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The Realm of Cultural-Human Ecology: Adaptation and Change in Historical Perspective

KARL W. BUTZER

Cultural Ecology: The Relationships between Nature and Society

The social sciences are prone to an unusually high level of dialectic because much of their theory and method has been borrowed. This is especially true for studies of the interactions between people and their biophysical environment, which have a long history of borrowing directly from the natural sciences at virtually all conceptual levels. The inherent difficulties of transferring models and methods from the natural to the social sciences have fostered much controversy and created more than a little confusion. But these difficulties also have stimulated critical reappraisals of such methodologies, sharpening those approaches seeking to understand the complex interrelationships between nature and society that have so long appeared to be intractable.

Under the label of cultural (or human) ecology, research directed to society–environment interactions has attracted contributors from at least three of the social sciences. At one end of the spectrum, sociologists primarily are concerned with human behavior in complex social environments. They have contributed significantly to theory and to understanding the goal – conflicts of individuals, especially in urban contexts – but they also tend to ignore the biophysical environment. On more intermediate ground, anthropologists are preeminently interested in the processes and structures whereby relatively simple human groups match resources with their needs, and incorporate them into cultural behavior. Their contribution to understanding community behavior has been singularly important, although some anthropologists adhere too strongly to a material and biological paradigm, whereas others seem to ignore it. In addition, many anthropologists have been reluctant to deal with urban communities. At the other end of the spectrum, geographers tend to focus on a much broader sphere of interaction with respect to resources, emphasizing the spatial matrix of the cultural and biophysical environment. Sometimes lacking in cultural sophistication, they have, however, directed more attention to the broader systemic context of which small communities are part. Each viewpoint makes valuable contributions; each complements the others. It must also be emphasized that the disciplinary boundaries are indistinct in practice, with the proclivities of the individual investigator determining both the methods selected and the framework in which conclusions are offered.

In the broader context of an interdisciplinary cultural ecology, the interactions between people and their biophysical environment can be examined from several perspectives. Firstly, human actions and behavior can be taken into focus at different scales – as individuals, as small communities, or as larger social groups. Secondly, interactions can be studied in either a diachronic (historical and synthetic) fashion or in a synchronic (contemporary and analytical) mode. Thirdly, emphasis can be placed on normative, deductive patterns or on particularistic case studies that provide experience and draw attention to behavioral variety. Each perspective offers certain advantages, illuminating different facets of a complex subject.

Cultural ecology is obviously indebted to biological ecology, a paradigm that presents both advantages and inherent difficulties. Ecology allows a structured organization of unlike variables, emphasizes function and hence interchanges between component parts, and is amenable to systematic and nondeterministic study of interrelationships within an organic whole. It is less satisfactory in that it was developed for plants and animals, offers no niche for the role of culture and human cognition, and can lead to unfortunate analogies between human and animal behavior. Systems theory has great heuristic value for understanding complex interrelationships, feedback loops, and equilibrium states. The systems perspective allows projection of long-term environmental impacts, such as ecological "simplification" or "catastrophic" readjustment. Simulation is very difficult, however, and quantification rarely possible. Cybernetics also has been productive, because culture and technology can be compared with information. In this perspective, adaptive choices and cultural variety can be seen as key variables, with human cognition assuming primary importance.

Drawing upon these transferred and transformed paradigms, societies can be regarded as interlocking, human ecosystems. They operate on the basis of individual initiatives and actions, embodied in aggregate community behavior and

institutional structures. Decisions are made with respect to alternative possibilities, within a social system characterized by established energy and information pathways, complicated by cooperation and competition at each trophic level, and screened by the experience and deeper values encoded in culture. At the individual level, built-it goal conflicts and human unpredictability represent powerful variables for change, whereas at the several community and institutional levels a range of negative feedbacks favors stability.

This view represents a heuristic model to understand social behavior, but its applicability is limited. Prediction, whether of long-term evolutionary change or of rapid modification, is difficult, even in probabilistic terms. Complex systems are almost impossible to simulate effectively, as exemplified by the failure of almost all economic prognoses. Retrodiction is almost as difficult, with past social behavior remarkably intractable to generally accepted explanation. Given these difficulties of comprehensive, normative study, cultural ecologists follow the precedent of biologists in focusing on small subsystems and a small range of variables in order to gain understanding of certain critical processes. The case study, typically directed toward a small, agricultural community, parallels the laboratory experiment of the natural scientist.

Cultural ecologists are therefore concerned with the role of people and the manipulation of resources within ecosystems, rather than the delineation or simulation of such systems as a whole (Butzer 1989). In their work:

1. Society and nature are seen as intimately interconnected, bound by complex, systemic interrelationships. Within that unified framework, particular attention is given to how people manage resources via a range of strategies in regard to diet, technology, settlement, reproduction, and system maintenance. The variability of the biophysical environment in time and space is an integral component of such research, as is the role of environmental constraints.
2. Cultural behavior and diversity are explicitly considered in their functional role and with respect to material and nonmaterial culture. This consideration is normally achieved by in-depth field studies to gain a comprehensive understanding of how energy and information flows operate, how alternative options are developed and selected, and how process and form are interrelated. Empirical detail is crucial to such work, as is the connectivity between data and conclusions.
3. Food production is a fundamental theme, especially in relation to demographic variables and sustainability. Most studies in cultural ecology are in fact directed to rural and agricultural societies, and they generally exhibit a specific interest in understanding alternative outcomes and change, rather than causation or prediction.

In effect, the successful implementation of cultural ecology requires two kinds of expertise, namely sophistication in cultural matters and a solid background in one or more of the related, "hard" sciences. Intensive empirical research in a micro-setting is equally indispensible. Cultural ecology also employs both the synchronic and diachronic perspective with good results. The "contemporary" approach begins with a series of local case studies to develop a methodology, as successive examples offer more thematic insights at higher levels of generalization. Such synchronic work has been applied increasingly to a new view of Third World development. In contrast, the "historical" approach employs local studies to examine technological and related demographic changes over time so as to understand the dynamics of sociocultural adaptation and change. Such historical experience provides a different perspective on equilibrium properties and helps identify alternative scenarios relevant to contemporary problems. Although fundamentally different, these synchronic and diachronic methods are complementary.

Two methodological options are available. One is to develop a deductive model, such as would be appropriate in a general, positivistic work that seeks to create a measure of conceptual order and to direct research to specific, open questions (e.g., Adams 1988; Butzer 1982; Hawley 1986). Apart from being next to impossible to operationalize with quantitative data, however, deductive models are by their very purpose no more than simplified generalizations of reality. Beyond a certain point, they have little explanatory, let alone predictive value.

Models also can be used to formulate problems, develop field projects, and determine research design. In such a case, the empirical data generated by successive field seasons are used repeatedly to revise conceptual structures. The final model is as much a result of inductive as of deductive input, thus offering a better approximation of "reality." But even an inductive model of this type is ultimately limited to a particular scale, set by the initial assumptions and boundaries of the project. Because relationships are hierarchical, in that systems are both vertically and horizontally organized, examination must eventually be extended to higher orders of relationships. But assumptions, facts, or processes that may be valid at one scale may not be appropriate at another. To adjust the model so as to accommodate the open-ended, higher-order relationships integral to satisfactory interpretation is an awkward, if not impracticable task. It is more reasonable to reformulate and attack the problem at a different scale. In this way, different orders of relationships can be identified and discussed on their own terms.

The presentation that follows is structured around a brief case study that reveals and elucidates the complex web of interactions between a community and its environment by means of a culture ecological approach. This inductive microstudy of a small village in eastern Spain is used to delineate an informal model. That information is then discussed in higher-order context, and is generalized to derive a set of concepts and principles, valid or at least useful for meso-scale interpretation of sedentary, agricultural communities. Subsequently, we turn to macro-patterns that incorporate and reflect many of the same processes, but that must be reevaluated at this larger scale. Finally, the insights gained at both levels are examined for their potential to understand society–environment relationships in an era of accelerating transformation.

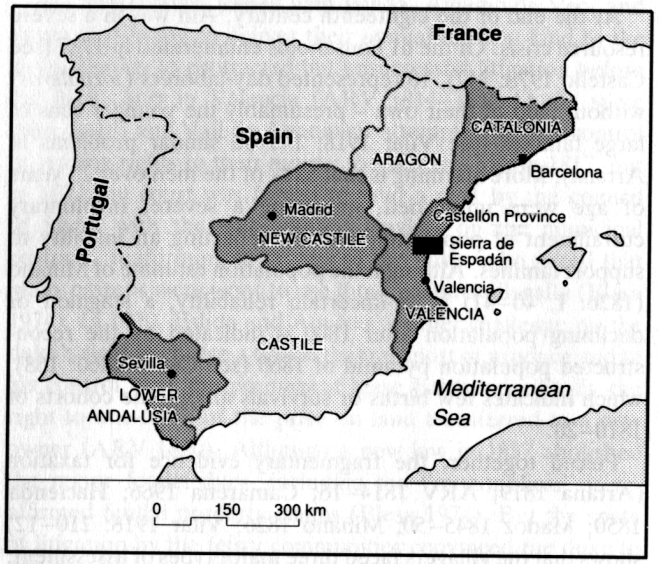

Figure 42.1 The Sierra de Espadán, Province of Castellón, Autonomous Region of Valencia. Shaded areas delineate the hinterlands of the four major cities of early modern Spain.

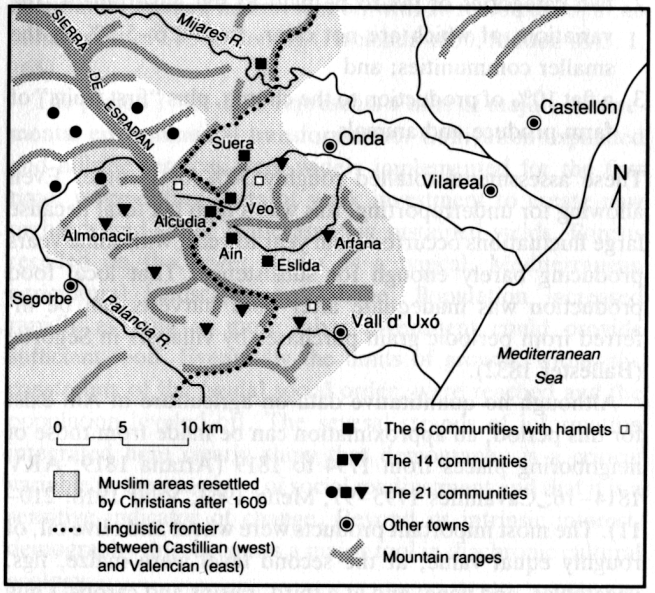

Figure 42.2 Aín, in the heart of the Sierra de Espadán. A Muslim population, speaking Arabic, remained in the central, shaded area until 1609. After resettlement by Christians, the linguistic frontier between Castilian, to the west, and Valencian (Catalan), to the east, consolidated about midway in the abandoned area.

Micro-Study As Laboratory: A Mountain Village in Eastern Spain[1]

Aín (formerly Ahín, pronounced *Ah-een*) is a village in the heart of the Sierra de Espadán, some 50 km north of Valencia, in eastern Spain (Figs. 42.1 and 42.2).[2] The Espadán is a cluster of rough mountains (maximum elevation 1,083 m), with narrow intersecting valleys at 300 to 500 m below the adjacent crests. The natural vegetation consisted of pine (*Pinus nigra, P. halepensis*) and cork oak (*Quercus suber*) forests, which palynology shows have been partially cleared or degraded since Bronze Age times (Butzer, Butzer, and Mateu 1986; Butzer and Mateu n.d.). The climate is warm-temperate and subhumid, with 550–700 mm of rainfall, concentrated in the autumn (Quereda 1985); precipitation between late April and early October is inadequate for successful agriculture. Irrigation is desirable during the last six weeks of the winter-crop season and is essential for all summer crops.

Topography, soils, and water sources in the municipal lands of Aín (11.8 km^2) and elsewhere in the Espadán require that irrigation be concentrated along the valley floors. Since runoff and stream discharge are intermittent, irrigation is linked to large springs and tends to be compartmentalized into autonomous or semiautonomous units. Unlike other municipalities, Aín is dependent on a single, unusually abundant and reliable spring (the origin of the Arabic toponym), which formerly irrigated a total of 30 ha (Catastro 1950). The remaining 302 ha of cultivated land was dry-farmed and much less productive; its average tax value per unit was only 12.5% that of irrigated land (see Catastro 1950).

Resettlement and Filling in: 1611–1700

The base line for this examination is given by the year 1609, when the 60 families of Muslims were expelled from Aín. The 16 or 17 Christian families who replaced them in 1611–12 settled in the core of the crumbling village, and the unoccupied areas were converted into corrals for livestock. Rebuilding included a different style of two- or three-story houses, with animal stalls at ground level, living quarters of 11–22 m^2 on the second floor, and possibly a partially open attic above for drying and storing food. The regional distribution of family names suggests that the new settlers were derived from both the Castilian-speaking area around Segorbe and the Valencian (Catalan)-speaking area north of Onda (see ARV 1646) (Fig. 42.2). The majority came from quite similar environments, where they had already had some 300 years of ecological experience.

Most of the Espadán belonged to the Duke of Segorbe (later, Medinaceli), and the contract terms for the permanent lease holds stipulated that one-eighth of all grains and fruits (one-ninth of vineyard produce) was to be paid as agricultural rent (ADM 1769; ARV 1814–16), in addition to a fixed sum per head for different types of livestock, fixed charges for pasturage on the mountain slopes (*monte*) or the gathering of deadwood for fuel, as well as tithes on the feudal monopolies (use of the grist mills, bread oven, oil press, and traffic in the town shop and butchery) (ADM 1613; Butzer et al. 1986). With administrative and some family ties to Segorbe, that city became the traditional market center for Aín.

Population growth during the first century of resettlement was slow (0.41% annual growth), and the community was not yet stable: of 19 family names in Aín 1646, nine had disappeared by 1750. The forests, destroyed in the fifteenth century, regenerated, soils stabilized, and stream channels were in equilibrium (Butzer and Mateu n.d.). In 1621, the duke complained that wheat was not being cultivated on unirrigated lands of the Espadán, reducing his revenues (ADM 1621). The pastures were used primarily (from November through

April) by transhumant herds from Aragón, in contract to the duke, with the effect that development of local livestock was impeded. However, the manure left by over 400 Aragonese sheep assured soil fertility for the cultivated, irrigated land.

Temporary abandonment after 1609 and the much smaller population during the first century of resettlement relaxed pressures on resources, allowing both cultivated and grazing land to revert to forest and favoring ecological recovery of an environment subject to increasing stress from the eleventh to the sixteenth centuries.

A Traditional Mediterranean Village: 1700–1830

During the eighteenth century, the population of Aín expanded rapidly (growth rate 1.06%), despite periodic bouts of high mortality (possibly due to typhoid and to other epidemics, one of them probably smallpox, which selectively affected children), as well as reduced birth rates after harvest failures due to drought, killing frosts, or locusts. The population doubled between 1700 and 1751, and trebled by 1787. Growth was not entirely autochthonous: 22 new family names appeared in Aín during the period 1667–1754, of which eight had not been present in the Espadán in 1646 (ARV 1646). These families were derived mainly from Valencian villages, most of them nearby. About 1700–1750, Aín crystallized as a stable, Valencian-speaking community. In 1737, it still was a very simple village with a town hall, two grist mills, a bread oven, and a jail. There were only farmers – no officials, no craftsmen – and the land was supremely poor, so that the village was exempt from some minor feudal dues (ARV 1737; 1765). New houses filled in the empty spaces on the streets of the old core, however, and new rooms (averaging 7.5 m^2 in area) were added to many existing homes, to accommodate the new families.

As pressure on resources increased, dry-farming of the lower slopes was begun. The Muslims had built no artificial terraces other than lynchets (berms), thus promoting massive soil erosion (Butzer et al. 1986). For the first time, now, complex terrace systems were constructed, primarily in areas that had grown over with cork oak since 1609; olive groves, figs, and vineyards were planted, and winter wheat was grown concomitantly on these terraced surfaces. Runoff was accelerated but little soil eroded, with the consequence that stream channels were incised in response to sediment starvation. A forest census of 1780 indicates that the proportion of oak to pine (3:1) in the municipal territory was exactly the same as about 1930 (Catastro 1950; Croix 1801), implying a similar forest cover, including 102 ha of pine, compared with only 40 ha in 1900 (Sarthou 1912: 909). By 1791, however, the former oak woodland was being converted to vineyards, fig orchards, and olive groves (Cavanilles 1797: 136), and by 1825 constant friction existed with neighboring Eslida over illegal collecting of deadwood (ARV 1831).

By the late 1700s, a new street had been laid out on the north end of town and new houses rapidly were built along it. In 1787–91 four craftsmen and two servants lived in town, and agriculture was flourishing (Castelló 1978: 347; Cavanilles 1797: 136). By the 1820s, three small distilleries for brandy also existed (Miñano 1826: I, 41).

At the end of the eighteenth century, Aín was in a severe resource crisis. Of the 61 households enumerated in 1787 (see Castelló 1978: 347), 10 represented day-laborers (*jornaleros*) without land of their own – presumably the younger sons of large families (see Vilar 1918: 149 on similar problems in Artana). More alarming is that 52% of the men over 25 years of age were unmarried, indicating a severe, involuntary curtailment of population growth, reflecting an inability to support families. Although the population estimate of Miñano (1826: I, 40–41) is of uncertain reliability, a stagnant or declining population after 1800 is indicated by the reconstructed population pyramid of 1860 (see Censo 1860: 168), which indicates few births or survivals among the cohorts of 1810–20.

Pieced together, the fragmentary evidence for taxation (Artana 1819; ARV 1814–16; Camarena 1966; Hacienda 1850; Madoz 1845–50; Miñano 1826; Vilar 1918: 210–12) shows that the villagers faced three major types of assessment:

1. the land rents to be paid to the duke at an average rate of 11.5–12% of annual farm production, plus additional charges for grazing, deadwood, and use of the monopolies;
2. two categories of tax to be paid to the government, the variations of which are not clear, from 2.6–5.5% in the smaller communities; and
3. a flat 10% of production to the church, plus "first fruits" of farm produce and animals.

These assessments totalled roughly 30% of income. Even allowing for underreporting, this was a high tax total because large fluctuations occurred from year to year, with some years producing barely enough for subsistence. That local food production was inadequate after poor harvests can be inferred from periodic grain purchases by villagers in Segorbe (Ballester 1832).

Although no quantitative data on agriculture in Aín exist for this period, an approximation can be made from those of neighboring places from 1794 to 1819 (Artana 1819; ARV 1814–16; Cavanilles 1795–97; Melía 1963; Vilar 1918: 210–11). The most important products were wheat and olive oil, of roughly equal value; at the second level were maize, figs, vegetables, and wine; and at a third, raisins and carobs. Only about 10% of the wheat represented the "soft" variety grown on irrigated land, and the ratio of wheat to maize typically was 2:1, suggesting that a good part of the irrigated land was occupied by maize. The primary irrigated vegetables were string beans and broad beans. Cork had not yet acquired economic significance, and transhumant herds outnumbered local goats and sheep by 3 to 1.

But fundamental socioeconomic change was imminent. During the ineffective French occupation of Castellón (1810–13), the Espadán villages were subject to arbitrary exactions by guerillas and French alike, but rents and dues were not collectible by the duke after 1811. Furthermore, feudal property rights were placed in question by a decree of the Spanish government in Cádiz (Blesa 1974). When reactionary government was restored in 1814, the Espadán villagers moved from passive acceptance of their poverty to a 20-year period of legal challenges to feudal control.

Aín immediately joined with Eslida, Alcudio de Veo, and Suera in refusing to deliver their annual rents in kind to the duke, leading to protracted but unsuccessful litigation before the high court in Valencia (ARV 1814–16). At the same time, Suera and Vall de Almonacir attempted to gain control of grazing rights to their *monte*; the suit was lost in 1817, but in 1832 the court was forced to void a pact by the council of Suera with the transhumant graziers on the municipal pastures, reaffirming the rights of the duke, who noted that many citizens were wont to use those pastures illegally (Blesa 1974). In 1830, Eslida and Aín lost another challenge, to the duke's right to charge a tax on the transport of produce and to his control over the permanent lease holds, specifically the right to one-tenth of the price on land transferred to a new owner (ARV 1830). Although a new law in 1837 abolished the minor feudal dues, including the "monopolies," it reaffirmed feudal property claims (Blesa 1974). But the spate of litigation by the feisty communities convinced the duke to sell out, and by 1852 he was no longer a major landholder (Picó 1975). In effect, during the 1840s, Aín had gained control of its own affairs, with at least the woodland held as private or communal property (see Hacienda 1850). The community opened its first school, with 20 to 30 pupils, at an annual cost of £12 3s sterling (Hacienda 1850; Madoz 1845: I, 165).

The period 1700–1830 represents a time of major, if incremental environmental transformation. Cultivation expanded and hillside terraces were widely implemented for the first time, representing a major work investment to create new orchards and fields, while assuring sustained yields. Forests receded on the lower slopes as a typical, Mediterranean agricultural landscape took shape. Population increased rapidly as long as more labor investment could provide sufficient food. Eventually the limits of growth, within the constraints of the feudal social order, were reached and the population leveled off. The several strands of information integrated here clearly show that demography is a critical variable in the processes of social readjustment and that it is a sensitive indicator of change. Beyond its intrinsic interest, demography thus becomes a major tool in diachronic cultural ecology.

Intensified Agriculture: 1830–1936

As the duke's authority crumbled, the villagers of Aín proceeded to develop the *monte* without permission. Annual records of 1841–47 (Hacienda 1850) show that cork production suddenly increased by 154% in 1844; since cork can first be harvested 12 years after planting, large stands of cork oak evidently had been planted in 1832. Aín was responding to the new demand for cork bottletops. Olive production increased 130% in the same year, and because new stands begin producing after six years, but only achieve full production after 20, olive groves were probably trebled in area during the 1830s. Productivity also was increased as better methods of pruning were introduced. By the end of the century, five oil presses were in operation. To provide more feed for pigs, the major source of meat, carob cultivation was expanded, complementing the acorns collected in the oak woodland. Wheat production on unirrigated land was amplified by collecting water from minor springs into holding tanks, thence channeling it to small fields via shallow canals along the furrows of sloping terraces. Such micro-irrigation was limited to areas of 0.1 ha to 0.2 ha each (Butzer et al. 1985).

On the irrigated, prime bottom lands, maize was being displaced slowly to make more room for vegetables and summer wheat, as it lost favor as a human food and began to be used as animal feed. Processed wheat from 1841 to 1847 from the two major mills averaged 28,520 l. (26,920 bushels) a year, about 71.5 l. per person, presumably used for home consumption. This is 141 g of flour per person per day, or about 175 g of bread. With a population density up to 121 persons per km^2 of cultivable land, Aín was under intense pressure to feed its population, and the total tax load was increasing. Given that conversion from lease holds to private property involved long-term annual payments equivalent to the original agricultural rents paid to Segorbe, tax liabilities about 1850 were closer to 35%. One response to latent shortage appears to have been a shift to more animal protein, implied by the increase in pig feed and the increasing use of maize as fodder, primarily used for chickens and pigs. Conflicts with neighboring Eslida in 1825, 1827, and 1831 over the grazing of local sheep and goat herds (ARV 1831) also indicate that the citizens of Aín were expanding their livestock activities, and after 1860 the number of transhumant herders registered in the census reports declines. With more goats and sheep, the community was assured a larger supply of milk and cheese.

During the 1860s, phylloxera insects began destroying the roots of French grape vines, leading to increased demand for Valencian wine (Piqueras 1981). A decade later the citizens of Aín seized the opportunity and began to prepare vineyards on the communal grazing lands of the high mountain slopes. Small berms were constructed in the skeletal soils, the ditches were filled with mulch, and vines were planted in them. They did not compete with grazing, because the vines were dormant during the seven-month transhumant season. The practice also served as a means of soil conservation. By 1890, vineyards had expanded from about 20 ha to almost 250 ha, and Aín was marketing as much as 250,000 l. of table wine annually. Brandy was being made in two small distilleries. The remainder was carted to the coastal railroad stations or to the harbors. The resulting influx of capital transformed the village.

The other side of the coin was that the population exploded at an annual growth rate of 1.42% from 1825 to 1860. Growth then slowed dramatically to 0.33% from 1860 to 1877, however, and came to a complete halt by 1887, after which population began to decline. By now, the physical village had expanded to about its present configuration. It appears that severe curtailment of births was being practiced by the 1850s, because 78% of the men over 24 years of age were married in 1860 and yet there was no out-migration until about 1895. In addition to celibacy and prolonged periods of sexual abstinence, the widely known but rarely discussed "Catalan" method of contraception, namely interrupted coitus, was

certainly being practiced. In other words, birth control was a significant factor in the attainment of zero growth in this strongly Catholic community during the second half of the nineteenth century.

Before the population began to decline, however, the density of use on the cultivated land reached 159 persons per km^2, a figure that can be compared with 246/km^2 for the Nile Valley in 1882, where 100% rather than 9% of the cultivated land was irrigated. Whereas the villages of the eighteenth century, under feudal control, had little opportunity to buy land, this situation changed in the 1840s. Those families that competed most successfully now enlarged their agricultural holdings and bought up most of the communal lands opened for purchase. By 1930, 21 of the wealthiest proprietors held an average of 55.5 land parcels each, controlling 35% of the private land, but for all 364 individual landowners, the average holding was only 9.0 parcels (see Catastro 1950). Many families were reduced to abject poverty, and a significant part of the population obviously did not share in the flush of wealth brought in by wine export. A strong sense of community persisted, however – to the point that differential wealth was a taboo subject for all our informants. This very reluctance to discuss inequity suggests that the structural changes in land distribution during the late 1800s did not sunder the sociocultural fabric.

The wine boom came to an abrupt halt in 1907, when phylloxera, relentlessly spreading from France into Spain, hit the local vineyards (Piqueras 1981: Fig. 26, Table 44). Once again, Aín had to confront a major crisis. In a series of town-council meetings, the leading citizens outlined and debated the options:

1. A return to a mixed agricultural–herding economy, much expanded by projected purchase of the grazing lands of adjacent communities;
2. Out-migration to the coastal, industrializing cities;
3. Systematic planting of cork oak to meet the growing demand for that commodity.

By 1910, the six largest herd owners in Aín together ran 260 sheep and 140 goats, some even hiring outside herders to tend them. With a total of nearly 1,000 head of stock (including pigs) in Aín, livestock production was high, yielding milk, cheese, meat, and wool, mostly sold to itinerant dealers. The herds were tightly controlled, and because owners were strictly liable for damage to private plantings or communal forest, no permanent ecological damage occurred. The absence of evidence for soil erosion is also explained, in part, by the belt of closed woodland or terraced fields immediately below the high slope pastures. But infringement on pastures of neighboring villages led to increasing litigation, and strategies were reevaluated.

Under the guidance of two progressive and well-informed town fathers, the council eventually decided to select the cork alternative. As the dying vineyards were abandoned on the upper slopes, the area of cork oak on the lower slopes was roughly trebled, to almost 350 ha.

The first financial returns on the cork oak plantings of 1915–18, however, could not be expected until 1927–30. Because goats destroy young oak plants, the herds had to be cut back drastically, at high economic cost to the average citizen. For the poorer folk, work as domestic maids or industrial workers in Barcelona beckoned. The censuses show that 11 young people from Aín emigrated in the decade ending in 1900; by 1920 this number had swelled to 82, then 60 more by 1930, and 81 others by 1940. These numbers represent an average loss of six young adults per year from 1895 to 1940.

The cork venture also ran into trouble. An outside company moved into Eslida late in the 1920s, set up a processing plant, and established a monopoly for cork sales, attempting to buy out small local owners. As a result, Aín cork had great difficulty in getting sold in 1930, until the cork monopolists were bankrupted during the deepening economic depression that preceded the Spanish Civil War. Other market features were changing too. Prices for wheat were falling disastrously, and the poor quality of Spanish olive oil limited exports. By 1900, however, demand for almonds, cherries, and apples was growing. After 1920, olive groves were neglected increasingly and were even partially removed. Almonds were planted, and fruit trees began to appear on irrigated plots in place of summer wheat. Pine saplings began to recolonize the abandoned vineyards.

For all intents and purposes, Aín still appeared to be a thriving and diversified town. Business directories for the 1910s and 1920s confirm local information that there was a resident doctor, a nurse, and a pharmacy. There were two primary schools, one for boys and one for girls; a barbershop, a smithy, and a carpenter's workshop; a master stone mason, a resident mail-carrier, two millers, two olive-press operators, and eight part-time merchants for olive oil, cork, grain, and wine; a bottlecork factory, a factory for beeswax, a butchery, a tobacco shop, and two cafés. But the village was in obvious decline, with increasing poverty and a rapidly thinning labor force.

During the century following emancipation from feudal restrictions, Aín had embarked on a vigorous and flexible course of agricultural intensification, responding actively to market forces. Transformation of the environment into a primarily artificial landscape was completed. Yet this transformation was achieved without evident symptoms of degradation, demonstrating that sound management can contain the deleterious side effects of even such a fundamental, ecological transformation. But the costs in the social sphere were high: drastic demographic curtailment, increasing economic inequality, deepening poverty of the majority, and a community on the verge of disintegration.

Collapse and Simplification: After 1936

The Spanish Civil War placed Aín within Republican territory, but its citizens were ideologically divided, on economic lines (see Mirá 1974). In July 1938, the village was taken by Nationalist forces, but then remained under gunfire on the front for the last nine months of the War. With the men drafted into the Republican army, the women, children, and old folk were evacuated to Onda and elsewhere. After the War, until 1953, industrial activity was reduced and food

was scarce. As a result, some emigrants returned to Aín, the population stabilized for 20 years, and farming was revitalized. But wartime depletion of the transhumant and local herds led to a shortage of manure and lower productivity. Chemical fertilizers were reluctantly brought into general use, but plant pests then became a major problem. Unarable land was restocked with *Pinus maritima* seedlings. Severe frosts in 1946 and 1956 badly damaged the olive and carob trees, as well as the surviving vineyards. By the 1960s, it was evident that agriculture was being simplified. Almond, cherry, apple, and pear trees were planted, but wheat farming was given up, the olive groves were neglected, and local herding was abandoned outright. However, the economy remained market-oriented – excessively so.

A striking ecological change was that the discharge of the minor springs began to decline in the 1920s, and ceased entirely during the 1960s. Since grazing had stopped almost completely, and grass or mulch cover currently is very good, and since woodland is now more extensive than at any time since the 1600s, the failure of the surface aquifers cannot be attributed to devegetation. Informants blame it on the decline of winter snowfall, noting that snow melts slowly and that most of its moisture percolates into the soil. The last major snows came in 1956, and autumn rains during the 1980s were not sufficient to generate temporary seepage in favored areas. A climatic shift to slightly warmer and drier conditions is indicated, but the result is that micro-irrigation is no longer possible.

From 1960 to 1980, Aín lost 43% of its population, and most of its younger people. The ratio of people older than 65 years to those under 15 (the index of aging) increased from 10% in the nineteenth century to 100% in 1950, 170% in 1970, and 391% in 1981. Major support for the senior citizens is provided by the generous social-security program.

The government made Aín accessible by an asphalt road, however, and provided electricity, piped water, and a sewage system in 1961–63. Physical deterioration stopped. A new plaza, a town hall, and a bar-as-social-center were built, and three small condominium structures provided summer homes for wealthy city folk. In summertime, Aín became filled with people – not casual vacationers, but old *emigrés* or their children and grandchildren returning home to their roots. As soon as residents who had moved to Valencia 30 years ago were able to buy cars, they returned to Aín on summer weekends, donned their farming clothes, and spent two days pruning olive trees or picking apples.

Aging widows today line up to pay the annual property tax on abandoned land with money sent by the children of relatives who moved to Barcelona before the Civil War. Some families occupy their apartments in Onda only on school days, preferring to live in Aín on weekends and during the vacations, while the men commute to industrial jobs. Prices for agricultural produce are unrealistically low, and even imported American almonds can be purchased more cheaply than they can be produced locally. In effect, the key impediments to permanent residence in the village are that agriculture cannot provide a living and that there are no schools. But the pace of community life continues to grow, so that some young families have moved back, sending their children to school by bus as they drive to work in the city. Other younger men work in the coastal orange groves for eight months of the year, while young women paint tiles in the factories of Onda. Enough buildings are being remodeled to employ a full-time mason. The town council is active once more, mainly with younger adults, arriving at decisions through discussion and eventual consensus – the traditional way. The basic principle for all public behavior explicitly remains *comunidad* (community).

Aín today is very much alive, in the minds of hundreds of its citizens living in cities between Barcelona and Valencia, and for whom the people "back home" continue to act out a vital symbolic role. The ties are maintained through letters, transfers of money, visits, or part-time residence. Even the Sunday night train from Castellón to Barcelona is filled with interrelated Espadán people, dressed in "urban chic," giving proof of their sense of identity as they maintain relationships of support. As on earlier occasions, the citizens of Aín are again finding a way to cope with crisis, by adapting with the times, but without forgetting who they are.

During the past 50 years, the woodlands have thickened and matured, and are now closing in over vineyard furrows, abandoned fields, and crumbling terraces. The cycle of environmental transformation has been reversed, and agriculture has become a secondary occupation. Population has declined to the level of 1730. Aín's environment can no longer support its people, but the care that they have expended on its maintenance over almost four centuries remains apparent in the almost unscarred scenic beauty that now attracts vacationers. There is a lesson here: that socioeconomic circumstances can force people to alter, even transform, their environment; such changes, however, are not necessarily detrimental, and the complete replacement of a quasi-natural landscape by an agricultural one need not impair productivity, stability, or the capacity of the ecosystem to rebound to a more pristine state. The intensive, nineteenth-century land management of Aín probably could have been maintained indefinitely.

From Community to Open System: Aín in Context

The Espadán case study illustrates the level of resolution that can be achieved by historical cultural ecology in identifying constant reevaluation of agricultural and demographic strategies, community decision-making, the fine balance consistently maintained in ecological behavior, and the increasing influence of market prices on economic choices.

The demographic curve of Fig. 42.3 provides one measure of energy flow through time, with epidemics, harvest failures, and wars acting as external stochastic variables that temporarily affected energy flow, but did not determine its macropatterns. The various economic strategies and subordinate tactics experimented with, or implemented, over the generations represent those processes of cultural adaptation supporting this energy flow, matching energy needs with population. The other critical aspect of adaptation was the maintenance of some form of balance among population growth, resources,

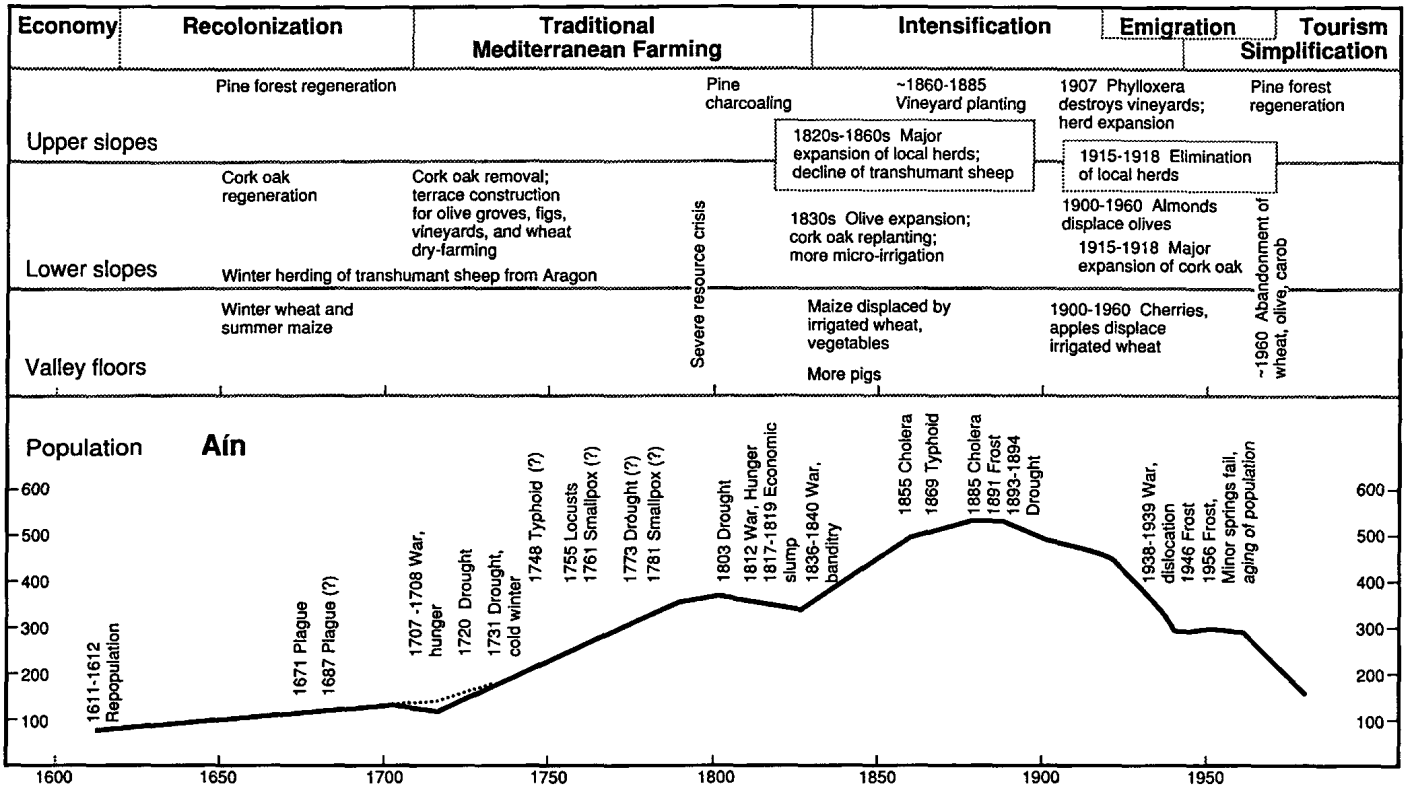

Figure 42.3 Population trends and changing adaptive strategies in Aín since 1610. The dashed line is probably more representative. Sources for population: 1646 (ARV 1646), 1692 (García Martínez 1974: II, App. 144), 1713 (Peña 1986), 1751 (ARV 1765), 1787 (Castelló 1978: 347), 1791 (Cavanilles 1795–97: 136), 1825 (Miñano 1826: I, 40), 1845 (Madoz 1845: I, 165), after 1857 (national censuses, Instituto Nacional de Estadística). A *padrón* of about 1737 (ARV 1737 and Camarena 1966) is omitted as patently too low. For 1646, 1692, 1713, 1765, and 1791 households are converted to inhabitants by factors of 4.4 to 5.0, derived from relationships established for the same *padrones* in villages where population totals were reconstructed from parish registers. For economic information, see text.

and agricultural productivity. Initially this balance was accomplished primarily by late marriage or celibacy, later by birth control, and ultimately by emigration. In the light of this fine-grained resolution, the debate as to whether population growth promotes intensification, or vice versa, becomes moot. Socioeconomic behavior as reflected in use and transformation of the environment is so intimately interlinked with population dynamics that the two become almost inseparable. Given the conservationist land management of Aín, the demographic trace of Fig. 42.3 indeed provides a surrogate for the direction and intensity of environmental transformation.

In effect, Fig. 42.3 represents the actual implementation of an inductive model, rather than an abstract heuristic device. But like all models, this one has its own structural limitations. By giving explicit, if general, attention to the market economy, the model does not assume a closed system. But it cannot accommodate the integration of Aín into a broader regional framework, as well as into the higher-order political economy of Spain, except as a microcosmic subsystem.

The adaptive histories of the different Espadán villages were to some extent unique (Table 42-1). Vall de Almonacir, located near Segorbe in much less rugged terrain, developed unusually rapidly, and intensified its vineyard potential a century earlier, to produce 250,000 l. of wine by 1791. Outmigration to Segorbe is apparent as early as the 1780s, however, and population peaked early, about 1850. Eslida, on the other hand, developed more slowly than Aín,

Table 42-1 *Population Density in Three Municipalities, Sierra de Espadán (per square kilometer; parentheses indicate density on land cultivated in 1936).*

Year	Aín = 11.8 km²		Eslida = 17.0 km²		Vall de Almonacir = 20.7 km²	
1646	8.2	(29.4)	6.2	(14.8)	11.8	(28.8)
1692	9.9	(35.4)	8.8	(21.0)	20.1	(49.0)
1787	29.9	(107.0)	34.2	(81.7)	37.6	(91.7)
1848	33.8	(121.0)	38.0	(90.8)	49.7	(121.4)
1887	44.5	(159.3)	53.8	(128.6)*	40.1	(97.8)
1950	25.3	(90.6)	39.1	(93.4)	29.6	(72.2)

* Peak density for Eslida 57.5 (137.4) in 1910.

continued to grow until 1910, and subsequently declined less precipitously. Eslida had the disadvantage of depending on six relatively modest springs, which irrigated seven small units of prime land. But Eslida also lagged in intensifying land use on its remaining territory.

Nonetheless, aggregate demographic and adaptive behavior in the Espadán was basically similar, judging by grouped data from 6, 14, and 22 municipalities representing some 35,600 people in 1970 (Fig. 42.4). At all three scales, there was sustained growth until 1860, then stagnation, and finally massive out-migration and decline after 1910. The largest

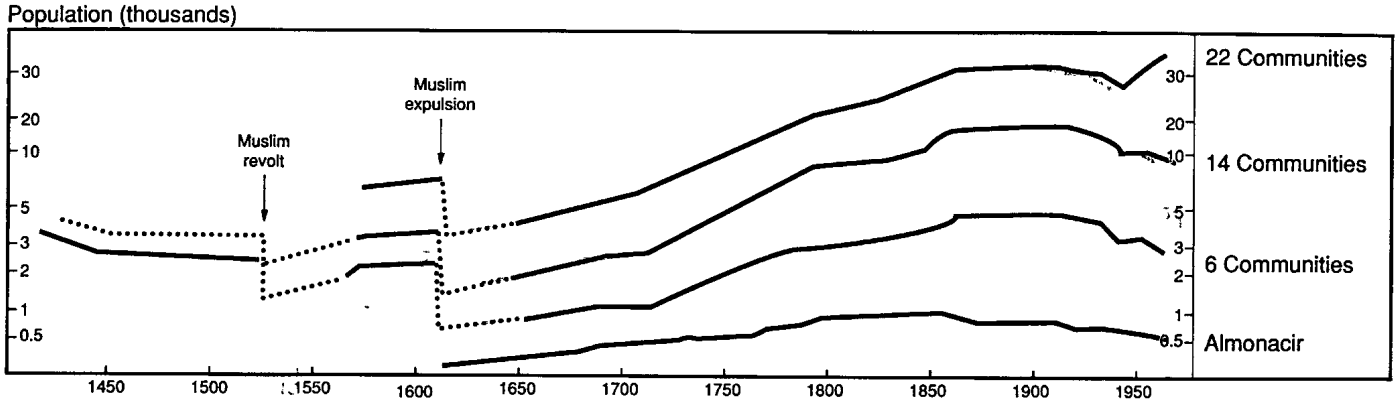

Figure 42.4 Population trends in the Sierra de Espadán since 1418. I = Vall de Almonacir, reliable data at 10-year intervals reconstructed from parish registers from 1611 to 1852, using family reconstitutions for selected years and net annual changes (courtesy of E. K. Butzer); after 1857, national censuses. II = 6 Espadán communities (Aín, Eslida, Alcudia with hamlet Xinquer, Veo with hamlet Benitandús, Suera, Fanzara (north of Mijares River), and Castro de Alfondeguilla (abandoned 1609). Sources as for Fig. 42.3; Butzer et al. 1986 for Muslim era. III = 14 Espadan communities, adding Alfondeguilla, Chóvar, Azuébar, Almedíjar, Vall de Almonacir, Algímia de Almonacir, Tales, and Artana. Sources as for II, except no data for 1751. IV = 21 Espadán communities, adding Vall d'Uxó, Castellnovo, Gaibiel, Matet, Pavias and Higueras, Torralba del Pinar, and Villalamur. Sources as for III. Logarithmic scale.

aggregate (IV) includes a town (Vall d'Uxó) on the periphery of the coastal plain, and shows renewed growth by 1950, supported by local industrialization and by inmigration. Comparisons with other historical studies of community demography and ecology (e.g., Adams and Kasakoff 1984; Netting 1984) extend such experience.

By including Muslim population trends during late medieval times, Fig. 42.4 also serves a retrospective purpose. Demographic recovery to the level of 1609 was achieved only between 1730 and 1770, and population levels comparable to those of 1415 were delayed until the early 1800s, just prior to the onset of intensification and increasing dependence on market forces. It could therefore be argued that the population of about 1800 approximates the "carrying capacity" of the Espadán, in terms of the technology, market access, and socially acceptable level of risk minimization of a traditional Mediterranean society. But the two-century struggle to regain this level required considerable labor investment and had high social costs. Population, as a surrogate for systemic energy, can be increased only by increasing per capita investment. To assume that acceptance of a new technology automatically leads to population growth ignores the human costs as well as individual and community decision-making.

The rebound to "carrying capacity" by the Christian resettlers of the Espadán, and subsequent intensification with maximum pressures on resources, were achieved without serious ecological repercussions. There was no soil loss, although channel scour, as a result of rapid runoff from terraced slopes and sediment starvation, did reduce the irrigation potential of larger floodplains farther downvalley. The vegetation cover remained reasonably intact and is now as good as at any point in the last millennium. This was no mean feat, and must be attributed to the conservationist technology and behavior of the new colonists. It stands in stark contrast to the intense degradation of vegetation and destructive soil erosion unleashed by high population pressure during the fourteenth and fifteenth centuries, in the different social context of the original, Muslim inhabitants (Butzer et al. 1986). The land-use practices of the two ethnic groups probably had diverged some centuries earlier, in different sociopolitical contexts or along different regional trajectories of trial and error. The Muslim minority, in particular, was faced with increasing uncertainty about its future, in a social environment of increasingly arbitrary repression after the 1360s (Butzer et al. 1986). There are, then, alternative modes of coping that involve different human investments and different optimization compromises, with distinct long-term implications.

Expanding the horizontal field from the Espadán to the broader region of Valencia, Fig. 42.5 shows a complex demographic trajectory, again as an index of socioeconomic and ecological change. After an impressive peak in 1418, population plummeted until 1475, then rose to recover its earlier density during the late 1500s. The loss of 130,000 Muslim inhabitants in 1609–10 had a catastrophic demographic impact, as did some 47,000 deaths during the plague of 1647–48 (two-thirds of these deaths were in the city of Valencia). The growth rate for 1692–1787 was 0.93% annually, regaining the population level of 1609 about 1740. From 1787 to 1900, growth remained strong (0.69% annually), even increasing thereafter (0.73%). By comparison, the growth rate of 22 Espadán communities for 1692–1787 was almost identical (0.96%), but faltering between 1787 and 1900 (0.48%). The spurt of growth from 1692 to 1787 was similar in Catalonia (0.67% annual growth), dampened in the hinterland of Sevilla (0.53% annually), and barely noticeable in the provinces around Madrid (0.19%). This pattern conforms to the established pattern of differential growth along the peripheries of the peninsula (Nadal 1984; Romero 1973).

Urban growth in all four cities lagged behind rural expansion. The urban population of Valencia, with respect to its region, declined steadily from 14% to 9% during the 1700s, rising minimally to 10% by 1870. Madrid finally began to boom in the 1830s, Barcelona about 1860, although Valencia and Sevilla grew only slowly until the 1930s. Rapid

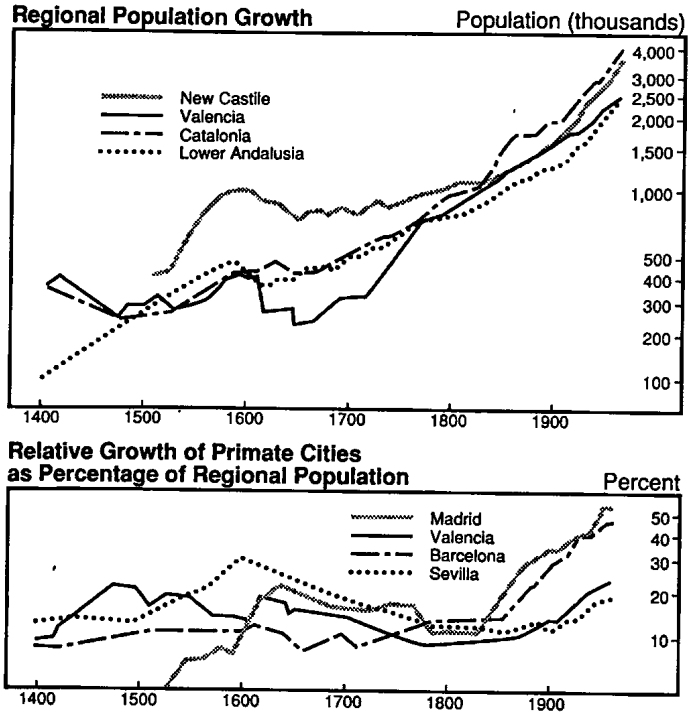

Figure 42.5 Population trends of major Spanish regions and their primate cities, 1400–1970. General sources: Censo 1787; Censo 1801; Domínguez 1970; Bustelo 1972; Romero, 1973; Kamen 1980; Nadal 1984; Molinié-Bertrand 1985; Arroyo 1986b; and national censuses since 1857. For 1830, a median value between Miñano 1826 and Moreau and Madoz 1835 was chosen. Population for Valencia reconstructed, using sample parishes (Castillo 1969; Casey 1979:5, Ortells et al. 1985; Arroyo 1986a; Butzer et al. 1986), from Casey 1979:11, Castelló 1978, and Pérez Puchal 1972. For Catalonia. after Nadal and Giralt 1960 and Nadal 1982, reconstructed with sample parishes. For New Castile and Lower Andalusia, reconstructed with sample parishes from Nadal 1984. For Madrid, see Ringrose 1969; since Toledo and Madrid competed as primate cities before 1600, the population of Toledo above a baseline 21,500 was added to Madrid. For Sevilla and Lower Andalusia before 1528, see Ponsot 1980.

rural expansion, in excess of urban growth, poses difficult problems of interpretation. Increasing urban demand was evidently not an independent stimulus for rural growth. Even during the earlier population surge of the sixteenth century, Valencia declined, Barcelona remained stagnant, Madrid lagged behind New Castille by 45 years, and only Sevilla outpaced the growth of Andalusia (Butzer 1988). In other words, rural Spain had a demographic and socioeconomic dynamism of its own, and one not always in phase with that of its leading cities. This situation should not be surprising for an agricultural nation, whose primary exports until the mid-nineteenth century were processed or raw farm products. Even the export wealth of Valencia at the end of the 1800s was almost exclusively agricultural.

The declining virulence of epidemics is frequently cited as a key factor in European population growth during the 1700s (Schofield 1985), but catastrophic mortalities from plague were mainly an urban phenomenon; although Pérez Moreda (1979, 1980) and Kamen (1980) suggest high rural mortalities in Castile resulting from plague in the 1600s, the Espadán evidence shows no impact of plague, typhoid, smallpox, or cholera on growth at the decadal level since 1609. Whether personal hygiene and general sanitation were better in peripheral Spain than in the interior, or generally better during the nineteenth than during the seventeenth centuries, are debatable propositions. Whether rural nutritional levels were higher after 1700 or 1800 is not obvious from the Espadán data. Improved road networks reduced susceptibility to famine in northwestern Europe in the seventeenth and eighteenth centuries (Schofield 1985). In Spain better roads and formation of the Guardia Civil served to reduce banditry after 1750 (Ringrose 1970); but roads in the Espadán did not improve until the 1930s, and banditry (rarely directed at country folk) was more of a problem from 1836 to 40 than during the preceding century. Finally, the mercantilist policies and agrarian reforms of the later eighteenth century are commonly emphasized (Anes 1970, 1983; García Sanz 1974). But no agrarian reform occurred in the Espadán until the 1800s, and it had mixed blessings, whereas Bourbon mercantilism did not improve the market situation in Castellon,

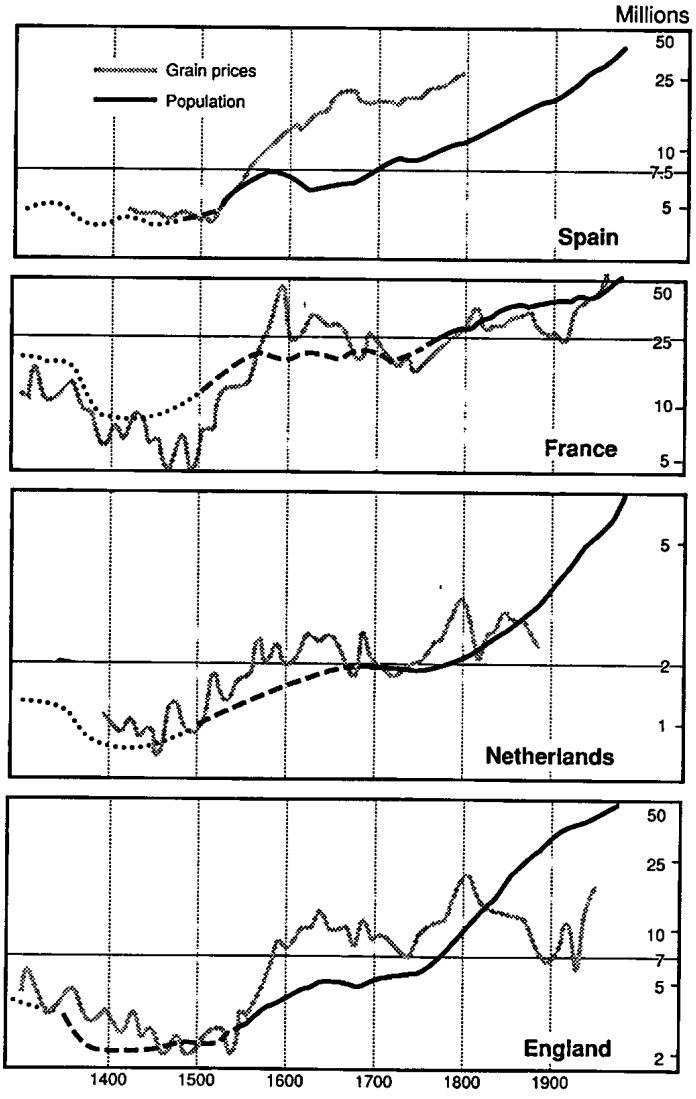

Figure 42.6 Population trends and grain prices in western Europe since 1400. In part after Hamilton 1934, 1936, 1947; Slicher van Bath 1963; Goy and LeRoy Ladurie 1972; Abel 1980; Grigg 1980; Wrigley and Schofield 1981; Day 1987.

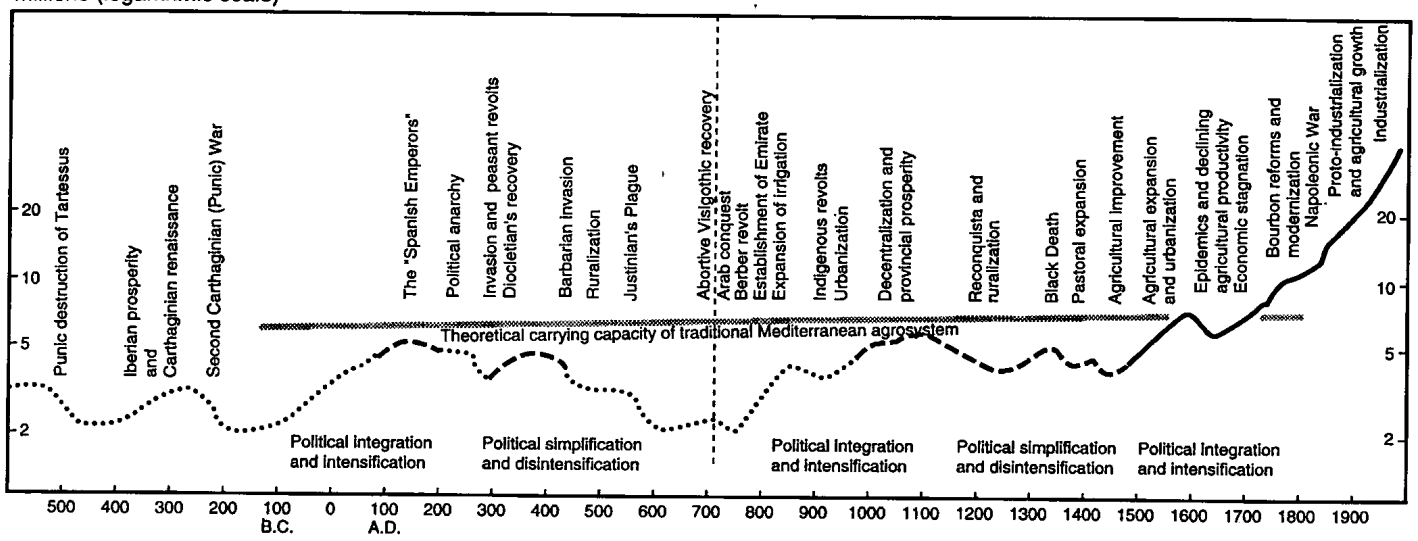

Figure 42.7 Long-term population trends of Spain (copyright 1988 Karl W. Butzer, with permission). For sources after 1400, see Figure 42.5. For the earlier period, population was estimated for ca. A.D. 150, 650, 1075, and 1300 on the basis of settlement reconstruction from archaeological and historical sources, town-site sizes, and regional economies; dotted lines are inferential.

although it did lead to higher and more consistent levels of taxation.

The macro-demographic pattern of Spain shows strong population growth during the 1500s (0.55%, 1528–91), possibly leading to a Malthusian crisis (Phillips 1987); during the 1600s decline occurred, but growth accelerated after 1700 (Fig. 42.6). This dynamism was closely paralleled throughout western Europe, a trend intriguingly matched by the price of grain (Fig. 42.7). The long-term price rises reflected inflationary pressures, although grain production increased from the late 1600s to the 1790s (Goy and LeRoy Ladurie 1972), except during spells of bad harvest weather (Butzer n.d.2; Pfister 1988). The growth surges of both the 1500s and the 1700s placed great pressure on resources throughout western Europe and led to accelerated agrarian change and environmental transformation. Whether population growth spurred productivity or vice versa is unclear.

The Espadán was always market-oriented in that olive oil and wine represented *the* traditional surplus until the mid-1800s, although some communities cultivated mulberry trees for silkworms and produced a little silk. Except for small quantities of silk, its produce did not reach the markets of Valencia, but only the small regional cities. While it is true that the economic well-being of Spain generally improved during the 1700s, it is not entirely clear why the trickle-down effect benefitted some rural sectors of the country and not others.

For Valencia the major growth factor was silk production from the 1750s to the 1790s, with perhaps half of the 700,000-kg yield of reeled and spun silk about 1790 exported (see Townsend 1791: 1634); silk manufacture employed perhaps 7,000 men (and an unknown number of women) in the capital and in numerous smaller places (Cavanilles 1795–97: 134–35; Censo 1801). Export was minimal in the subsequent war years, after which much of the Latin American market was lost. By the 1840s, the silk industry was dead, throttled by French competition and silkworm blight. The other major Valencian exports – grapes and mediocre brandy (Townsend 1791: 1636–38) – encountered similar economic problems after 1790, creating a long period of economic stagnation. This may have indirectly inhibited population growth in the Espadán until the 1830s. By the 1840s, the role of market forces for the Espadán economy becomes apparent as Valencian agriculture began to intensify on a broad basis for export purposes (Garrabou 1985). But for the seventeenth and eighteenth centuries we are left with many unanswered questions.

A basic problem is that macro-economic theory is best suited to examine major trade networks and the role of urban-centered institutions. It neglects rural micro-histories by overemphasizing the role of a few national markets for agricultural commodity prices (compare Herr 1965 with Arroyo 1986b). In so doing, it underestimates the significance of agricultural innovation in general, and the complex local and regional patterns of rural socioeconomic behavior. That adaptive strategies and efficiency changed significantly in Aín since 1609 requires no elaboration. That the ecological behavior and, hence, optimization strategies of rural Castellón also evolved prior to 1609 is apparent from the stark contrast of Muslim and Christian land use.

We emphasize, rather than question the relevance of, national and international economies for understanding the Espadán. But, in contrast to the many good case histories for the rural economies of medieval Spain, and a comprehensive agricultural synthesis for the sixteenth century (Vassberg 1984), there is a dearth of inductive studies to verify and elucidate the generalizations currently offered for eighteenth- and nineteenth-century agriculture. This precludes a more satisfactory systemic interpretation.

A hierarchical model to elucidate the role of Aín within an open system would begin with the individual communities

representing subsets within the socioeconomic matrix of the Espadán. Levels of interaction and reciprocity vary considerably between adjacent villages. Strong energy flows to the duke, the government, and the church were minimally reciprocated by economic and political stability, a little charity, and religious services. A random drain on productivity was engendered by poor weather and epidemics, with a more complex energizing role played by market forces. However, such a model, whether focused on exploitation or on economic theory, is not particularly productive. Far more significant are the conclusions that can be drawn from this discussion.

Deriving Basic Concepts and Principles

The preceding interpretation of the Espadán microstudy allows a number of general observations that can be explicated.

First, Adaptive decisions are consciously made by individuals, within the community context, as economic components are selected, rejected, or adjusted with respect to each other, in response to local needs and external demand.

Second, adaptation, at one scale or another, is an ongoing process of adjustment, as people cope with internal and external impulses, in the short or long term. The basic function of adaptation is to maintain a balance between population, resources, and productivity.[3]

Next, labor investment is the most flexible variable in meeting energy needs on a seasonal and year-to-year basis. Less flexible, but equally critical, are the population variables – nuptiality, natality, migration, mortality – ranging from voluntary to involuntary. Short-term adjustments serve as temporary expedients that alleviate periodic crises, but more fundamental responses include a generational time lag. Technology, in the broad sense, is a third option, but innovations may be inaccessible, socially unacceptable, or economically unfeasible, and they also require time and capital to implement with effect.

Fourth, population as a variable is subject to strong social controls (see Livi-Bacci 1968); birth rates are limited through celibacy, abstinence, or birth control, with emigration serving as the final safety valve. Self-regulation by net birth curtailment involves priorities and decisions on the one hand, and commonly requires personal or communal sacrifice on the other. As a result, curtailment carries human and social costs similar to those of mortality.

Fifth, agricultural intensification involves labor investment, innovation, and decision-making. The innovations are not necessarily unfamiliar. The novelty comes with the inclusion or reemphasis of such traits in the economic repertoire, as minor or major components of a highly dynamic continuum. "Conservative" innovations relate to productivity and can be accommodated within existing nutritional practices and market structures. More difficult are "progressive" innovations that require nutritional change, or the success of which depends upon sustained market demand. Most problematic in terms of both risk and social acceptance are unfamiliar innovations that affect diet or are controlled by fickle markets. Intensification must therefore also be viewed as a continuum, some parts of which are integral to any systemic growth.

Sixth, as a means of socioeconomic behavior and adaptation, intensification is tightly interwoven with parallel strategies controlling population dynamics. The two processes are difficult to isolate in terms of cause and effect. In traditional societies, population can be increased only by increasing per capita investment of labor. It does not therefore follow that innovation will spur population growth, at least not without personal and group acceptance of the labor and other social costs.

Next, integral to community and individual behavior is a constant balancing between economic maximization and risk-minimization. Acutely dependent on the weather, markets, and political stability, traditional societies search for a mix of strategies that reduce risk to a socially acceptable minimum but that normally assure an adequate production of staple foods and marketable commodities. Plants, animals, and terrain with different susceptibilities to cold or warmth, drought or excess water, are blended. The resulting mini-max strategies, arrived at by trial and error, are "optimal" only in a particular social context and at a particular time. When intercommunity reciprocity, external maket centers, or rural bank credits are available, the margin of security may rise from one to two standard deviations of the inherent variability. The role of "big" government in providing emergency assistance, let alone subsidizing rural populations, is a recent innovation in industrial societies. The rural sector has always been the last to receive tangible returns for its taxes.

Eighth, ecological behavior is another facet of mini-max targeting, because it balances short- versus long-term needs, with some degree of appreciation for the hidden costs. Some rural communities appreciate that soil, water, and vegetation are interlinked and that they must be used with care and moderation if they are to serve family needs indefinitely. The roots of such knowledge may be quite ancient, but it is a pragmatic approach, strictly limited to those ecological components that are understood and that are believed to be critical for long-term optimization. Other rural communities either fail to grasp such ecological relationships or have different priorities. Confronted by repeated crises that they cannot control, they see labor investment in the future and good husbandry as immaterial for short-term survival, particularly if the sociopolitical context provides little hope for continuity in a troubled future.

Ninth, whether conservationist or exploitative farmers are cognizant of or interested in the precepts of academic elites is uncertain, at least in traditional societies, and one must distinguish between the ecological behavior of rural people and the abstract land ethic of the culture realm of which they are part. Only in more recent contexts, as new information is widely and rapidly disseminated, can rural communities begin to make more knowledgeable choices. In earlier times, a degree of ecologically sound behavior was learned painfully through trial and error, and then was encoded in a particular methodology of farming as the "correct" thing to do. Requisite to such traditional ecology is long-term experience in a particular environment and using a specific technology.

Great damage can be sustained when people are resettled in alien surroundings or when they begin to experiment with unfamiliar technologies. Another requisite is sociopolitical stability, specifically the prospect that particular parcels of land, leased or owned, will also serve the survival needs of their grandchildren and beyond. Conservationist behavior is learned and, because it is costly and pays only in the long run, it is not adopted or maintained readily or without protracted thought. Conservation is very difficult to impose "from above."

Next, traditional villages rarely are self-sufficient. Market demand is a very powerful variable, and rural communities have innumerable opportunities to estimate demand, as prices for what they sell or buy change rapidly during the course of the seasons, and from one year to the next. Not surprisingly, they shrewdly manipulate their own activities and "supply" accordingly. Whatever labor they invest beyond their subsistence needs is gauged by the prices they hope to receive, the tax demands they will face, and the likelihood that they will be able to sell everything they produce for the market.

Next, strong and sustained demand is as much an incentive for intensification as is the scarcity of staples for simple subsistence. But a seemingly insatiable market demand introduces a hazard, as short-term maximization becomes possible and increasingly attractive. When communities switch from a balanced optimization to a maximization strategy, they become increasingly vulnerable to the boom-and-bust cycles of the market and of the general, national economy, particularly if they neglect subsistence staples. An unstable equilibrium develops as market crops are switched repeatedly, even when they require long start-up periods. The probability of badly misjudging future market or weather trends increases, until the community spirals downward into a survival crisis. The coherence or continuity of the community may be destroyed, leading to an unhappy choice among undesirable alternatives: a hemorrhage of temporary or permanent emigration, or even abandonment. The individual survivors may maintain a semblance of social integrity as a diaspora, or they may lose their identity altogether in amorphous, periurban slums.

Finally, a surprising thread through all the decisions and adaptive choices that communities make over decades and centuries, both as a collection of individuals and as a whole, is that demographic behavior is not stereotypic. For one, stability or homeostasis may well be the exception rather than the rule in traditional societies. But, contrary to the projections and assumptions of global specialists, based on gross generalizations as to levels of "development" and religious bias, communities in the past and in the present adjust their demographic strategies constantly, as they attempt to match resources and needs. There may at times be inadequate information, so as to produce a lag in self-regulation, but more often than not, difficult social decisions repeatedly are made to bring human needs into line with local, regional, or national economic realities. Of course, mortality and emigration are included among these variables, complicating prospects and potentially leading to regional divergences in population trends. As long as emigration is a viable if undesirable option, it remains a major variable in the decisions made in regard to birth curtailment. But demographic strategies must be indeed accepted as strategies, not as unthinking, uninformed, primal behavior.

These inferences have been drawn from seven years of alternatingly living within and then reconstructing and reflecting on the historical trajectory of a little community. By learning to understand the options that confronted dead but very real people and the choices they might have made, the particularistic case study can be, and to some degree was, converted into a universal microcosm. The inferences are in varying measure normative, in that they find broad if fragmented support in numerous other studies, in both Western and non-Western societies. The themes selected and emphasized reflect a pragmatic cultural ecology, in which individuals and communities make conscious decisions with respect to their lifeways and lifestyles. The obvious limitations are those of economy and scale.

Aín was part of a rural society, which lived on the land and from the land; it was a small, but therefore functional, community. A transfer of the lessons learned to a complex urban-industrial society would raise major questions as to scale and appropriateness. But cultural ecology, as currently implemented, does not presume to tackle the problems of mega-societies singlehandedly. What it can do is contribute a particular kind of insight to an immensely difficult set of problems, for which none of the other social-science approaches is uniquely qualified either. That special expertise involves the systemic appreciation of socioeconomic behavior with respect to resources.

Prospects for Macro-Study

Macroscopic analysis of major historical trajectories is to some degree experimental in the social sciences. The task is so complex and intractable that research focuses on a small selection of variables, to derive interpretations that unduly reflect individual problem formulations and methodologies. But each different perspective enhances cumulative understanding.

For historical cultural ecology, the most informative variable to identify socioenvironmental stability or change is population. Demographic growth is rarely possible without improved technology or better social access to resources, or a combination of the two. Decline, on the other hand, points to fundamental social or environmental problems. Growth, stability, and decline also raise different questions about the quality of life. Historical demography, therefore, provides a sensitive index of general systemic "health" and potential pathologies, although diagnoses are not necessarily simple or unambiguous. It can, in fact, offer a valuable, macroscopic perspective on the exponential acceleration of demands placed on global resources during the past two centuries.

The prehistoric record includes some very long intervals of demographic steady state or homeostasis, but after about 35,000 years ago there is worldwide evidence for shifts into a trajectory of dynamic equilibrium, followed by increasing stability about 10,000 years ago (Butzer n.d. 1). At a slightly

more restricted scale and with better resolution, archaeological estimates of population suggest an oscillating trend of net growth, characterized by cycles of growth, stability, and temporary decline during late prehistoric times (e.g., Van Andel and Runnels 1987). In the case of ancient Egypt, five such cycles (millennial waves) span the 3,500 years prior to A.D. 100, with net growth from less than 500,000 to over 7 million inhabitants (Butzer 1976, 1980), representing a density of about 250/km^2 on the irrigated alluvium. A similar pattern is apparent in Mesopotamia (chap. 40).

In Egypt, demographic growth was made possible by incremental improvements in water control, by enlargement of the repertoire of food staples to allow winter and summer cropping, by the inclusion of nitrogen-binding fodder plants, and by the addition of commercial crops. But growth always coincided with episodes of increasing governmental integration that evidently assured reasonably efficient and equitable "energy" pathways, linked with an active interchange of "information." Stabilization followed when productivity presumably no longer could be increased, given the available technology and institutional structures. Increasingly scarce resources now set off greater competition between social classes, to the point where existing institutions became ineffective. The societal system became metastable and vulnerable to perturbations, such as changes in flood volume or foreign relationships. A concatenation of crises triggered positive feedback loops that undermined the institutional structures, leading to systemic breakdown and demographic collapse (Butzer 1984).

The resulting demographic trajectory of ancient Egypt consequently represents an oscillating, dynamic equilibrium, made possible by an enlarging, technological repertoire. The superimposed cyclic fluctuations coincided with alternating trends of political integration and simplification. The technological and sociopolitical variables interlocked, to stimulate episodes of agricultural intensification with accelerated energy flows, followed by episodes of disintensification and atrophied energy exchange.

Drawing in the scale still further, Fig. 42.7 attempts to characterize the population of Spain over the past 2,000 years. Presumably, intensification to the level of the traditional Mediterranean agrosystem was completed in Roman times, by A.D. 150. Thereafter, population oscillated strongly, approximating the Roman level during the Islamic Middle Ages and by the late 1500s, with striking lows in the European "Dark Age" and again about 1400. An abortive, late medieval expansion was cut off by the Black Death. It appears that a population of about 7 million represented the carrying capacity of the traditional Mediterranean agrosystem, given the agricultural productivity of Spain within those parameters. Overall population density was 14 persons per km^2, rising to 30 or 40 per km^2 in the most intensified rural landscapes with limited irrigation (Butzer 1988). Again there is a notable correlation between population growth, agricultural intensification, and political integration, on the one hand, and decline, disintensification, and simplification, on the other.

The broad spectrum of demographic trends and cycles in human history shows that population is rarely stable. Technology and social organization set broad boundary conditions, but population approached these presumed limits only briefly, and under unusual politicoeconomic circumstances. For much of the time, systemic energy flux was well below capacity and relatively stagnant. The intriguing question of exactly which political and economic factors serve to accelerate growth or decline becomes particularly acute when comparing the broadly parallel patterns of demography and prices in western Europe since 1400 (Fig. 42.6). This problem of multiple feedbacks aside, the dramatic demographic cycles suggest that adaptive success in matching population with productivity was ephemeral in the long run. At some point, growth invariably led to metastable equilibrium, and it is uncertain whether political devolution facilitated collapse or whether socioeconomic stress facilitated political devolution. The matter of abrupt change and political or civilizational discontinuities is of more than metaphysical interest. Following a trajectory of sustained growth for almost 500 years, the possibility of drastic simplification seems almost unthinkable. But symptoms of latent instability are present in the modern, interdependent global economy, and the problem of matching population with resources is becoming ever more difficult.

Avenues for Contemporary Application

The purpose of historical studies is not to extrapolate from the past to predict future scenarios. The goal is to understand how communities and societies cope with crises or respond to change. Such an understanding is critical for effective policy formulation in regard to environmental management or the matching of resources with demands.

At the small scale, the case study in this chapter showed how people make collective and informed decisions, which weigh alternatives and which favor options most compatible with sociocultural integrity. Hägerstrand and Lohm (chap. 37) point out that environmental legislation in Sweden could be implemented only after the communities affected were properly informed, in order to convince them to comply. The U.S. effort in soil conservation has had a similar history.

One can also argue that individuals and communities, in the broad sense, can create pressures for government that lead to the formulation and passage of such legislation. But can one expect to see analogous developments in Third World countries, in which priorities and values are different? Success here ultimately requires that western advisers first learn the mini-max rationale of local traditional agriculture before they prescribe change, and that any changes incorporate and emphasize the best components of the traditional system (Knight 1974; Porter 1978). Change imposed from above, and in a cultural vacuum, will probably be ineffective or even ecologically disastrous.

Change is almost always costly in terms of labor or sociocultural dislocation or both. The relative costs and benefits of socioeconomic transformations affect successive generations differently. This disparity goes beyond the long-term investment of conservationist strategies in agriculture, in which the investments of one generation benefit the next. Industrialization and urbanization of western Europe since the late 1700s

offer an equally valid example. While the first few generations of farmers turned factory workers paid a very high human price, later generations profited from a greater food supply and from better health care and education, although at the cost of some important cultural values, as community anchoring was lost. The present generation of urbanized Europeans and Americans exhibits blatant consumerism (chap. 40) in a deteriorating environment that threatens to impair the quality of life. Remedial environmental "clean-ups" are expensive, and better ecological behavior may require a curtailment of lifestyles, if future generations are to live more modestly but in better environmental surroundings. The present generation and the next will have to make difficult decisions: Will the population at large bear the high costs of the environmental transformations now underway, or will the few who have directed these transformations for the sake of immediate profits pay? A great deal of "information" will need to be expended before the average citizen can be convinced to make such a personal investment in the future.

Change will be even more difficult in the Third World, where local resource users have been impelled to adopt short-term exploitation strategies with respect to water, soil, and forest resources. Much of the stimulus and some of the agencies fueling this exploitation derive directly or indirectly from the same western entrepreneurs who have profited from degradation of the environment in the industrial world. In this vicious circle of economic and demographic pressures, under which traditional social values and integration are breaking down, Third World countries rarely have the resources to accommodate massive social readjustment, as dislocated people struggle to match expanding populations with deteriorating resources. Ultimately, faced with massive defaults on immense loans, international financial institutions will channel their losses back to middle-income taxpayers in the industrial world. Thus, willingly or not, the costs of remedial action on a global scale will most probably be born by the general population of the industrialized world. This double burden will not be accepted readily, and as time slips by, the ultimate costs increase exponentially.

Environmental degradation is a major hazard, both in times of population growth, while resources are prone to be overexploited, as well as in times of decline, if the better traits of husbandry are discarded. Prehistoric and historical studies show, however, that population numbers are not necessarily proportional to ecosystem stress. Often enough, relatively small populations have done great damage to the environment – sometimes to the point where a way of life has had to be given up, allowing the ecosystem to recuperate while the remaining human population is forced to reevaluate and reformulate its priorities and strategies (e.g., Butzer 1981; Butzer and Mateu n.d.; Van Andel and Runnels 1987). Similar processes can be observed in parts of the Third World today, as new technologies are introduced to unsuitable environments. Expansion or intensification have become counterproductive to sustainable growth in productivity, and traditional husbandry has been forfeited. Cultural preservation therefore becomes all the more imperative in the short- and medium-range view.

The contemporary crisis of population explosion, resource pressures, and environmental quality is unique in terms of its scale and universality. It also has been accompanied by an unprecedentedly rapid economic transformation, in that the majority of the people in urban-industrial societies are employed in the service sector, while per capita farm and factory productivity declines. We lack the long-term experience to judge whether this trend introduces new, latent problems for systemic equilibrium. At the same time, government itself has become a huge management machine, increasingly top-heavy, with dispersal of authority and decision-making among the broad ranks of a vast bureaucracy, far removed from community concerns and inputs, but increasingly vulnerable to special-interest groups. In response, information flows horizontally as much as it does vertically, while energy demands at the top, for nonproductive or inefficient goals and programs, continues to increase. Past experience warns that such "over-loaded" politicoeconomic structures are metastable (Butzer 1980; 1984; Cowgill 1988).

The great oscillations traced by historical demography through the many millennia of human experience were tightly linked with economic and political trends. The regularity of economic collapse and political simplification in the wake of each hemicycle of growth and integration is deeply disturbing. Devolution may not be certain, but it is probable. As steep as the human and social costs of accommodating growth evidently are, in the past as in the present, the price of devolution is difficult even to imagine.

Given the grim possibilities of catastrophic, downward readjustment, broader segments of society need to weigh the alternatives and to make informed decisions that will preserve the essentials of what is of highest sociocultural value. Given the level of "noise" incorporated in megasystems, this seems an almost insurmountable task. Our human experience suggests that information and responsibility are the most essential components for successful adaptation. The towering vertical structures of national societies are the most formidable obstacle to reimplementing "bottom-up" community response. The problem therefore seems to be systemic, rather than societal. The degree to which government can provide leadership, prove responsive to its constituencies, and reinvolve its diverse communities in decision-making will prove critical as to how or whether priorities can be revised and sociocultural values can be preserved.

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B. L. Turner II (Clark University) provided both challenge and feedback.

Notes

1. E. K. Butzer and J. F. Mateu collaborated in the preparation of this section.

2. The materials presented in this section are based on six field seasons, 1980–87, devoted to interdisciplinary, micro-regional study. The project was directed toward the history of settlement, demography, and land use over the past 800 years, and included intensive archival research and four excavation projects. Attention was focused on one corporate community, Aín, with supplementary work in nine other villages and two abandoned hamlets. Earlier publications, dealing with the medieval period, include Butzer and others (1985, 1986, 1989). The following synopsis is limited to the period after 1609, when the residual Muslim population of the area was expelled and entirely replaced by new Christian settlers. This unpublished segment of the project is based heavily on historical land-use study, ethnographic work, and analysis of the parish registers of four Espadán municipalities (Vall de Almonacir, 1611–1852; Alcudia de Veo, 1624–1723, 1833–70; Eslida, 1695–1742; and Aín confirmation records, 1737–54). Municipal archives of Aín were destroyed in 1936, but informants allowed a reconstruction of local events in Aín since about 1890, and families were reconstituted back to the mid-1800s from other sources. Partial documentation is available in several outside archives.

3. Implicit here is that adaptation represents continuous, complex adjustments, whether the long-term outcome be good or bad. It is a process, to be examined empirically, rather than a measure of success or failure.

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