions to a sustainable, steady state economy include pollution control and some redistribution of resources. The redistribution of resources and the improvement of environmental quality are more important than increased production by sophisticated technology. This strategy calls for improved social and educational organization more than technological style. Styles of technology must be determined by culture and context. Development requires a local authority working with suitable economic and ecological conditions. No authority can be effective without the participation of the people.

Limits of Government

When a place has a reputation for being small and livable, as many towns in the Palouse do, it attracts more people, until it is no longer small and livable. How do we impose limits? How do we keep things from growing? Limits on birth through licenses? (maybe leading to rebellion?) Limits on housing and public services? (perhaps causing shanty towns?) Peer pressure? (possibly contributing to social disorder?). Nature is self-organizing, and society is self-organizing, but we need to recognize some limits and define others, and then take responsibility for keeping to those limits.

*Limiting Size.* To restore participation, we have to consider the limits of participation. The current population of 682,000 seems to be too large for direct democracy, as does any of the projected optima.

25,000 is large for direct democracy. Many of the cities and towns in the Palouse are approaching or have exceeded this size. The size has to be small enough for people to meet and "exercise government" (in James Madison's words). Kirkpatrick Sale concludes that the optimum size for direct meeting is 500. Probably participation becomes more difficult as the size increases. Bryan and McClaughry suggest 2,500 as a maximum, since in larger groups people cannot all know one another and the assemblies become a debating forum for a few.

Putting these figures together, we expect good sizes of neighborhoods to be 500-2,500; these would make up communities of 5,000-25,000 (about 3,000-4,000 people are needed to support an elementary school, for instance); and the communities would bring the Palouse population to 400,000. Differences in size seem to be a unit of 10. Each Community legislature would be 40-60 people. The size of a Palouse legislature would be about 50. Perhaps these sizes are close to the optimum.

There is a point in critical mass reaction where the mood of the mass becomes indifferent. As long as the size is small enough for recognized identity, people will behave with concern. At a larger size the ideology, which is capable of anything through indifference, takes over.

Small communities are essential to the democratic ideal. The uniqueness of place gives belonging and identity. The whole community gives meaning and richness to life. The population distribution of much of the Palouse may cause some difficulty, however. People will not be within walking distance, but may have to drive 20-30 miles to meetings or communicate remotely through telephone, computer, paper, or friends.

*Protecting Ways of Life*. One way to protect a style of life is to put a limit on the intensity of development of the entire area with Transferable Development Rights (TDR) assigned to each unit of area. Any project would have a TDR value (25 for an apartment building, for example); TDRs would have to be bought or traded from other landowners. All land could be held in communal ownership and leased to farms and businesses, except preservation and conservation lands.

The landscape needs to be zoned (compartmentalized) to provide a safe balance between protected ecosystems and used ones. Restrictions on land and water are one means of avoiding overpopulation or overexploitation. Compartmentalization avoids the need to compromise every ecosystem for human use. Multiple use systems should only be part of the picture—first a protected environment of mature ecosystems, then productive systems, multiple use, and urban areas.

*Paying Costs and Leveling Extremes*. Relative to European communities, we have less funding for public services, such as parks and public transportation. We traded public support for higher levels of private affluence, which has not made us any happier. In fact, we have become more insecure, as our difference in wealth have become more extreme, allowing us to be far richer or far poorer (and then second-class and neglected).

The communities could levy taxes on property. But there is a discrepancy in the wealth of communities. The Palouse could collect income taxes, and communities could claim a percentage of taxes collected. The community and Palouse could both tax the same bases: income, sales, meals, property, fuel. The Palouse would set a ceiling on each; the community rate could be zero on some. Or the communities could do all taxes and give the Palouse government a percentage, although differences in wealth might be maintained; then, the state could return a percentage to make up equality in education or environmental protection. The important thing is that taxes are used to direct development and reflect the true costs of the society we want to have.

We could change taxation procedures to reduce growth instead of stimulating it. Parkinson suggests that taxation beyond a certain point yields declining marginal returns. We could use a single tax rate flat at some percentage (from 10 to 25); and then pay everyone a fixed amount of income for basic needs (from 3,000 to 10,000 dollars).

Similarly, property taxes could be appropriately scaled to use. One way to keep farms as farms is to tax land by use. The more important the use, farming for instance, the lower the taxes. Buying farmland for shopping centers would result in discouragingly high taxes.

It is difficult to persuade people to pay more in taxes, to vote to keep less. We could, through education, expand the understanding of the self and expand self-interest in that way. We could let some catastrophe work towards equality, but that might have other high costs to society.

Convening a Constitutional Meeting

A constitutional convention could be called in 1992 to work out a new Palouse government, possibly more radical than the 1972 Montana constitution, which required a local government review process; it mandated real change in the form of government, although few changes took place. The convention would suggest the forms of areas, according to watersheds or other boundaries, but local people would decide the areas. An example can be found in the Washington State statute of 1967.

Once the constitution sets up representation in a legislature, then the legislature has authority to make policy. There would be no limitation on taxing and spending, except maybe common sense—

people do not respond well to tax rates over 30 percent. The legislature would work to protect the uniqueness of the Palouse and its history.

Because of the differences in size, and the need for even the smallest community to be enfranchised, it may be useful to adopt a floterial district system as in Idaho. A representative could then represent 2 or 3 communities.

*Summary*

The establishment of the Palouse as an independent region would not be unrealistic or utopian. For some people in the Palouse, now, even freedom from hunger and sickness is utopian. For other people in the industrial system, the choice of a fulfilling profession is utopian. Grinding poverty, economic dislocation, homelessness, are more painful than a transformation to a sustainable, independent community. Already much of our environment has been transformed by cash crops, mining, tourists, highways, high-rise housing, and condominiums. Physical disruption has been more extensive with our current system than through a transition to sustainability. Industrial culture has replaced older patterns with great suddenness. This transition cannot seem more sudden than the loss of a home or place. Industrial cultures have reduced people's control over the means of production and power. This plan does not offer less control. Whole communities are being destroyed by industrial scale. Our social structures are already changing rapidly and impractically. Let us just make the changes conscious and more practical. This ecological plan offers movement towards common, achievable goals.

There will be questions regarding the wisdom of independence. Some people will want to decide boundaries through culture, watershed, or political power. These questions can be answered in meeting. This plan seeks to improve people's circumstances by enlisting them to save their own environment and their own way of life.

People cannot be given material equality instantly. People may object to giving up too much or not gaining enough. Providing work for everyone is one way to narrow income differences. The Palouse government, communities, and families must provide the opportunities.

Crime and civic unrest will not disappear. Dangerous weapons, from automatic guns to tanks, and dangerous products, including nuclear reactors and biocides, would be strictly regulated. People will still choose badly sometimes. But, if a form of government is bad or ineffective, they can alter it. They can learn from mistakes or unintended effects. The scale is small, so the catastrophe is small. There will always be some injustice, inadequacy, and unpredictability. Large political and economic institutions have only made it worse.

There should be a proper mix of handicraft labor, intermediate technology, and heavy industry. The root problem is how to live with technology in a mature manner. We need an ecological awareness at all levels; a humane, existential ecology, where humans are part of the system and aware of it. But that may not be enough; we may have to legislate limits or induce adherence with economic incentives, if awareness and reasoning are not enough.

A number of concrete recommendations can be made to address the goals of the Palouse: (1) educational campaigns for public awareness of the uniqueness of the Palouse and of the effects our lifestyles have on it, (2) the promotion of equity in opportunities and rewards for all people, (3) the offer of tax incentives to private and public corporations to redesign their paths in the community, (4) the gradual increase in preservation of wild and restored grasslands, perhaps up to 20 percent by 1999, to protect ecosystems and resources, and (5) a geographical/environmental data base for the intelligent management of the land.

The goal of planning is community success and personal happiness, based on self-reliance in food and shelter, self-sufficiency in agriculture, and self-limitation in size and desires. If human patterns were based on mature ecosystems, civilization would be far more complex; human values would allow for the welfare of humans, animals, plants, and land. We have to be wise enough to be disciplined, to leave wilderness for other beings, and yet to make good places for ourselves.

Planning must include every dimension of human life. This plan is such a framework. It is incomplete, but open to improvement and suggestion. You can add to it, or transform it.

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## Tables

Table 1: Light Energy and Photosynthesis
(after Odum 1971)

| Sunlight | $m^2$ per day | ha per year |
|---|---|---|
| mean sunlight | 3800 Kcal | 139.00 x $10^8$ Kcal |
| photosyn fix | 23 Kcal | 0.83 x $10^8$ Kcal |

Table 2: Productivity (after Lieth 1963)

| Land | Area (ha) | NPP | NCP |
|---|---|---|---|
| grassland | - | 2,500 | 2.5 • $10^7$ |
| Palouse | 6.0 • $10^6$ | 1,225 | |
| cultivated | 1.8 • $10^6$ | 3,000-12,000 | 4.0 • $10^7$ |

Table 3: Energy and Protein of Principal Crops

| Crop | Energy (Kcal/kg) | Kcal/$m^2$ | Protein (%) |
|---|---|---|---|
| Soybeans | 4030 | 800 | 34 |
| Oats | 3900 | 15 | |
| Potatoes | 770 | 2,000 | 2 |
| Wheat | 3300 | 1400 | 12 |
| Sorghum | 3300 | 11 | |
| Corn | 3520 | 9 | |
| Dry Beans | 3400 | 22 | |
| Algae | | 10-40000 | |

Table 4: Agricultural Production in the Palouse (1990)

| Crop | Unit | Crop | Unit |
|---|---|---|---|
| Wheat | 3,872,000 kl | Barley | 63,7000,000 bu |
| Apples | 1,350,150 mt | Potatoes | 2,880,000 mt |
| Peas | na | Lentils | na |
| Oats | na | Hay | 2,077,931 mt |
| Cattle | na | Milk | na |
| Pears | na | Cherries | na |
| Corn | na | Onions | na |
| Aspar. | na | Grapes | na |

Table 5: Energy in the Palouse

| Form | Trillion Kcal | Form | Trillion Kcal |
|---|---|---|---|
| Coal | 24.0 | Oil | na |
| Gas | na | Organic | 1.3 |
| Water | 184.0 | Wind | 0.7 |
| Solar | 1.2 | Geothermal | 0.1 |
| Nuclear | 15.0 | Chemical | na |

Table 6: Minerals in the Palouse

| Metal | Metric tons | Metal | M tons |
|---|---|---|---|
| Zinc | 24,000,000 | Nickel | 100,00 |
| Cobalt | na | Manganese | |
| Platinum | na | Iron | 10,000,000 |
| Copper | na | Lead | na |
| Molybdenum | na | Tungsten | na |
| Silver | na | | |

Table 7: Land Use in the Palouse

| Form | $10^1$ hectares | Form | $10^1$ ha |
|---|---|---|---|
| Urban | 132,000 | Rural, roads | 64,000 |
| Crop | 1,244,400 | Pasture | 180,000 |
| Range | 748,000 | Wilderness | 250 |
| Parks | na | Water | 66,000 |
| Greenhouse | na | Other | na |

Table 8: Population by County (1987)

| State | County | Total | Palouse % | Palouse # |
|---|---|---|---|---|
| OR | Wallowa | 7273 | 50 | 4137 |
| | Union | 23,921 | 10 | 2392 |
| | Umatilla | 58,861 | 30 | 17,658 |
| | Wasco | 21,732 | 50 | 10,866 |
| ID | Latah | 28,749 | 20 | 5750 |
| | Nez Perce | 33,220 | 30 | 9966 |
| | Lewis | 4118 | 40 | 1648 |
| | Idaho | 14,769 | 20 | 2954 |
| WA | Okanogon | 30,663 | 30 | 9198 |
| | Spokane | 341,835 | 50 | 170,918 |
| | Lincoln | 9604 | 85 | 8164 |
| | Douglas | 22,144 | 95 | 21,037 |
| | Chelan | 45,061 | 10 | 4506 |
| | Whitman | 40,103 | 95 | 38,098 |
| | Adams | 13,267 | 100 | 13,267 |
| | Grant | 48,522 | 100 | 48,522 |
| | Kittitas | 24,877 | 35 | 8708 |
| | Asotin | 16,823 | 70 | 11,774 |
| | Columbia | 4057 | 60 | 2436 |
| | Garfield | 2468 | 60 | 1482 |
| | Walla Walla | 47,435 | 85 | 40,324 |
| | Franklin | 35,025 | 100 | 35,025 |
| | Benton | 109,444 | 100 | 109,444 |
| | Yakima | 172,508 | 60 | 103,500 |
| | Klickitat | 15,822 | 60 | 9492 |
| Total | | | | 682,068 |

Table 9: Recommended Daily Intake of Nutrients
(after FAO 1972)

| Age | Weight (kg) | Kcal | Protein (gr) |
|---|---|---|---|
| 6 | 20.2 | 1830 | 20 |
| 13-15 male | 51.3 | 2900 | 37 |
| 13-15 female | 49.9 | 2490 | 31 |
| Adult male | 65.0 | 3000 | 37 |
| Adult female | 55.0 | 2200 | 29 |

Table 10: Acreage Per Capita (after Odum 1970)

| Kind of land | % | GA ha | Pal ha |
|---|---|---|---|
| Food-producing | 30 | 0.61 | 1.36 |
| Fiber-producing | 20 | 0.40 | 0.88 |
| Natural support | 40 | 0.81 | 1.76 |
| Artificial | 10 | 0.20 | 0.44 |
| Totals | 100 | 2.02 | 4.44 |

Table 11: Simple NPP Calculation of Population

| Vegetation | Area | NPP | Avail. | Pop. |
|---|---|---|---|---|
| Units | $10^6$ ha | Kcal/ha/yr | Mult. | $10^6$ |
| Shrub steppe | 4.1 | 3.9 | 0.1 | 1.59 |
| Cropland | 1.8 | na | 0.1 | |

Table 12: Simple NCP Calculation of Population

| Vegetation | Area | NPP | NCP | Pop. |
|---|---|---|---|---|
| Units | $10^6$ ha | $10^{12}$ Kcal | $10^{12}$ Kcal | $10^{-1}$ |
| Shrub steppe | 4.1 | 1.4 | 0.35 | 317,000 |

Table 13: Cost Equivalencies (December 1991)

| Item | Cost/unit (USD) | Cost/metric ton |
|---|---|---|
| Wheat | $3.90 bu | $110.00 |
| Soybeans | 5.40 bu | 163.00 |
| Sugar | 0.21 lb | 480.00 |
| Cotton | 0.98 lb | 2156.00 |
| Lumber (pine) | 204.50 1k bd ft | 172.00 |
| Oil (Cal crude) | 20.39 bbl | 132.60 |
| Aluminum | 0.51 lb | 1122.00 |
| Copper | 0.98 lb | 2156.00 |
| Zinc (hi grade) | 0.57 lb | 1254.00 |

All prices: Wall Street Journal, 6 December 1991.

Table 14: Per Capita Rates of Use in the Palouse

| Used | Unit per year | Used | Unit per year |
|---|---|---|---|
| Energy | 94 million Kcal | Water | 2,628,000 liters |
| Food | 1 metric ton | Wood | 4 million Kcal |
| Plastic | 15 kg | Aluminum | 0.02 metric ton |
| Mercury | 0.68 kg | Waste | 1.04 metric ton |
| Dollars | 9,700.00 | | |

Table 15: Equations

$$P = \frac{[(A \bullet N) + E] \bullet T \bullet C}{U}$$

$A = A_0 - A_1 - A_2 - A_3 - A_4$

$E = E_1 + E_2 + \dots E_n$

$N = NPP - M$

$U = F_r + R_r$

where:

$A_1$ = wilderness $A_2$ = conservation

$A_3$ = fiber $A_4$ = artificial

A = area used $E_{1-n}$ = individual resources

P = population N = net used productivity

NPP = net primary productivity

M = total unavilable productivity

$F_r$ = food requirements

$R_r$ = resource requirements

C = culture modifier T = technology modifier

Alan Wittbecker is a senior ecologist with the Marsh Institute. He is the author of numerous papers on ecology and design. This article is a special application of a 1991 article entitled "Goals and limits in ecological development plans." Portions of this article were accepted for presentation in 1992 at conferences on BioPhilosophy and Conservation Biology

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