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PROFILE

Industrial Development Versus Environmental Conservation at Local Scale: A Case Study from Southeastern Spain

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ABSTRACT / Local scale has an important role in environmental management. In Spain, rapid industrialization has occurred in the last three decades, leading to substantial changes in socioeconomic relations and resulting in significant environmental degradation. This paper describes the environmental status of the township of Sax (Alicante, in southeast Spain), which has passed from agriculture to industrial manufacturing in 50 years. The human population has grown exponentially during the second half of the 20th century, with a 91% increase from 1955 to 1995, coinciding with strong growth in manufacturing (factories increased fivefold in the period 1955–1976) and important changes in the working population and land use. Illegal rubbish dumps, water pollution, forest fires, erosion, and degradation of wildlife habitats are the main outcomes of these dramatic socioeconomic and demographic changes. The administration has focused on the control of water pollution and waste management, while nongovernmental organizations have concentrated on the prevention of forest fires and the development of environmental education programs. These measures are insufficient to manage current environmental degradation, and an environmental management plan for the study area is discussed. Increasing effort in waste management and industrial wastewater control, changes in land-use policy, and the creation of an advisory committee to increase public participation in decision-making have been identified as environmental target objectives for the coming years.

Despite much of the current debate and initiative about how to manage the environment taking place at national or international levels, in practice a considerable proportion of environmental management is being done at the local level (Keen and Mercer 1993, Pretty and others 1995, Tisdell and Xiang 1996). Local policy is an important determinant of environmental outcomes (Farthing 1997), and management measures taken at this level influence broader scales (Orland 1992, Turner 1994, Mitchell 1996, Sierra and Stallings 1998). The local scale has a significant role in biodiversity conservation (Garrod and Willis 1994, Breininger and others 1998) and is of great importance in establishing effective procedures to achieve sustainable development (Kenny-Gilday and others 1995, Furuseth and Cocklin 1995, Maser 1996).

In Spain, politics and economics after the Spanish Civil War (1936–1939) caused a decrease in the industrialization started during the second half of the 19th century (Bustelo 1996). This decline continued into 1950s, when the international openness of government and the improved economy began to revitalize industry, which quadrupled production between 1960 and 1974 (Bustelo 1996). This accelerated industrialization, together with important growth in the population during the last part of the 20th century, has led to dramatic modifications in socioeconomic relations (Nadal 1984). These changes have affected the environment by the exponential increase in the production of urban and industrial waste (Mulero 1999), pollution of water and air (López 1994), increase in erosion (Cerdà 1997), and degradation of natural landscape and wildlife habitats (Cáncer 1999).

In Spain, local authorities play an important role in environmental management, including land-use planning, an activity that has a great impact on the environment (Johnson and Lewis 1995, Dale and others 1998, Honachefsky 2000). Local governments also have the power to control environmental impacts through landscape and industrial development and by managing waste disposal (López 1994).

Despite the importance of the local scale, there are few studies that explore the relationship between socioeconomic changes and environmental degradation at this scale. Here I describe what has happened to the environment in a particular part of southeastern Spain, the township of Sax, which has industrialized enormously during the second half of the 20th century, a process common to many Spanish regions (Nadal

KEY WORDS: Industrial development; Environmental conservation; Environmental impacts; Local scale; Spain

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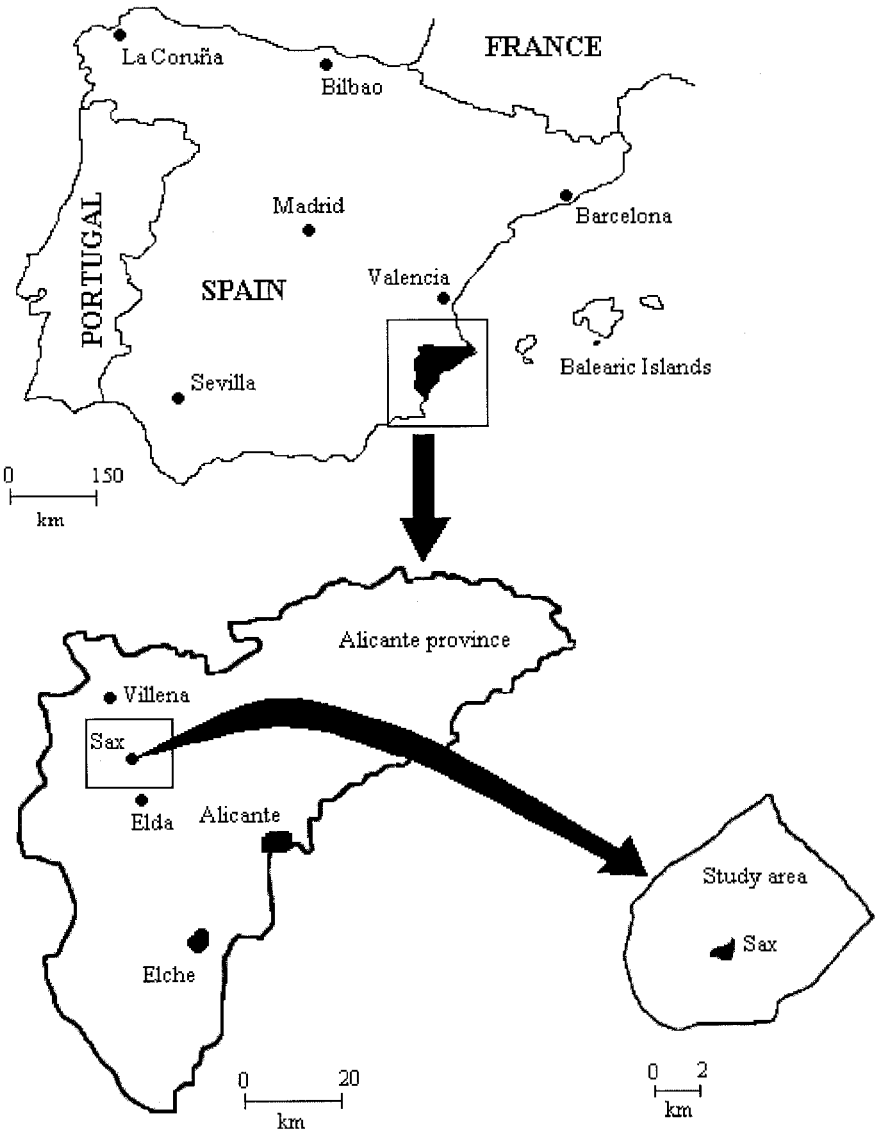

Figure 1. Location of the study area.

1984). The objectives of this study were to: (1) examine the main environmental impacts of human activities in the study area, (2) relate them to the population, socioeconomic, and land-use changes of the last centuries, (3) discuss the management measures carried out during the last decade, and (4) propose an environmental management plan to improve the environment of the region.

Study Area

The study area encompasses the township of Sax, located in the east of Alicante province in southeastern Spain (Figure 1). It covers 6300 ha and is surrounded by mountains, with a central valley that crosses it from northwest to southeast in which the Vinalopó River flows. The climate is semiarid, with a mean annual rainfall of 315.4 mm and a mean annual temperature of 16.4°C (Maestre 2000a). Peak rainfalls occur in spring (March and April), with a second high peak in October. There is a pronounced dry season from May to September, and large variation both in the pattern and total amounts of rainfall from year to year (Jaén 1996).

Most of the region is dedicated to agriculture, with vine grape (*Vitis vinifera*), olive (*Olea europaea*), and almond (*Prunus dulcis*) as main crops. Forests of Aleppo pine (*Pinus halepensis*) and shrublands cover about 30% of the region and are mainly in the mountains and in areas that are not suitable for agriculture. Urban and

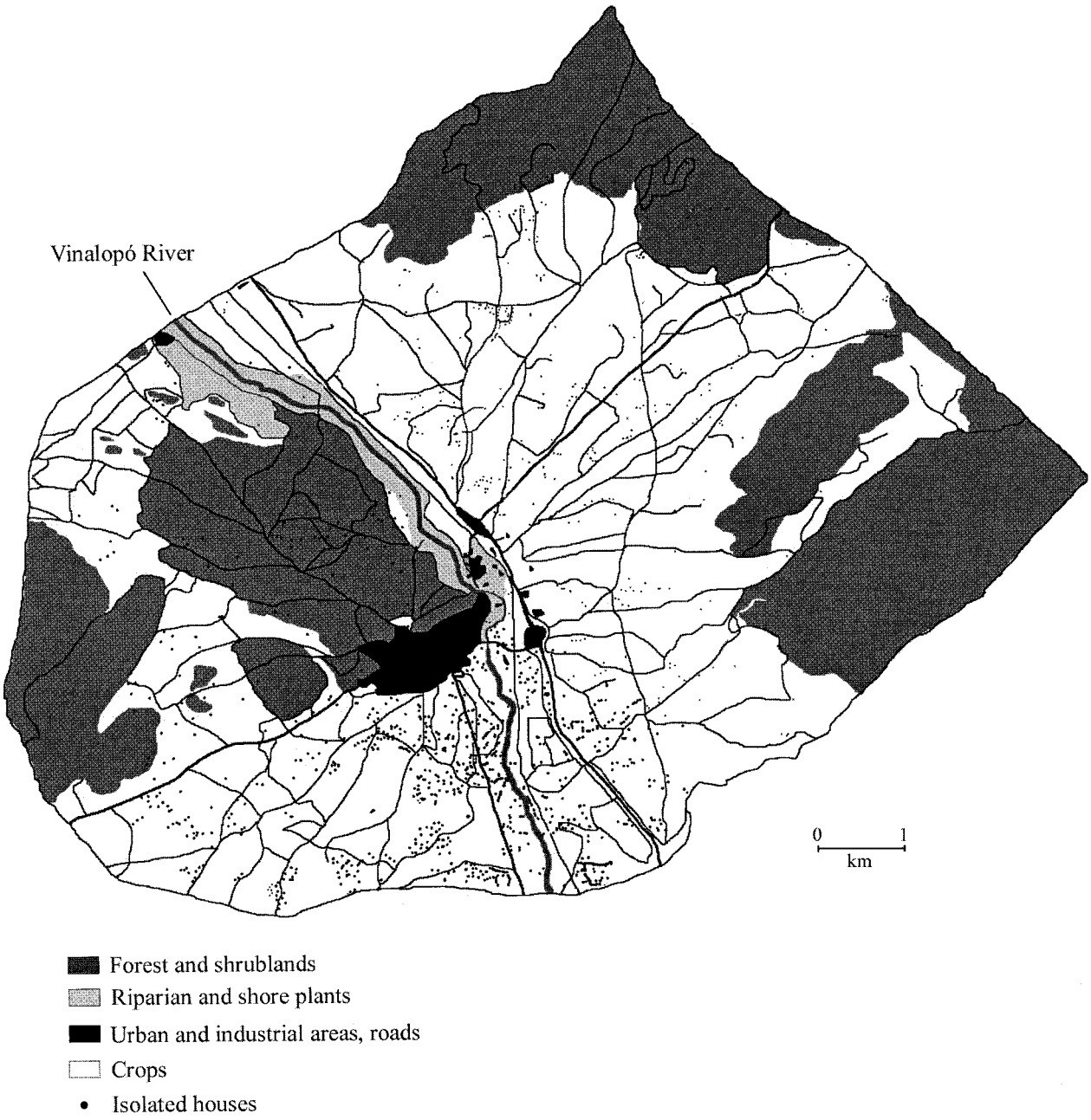

Figure 2. Main land uses in the study area.

industrial zones, roads, isolated houses, and other uses occupy the rest (Figure 2).

Biological diversity has begun to be monitored recently. A total of 488 vegetal taxa (Maestre 1999a) and 78 vertebrate species (Maestre 2000a) have been catalogged. The presence of 42 plants native to southeastern Spain (Maestre 1999b), with a density of 0.67 native taxa/km^2, indicates the ecological importance of the area. More than 45% of these species are rare within the Valencia region (Mateo and Crespo 1998), and their density is higher than in other zones of Alicante province (Maestre 1999b). There also are 22 vegetal communities incorporated in the Directive 92/43/EEC (Maestre 2000b), translated into Spanish legislation by Real Decreto 1997/1995, which recommended the creation of special conservation areas to preserve them (European Communities 1992).

Data Collection

The data for this study were collected from 1994 to 1999. The information presented in this paper are a synthesis of an exhaustive field study; personal interviews with members of the town council, regional government, nongovernmental organizations and businessmen, and a bibliographical compilation.

This has now enabled me to provide information on the evolution during the last three centuries of the population and its work, land use, and manufacturing. I concentrated on five of the main environmental problems now present in Spain (López 1994, Mulero 1999): the management of urban and industrial waste, water pollution in households and from factories, forest fires, soil erosion, and degradation of wildlife habitat. The first focuses on the production, recycling, and allocation of urban and industrial waste, together with a detailed analysis of illegal rubbish dumps in the study area. Water pollution problem arises mainly because industrial wastewater pours into the Vinalopó River, and unpublished data are given on measurements of pH, electrical conductivity, biological oxygen demand (BOD_5), chemical oxygen demand (COD), ammonia, nitrogen, detergents, chromium and zinc registered periodically during 1989–1998. I present information on the location, size, and causes of all forest fires during 1986–1999. I have added detail to the existing map of soil erosion. I record the degradation in wildlife habitat by analyzing the main factors that have affected it (development of rural houses, construction of roads, and infrastructure). Finally, I have compiled a list of measures taken by government, and nongovernmental organizations during the last decade and analyze the economic investments in environmental issues carried out in the region.

Social and Industrial Development

Humans were present in the region as early as 2000 B.C. (Ponce 1985). For most of the time since then, the main activity of people was subsistence production of traditional dry crops, olives, grapes (for wine), and wheat. The increase in the population during the 18th century (Figure 3A) produced important changes in land use; more land was cultivated, large areas of forest were cleared, and new crops such as almonds, maize, and oats were introduced (Ponce 1985). The next important change came during the second part of the 20th century, with the development of manufacturing industry brought about by the favorable political and economic climate after the Civil War and World War II. The number of factories increased threefold from 1955 to 1961 (Figure 3B). This industrialization was accompanied by an influx of people from other regions, so the population grew from 4529 habitants in 1955 to 8639 in 1995, a 91% increase (Figure 3A).

This combination of industrialization and population growth had a dramatic impact on land use and the economy, as during the last 50 years the region has passed from an agricultural to an industrial township. The percentage of people engaged in agriculture has dropped from 63.9% in 1935 to 2.9% in 1995, while those working in manufacturing have grown from 19.7% to 67.7%. During the last three centuries agriculture expanded (Table 1), a tendency that slowed dramatically as consequence of industrialization and the abandonment of crops. Although there are few data on the evolution of forests, their area has increased somewhat in the last 20 years, mainly as a result of the recolonization of old fields by shrubs. There has also been a large growth in the area occupied by houses and factories; ca. 125% in the last two decades (Table 1).

Environmental Impacts

Households and factories produce between 14 and 17 t/day of municipal solid waste, or a mean per habitant of 1.69 kg/day. Some of this is industrial hazardous waste, which is not adequately treated. The illegal disposal of municipal solid waste is serious throughout the region studied. A total of 19 illegal rubbish dumps >0.1 ha in size have been located (Figure 4). Solvents, glue, stains, used batteries, and other hazardous materials are dumped without any control in these installations (Table 2). In many cases these illegal rubbish dumps are burned, polluting the air with emissions of carbon monoxide, methylene chloride, formaldehyde, nitrogen oxides, and other toxic pollutants.

The Vinalopó River is gravely polluted in the region, as industrial effluents pour in it from many factories located in La Estación zone (Figure 4). They contain large quantities of organic matter, particles in suspension, ammonia, detergents, and toxic metals such as chromium and zinc, and often exceed the limits imposed by Spanish law (Table 3). Values of pH are higher than 7 in all cases, showing a deviation from the values corresponding to clean water, which should be about 5.6–5.7 (Laws 1993). The extremely low values of dissolved oxygen, <0.5 mg/liter in more than 60% of the sample periods, are a clear indicator of the low water quality in the region and are caused by organic wastes poured into the river by shoe and tanning manufacturing factories. The limit of suspended matter imposed by the law (300 mg/liter) was exceeded in more than 70% of the surveys, with peak values four-

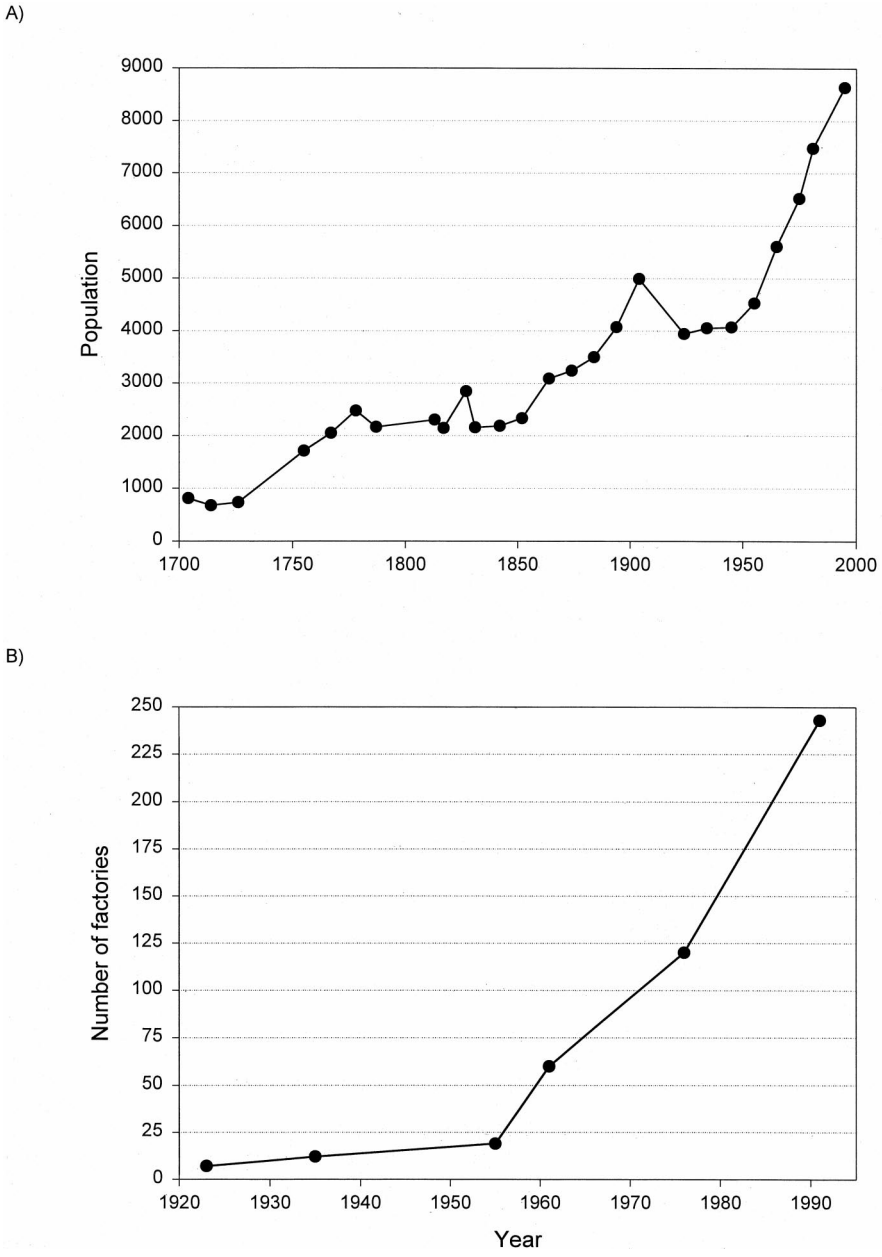

Figure 3. Evolution of (A) population growth during last three centuries, and (B) number of factories from 1923 to 1991. Source: Ponce (1985), Vázquez (1990), Ayuntamiento de Sax (1991), Diputación de Alicante (1996).

fold and fivefold above the limit. The same occurs with BOD_5 and COD, whose limits (300 mg/liter and 500 mg/liter, respectively) were exceeded in more than 73% and 93% of the sample periods, respectively. Ammonia limits were surpassed in more than 50% of surveys. The limits of nitric nitrogen and detergents were exceeded in <25% of surveys. Among toxic metals, chromium values were only higher than the limit in two surveys. Zinc, an important water pollutant, (limit 20 mg/liter), extensively exceeded the limit, with peak values 10-fold above this value. Until the construction of a wastewater treatment plant in Elda (12 km north) in September 1998, urban effluent also poured into the river without any treatment with an approximate flow of 37 liters/sec in Huerta Nueva zone (Figure 4).

Nineteen forest fires were recorded in the study area during the period 1986–1999, with a total of 10 ha burned, about 1% of total forest area (Table 4). Although this area is small, we should recognize than the burning of agricultural residues and municipal solid wastes in illegal deposits near forests and shrublands caused more than 36% of fires. These formations are dominated by Mediterranean fire-raiser species, such as Aleppo pine (*Pinus halepensis*), gorse (*Ulex parviflorus*),

Table 1. Evolution of land use in the study area

Year	Land use (ha)		
	Agricultural	Forest	Urban and Industrial
1755	1749	—	—
1847	2173	—	—
1857	2740	—	—
1912	3130	—	—
1980	4012	863	122
1995	3717	882	151.13
1999	3714	891	269.33

Source: Ponce (1985), Vázquez (1990), Sax Town Council (unpublished data).

and rosmarine (*Rosmarinus officinalis*), that can propagate a fire quickly once started (Vélez 1990).

Despite the lack of work to evaluate soil erosion quantitatively, available data suggests the presence of erosion problems (Figure 4). The climate, geological substrate, and topography, together with human degradation of vegetation cover, the abandonment of agricultural land, and increase in infrastructure have exacerbated erosion. Although it is slight in most of the region (more than half of the total area has low or quite low erosion rates), there are areas where it is serious, mainly mountain areas with a combination of high slopes and erodible soils. The most evident effects of erosion in the region are the presence of gullies in places disturbed by human activities, such as former sand mines and the slopes of roads. In the study area, the construction of roads, infrastructure, and rural houses during the last few decades have been identified as key factors in the degradation of natural habitats (Maestre 2000a, Vázquez 1990). The proliferation of rural houses used as second homes occurred mainly between 1970 and 1985, and now more than 50% of the study area has 50–100 houses/km^2 (Figure 2). Rural houses and roads occupy the 5% of the total area, and their construction has promoted significant fragmentation of natural habitats, and this is a major factor contributing to the decline of biological populations (Dale and others 1995, Hobbs and others 1993). Species protected by the Spanish Endangered Species List (Real Decreto 1990/439), which 30 years ago were abundant in the study area, such as the genet (*Genetta genetta*), wild cat (*Felis sylvestris*), eagle owl (*Bubo bubo*), golden eagle (*Aquila chrysaetos*), and Bonelli's eagle (*Hieraetus fasciatus*), are nowadays practically extinct. Infrastructure projects also have degraded natural habitats in the region. During the 1980s, several projects channeled the Vinalopó River in the urban area to prevent flooding, destroying the original riparian vegetation. In October 1991, the consolidation of a rock zone near the town in the Castillo de Sax (UTM coordinates: 30SXH9067), damaged the natural habitat of the locally rare native subshrubs *Teucrium buxifolium* subsp. *rivasii, Dianthus broteri* subsp. *valentinus, Hypericum ericoides* subsp. *ericoides* and *Chaenorrhinum origanifolium* subsp. *crassifolium*. In February 2000, preparation of land for an afforestation with Aleppo pine (*Pinus halepensis*) and holm oak (*Quercus ilex* subsp. *rotundifolia*) in the same area considerably reduced the amount of surface occupied by the *Gypsophilo struthii–Teucrietum libanitidis* association, a vegetal community included in Directive 92/43/EEC.

Measures Carried Out by Administration and Inhabitants

During the last decade several measures were taken by the authorities, nongovernmental organizations, and inhabitants to improve the environment. Government action by national, regional, and local authorities has been concerned principally with controlling water pollution and waste management, while the activities of nongovernmental organizations and the inhabitants have focused on the prevention of forest fires and on environmental education (Table 5).

Recycling started in 1994 with the installation in the streets of containers for paper cartons and glass; in 1997 more containers were added, and new receptacles for batteries and neon lamps were also supplied (Table 6). During 2001, the regional government will build a recycling point in the town, where new containers for municipal solid wastes (cartons and paper, plastics, aluminum beverage cans, glass, and batteries) and industrial solid wastes (wood residues, solvents, and scrap iron) will be installed. During 1997, a local nongovernmental association developed an environmental education program in collaboration with local tradesmen to reduce waste production and increase recycling. Together with informative campaigns about the problems caused by uncontrolled waste disposal and the environmental benefits of recycling, more than 800 reusable fabric bags were distributed to inhabitants with the aim to reduce the use of plastic bags.

A great effort has been made to minimize water pollution. The national government in 1997 constructed a sewage and wastewater plant in neighboring Elda. This plant receives urban effluents from the region and treats them. It does not, however, take some industrial effluents, which it cannot treat. The main progress in the control of industrial effluents is a network of pipes that collects wastewater from several isolated factories and a local law approved in 1996 to

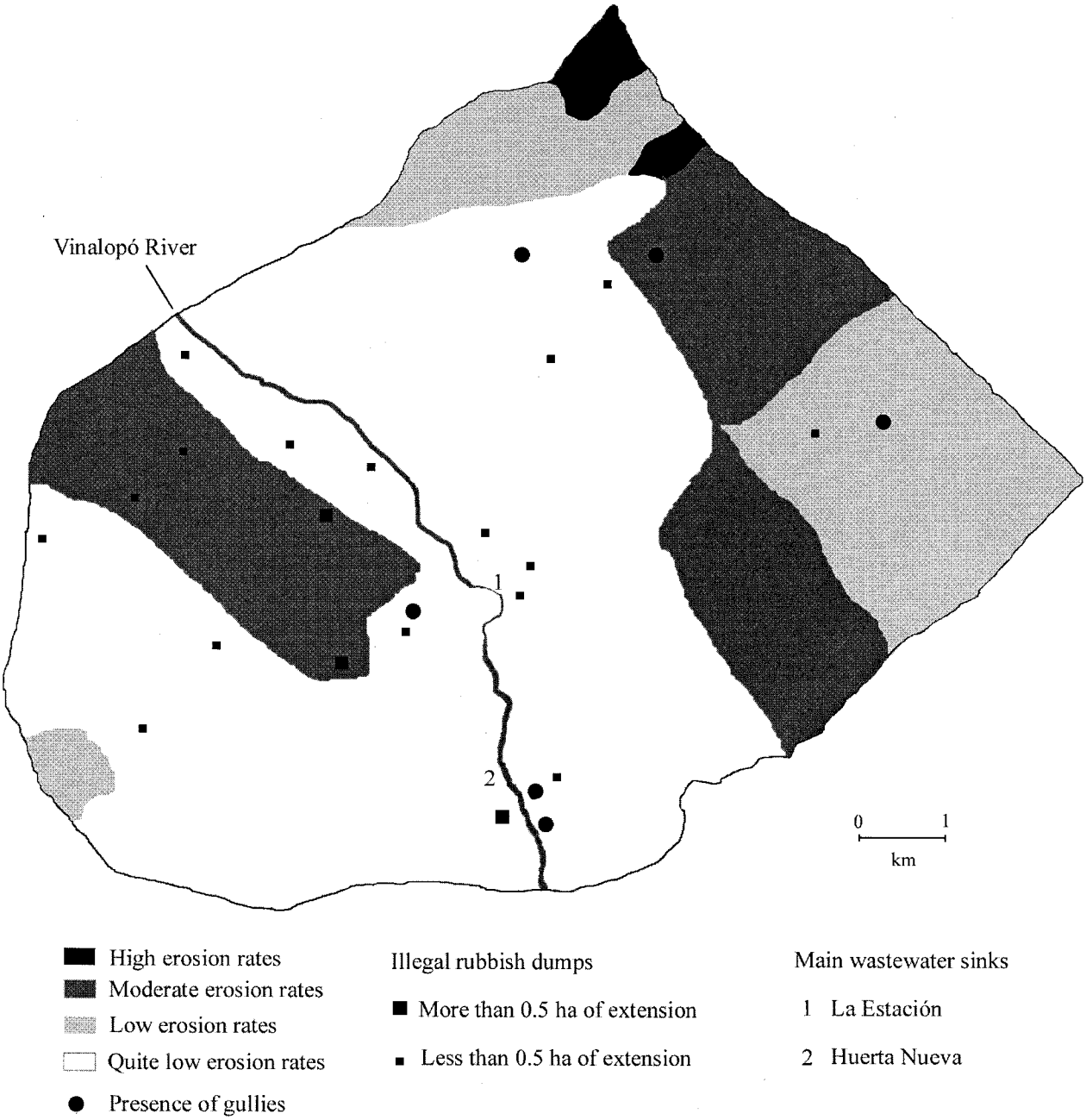

Figure 4. Study area erosion map and distribution of illegal rubbish dumps and main wastewater sinks in 1999. Source for erosion data: Ingemisa (1991).

control industrial pollution by limiting the emission of industrial effluents into the river. Local government is currently implementing a monitoring system with the aim to control the effluents of the different industries, but it still is not fully functional.

Several measures have been taken during the last years to control forest fires by limiting the amount of combustible wood where there is a high risk of fire, as in El Plano (UTM coordinates: 30SXH8967) and La Argueña (UTM coordinates: 30SXH9569). Several local nongovernmental organizations, with the support of the regional government and the CAM (Mediterranean Saving Bank) Foundation, have developed a scheme to monitor main forest areas during the summer (June–October), combining this task with forest plantings during the winter.

Economic investments in the environment during

Table 2. Main hazardous materials on illegal dumps in study area

Waste product	Source[a]	Amount[b]
Solvents and glue residuals	TI, SI	***
PVC and other plastics	H, PI	***
Stains, varnishes, and lacquers	FI	**
Dry-cell batteries	H	**
Coloring residuals	TI	**
Hydrocarbon residuals	TI, MI, PI	**
Used batteries	G	**
Pesticide sprays and dusts	A, H	*
Latex and oil-based paints	H	*
Cyanide	TI, PI, MI	*

[a]A = agriculture, G = garages, H = houses, TI = tanning industry, SI = shoe manufacturing, FI = furniture industry, MI = metallurgic and galvanic industry, and PI = plastic industry.

[b]*** Present in more than 50% of illegal dumps, ** present in 25–50% of illegal dumps, * present in less than 25% of illegal dumps.

the last decade have been heavily tilted toward water pollution control (Table 7): more than 95% of the total expenditure. Despite its importance, the treatment of municipal solid waste (MSW) receives less than 1.5% of the total. Investments to control erosion are also very low, <0.05% of the total capital during these years, while the amount dedicated to environmental education is about 1.25% of the total investment, with a strong increase during the last few years.

Environmental Management Proposal

Despite the progress made during recently, measures carried out by the government and citizens are insufficient to handle existing environmental problems, and implementation of an environmental management plan is needed. Some guidelines that should be included in this plan are discussed next.

Waste Management

The amount of municipal solid waste produced by each person per day (1.7 kg) is higher than the mean values produced in Spain (0.55 kg/inhabitant/day in cities with less than 20,000 habitants) (Ruza 1993), the Valencia region (1.41 kg/inhabitant/day) (Generalitat Valenciana 1998) and Alicante province (1.20 kg/inhabitant/day) (Generalitat Valenciana 1998). To reduce this amount, an integrated waste management system (Buchholz 1993) should be implemented. This system should include the following strategies:

Increase waste planning and management information to citizens and industry. This would include information campaigns by local government, citizens' associations, and local nongovernmental organizations about how serious the problem is in the region and how to minimize its negative impacts.

Enhance source reduction activities. Source reduction is a strategy to decrease the amount of waste before it is created, and in the study area should be applied to both inhabitants and industry. Some market incentives, such as a rebate when consumers provide their own bag during shopping and the subsidies for redesigning manufacturing processes to use less material in local industries, would be useful to achieve this end.

Improve recycling network. The current network of containers should be improved, with the addition of containers for plastic and aluminum cans and an increase in the rate of container collection. New containers for industrial wastes, such as scrap iron, glue, and solvents, should be established in the main industrial areas. Here also, market measures, such as a reduction of municipal taxes to those citizens and industries using recycled products, or levying trash taxes on products that can reduce household waste, such as plastic bags or glass bottles, also would be effective to increase the recycling rate.

Establish funds to help industries. There are several funding opportunities provided by both the national (Real Decreto 937/1989) and regional (Orden de 17/4/2000) governments to improve the management of wastes and recycling activities of industries. Local authorities should inform industries of these possibilities and help them to ask for these funds.

Together with waste reduction, management of illegal rubbish dumps is urgent. This topic is one of the main environmental issues in Spain, as there are over 3700 illegal rubbish dumps that receive more than 2,600,000 t of municipal solid waste, 17.6% of the total (Mulero 1999). In Alicante province, this percentage is 35% (Generalitat Valenciana 1998). The main illegal dumps located in the study area should be cleaned and restored. Along with this, it is necessary to construct a new sanitary landfill to spread nontoxic municipal solid wastes—such as debris from houses—that currently are deposited without any control. Both the restoration of illegal dumps and the construction of a new one will require major investments by authorities.

Waste management legislation has improved considerably in Spain in the last years. European Directive 94/62/EEC, translated into Spanish legislation by the Ley 11/1997, requires member states to recover a minimum of 50% by weight of packaging waste, with recycling of 25%–45% by weight of packaging materials (Karl and Ranné 1999). Together with this directive, the recent Spanish Residue Law (Ley 10/1998), which regulates the production, disposal, and recycling of urban and industrial residues, establishes that citizens

Table 3. Evolution of water quality in Vinalopó River[a]

Date	PH	DO	SS	BOD_5	COD	Am	N	Det	Cr	Zn
11-22-89	—	—	618.0*	400.0*	591.0*	50.0*	—	15.0*	1.0	6.0
12-3-91	—	—	406.0*	470.0*	900.0*	219.4*	—	34.0*	0.1	0.1
12-11-92	—	—	478.0*	76.0	673.0*	16.9	—	1.2	0.1	17.5
6-22-93	—	—	406.0*	511.0*	1079.0*	46.1	—	3.3	9.3*	230.5*
9-7-93	—	—	851.0*	853.0*	1594.0*	67.8*	—	4.9	0.9	80.6*
11-2-93	—	—	685.0*	545.0*	1399.0*	60.9*	—	25.8*	0.2	23.9*
10-19-94	—	—	407.0*	700.0*	1490.0*	—	—	5.0	0	4.0
1-17-95	8.5	2.9	141.0	117.5	254.0	—	—	0.4	0	20.9*
3-23-95	7.3	<0.5	785.0*	643.0*	1572.0*	<1.0	<1.0	2.2	5.8	60.0*
6-8-95	7.7	1.9	233.0	238.0	674.0	99.0*	<1.0	5.4	0	3.8
11-2-95	8.8	<0.5	1420.0*	706.0*	2218.0*	21.0	8.6	2.5	0.4	114.0*
12-14-95	8.4	2.1	270.0	283.0	868.0*	89.0*	<1.0	2.5	3.8	25.8*
1-23-96	8.1	<0.5	935.0*	392.0*	1437.0*	44.0	12.8	1.6	6.0	122.0*
7-9-97	8.3	<0.5	169.0	450.0*	761.0*	—	97.6*	3.0	3.2*	1.2
1-14-98	7.1	<0.5	396.0*	580.0*	1458.0*	—	1.2	—	0	2.0

[a]Analytical measurements made at La Estación zone from 1989 to 1998. (Source: Sax Town Council (unpublished data). Asterisks indicate amounts that exceed legal limits in Spain (Real Decreto 1986/1338).

DO = dissolved oxygen (mg/l), SS = sedimentable materials (mg/l), BOD_5 = biological oxygen demand (mg/l), COD = chemical oxygen demand (mg/l), Am = ammonia (mg/l), N = nitric nitrogen (mg/l), Det = detergents (mg/l), Cr = total chromium (mg/l), and Zn = zinc (mg/l).

Table 4. Main forest fires during 1986–1999 in study area

Year	Location	UTM coordenates	Burned area (ha)	Cause of fire
1986	Casa del cojo	30SXH9172	0.15	Unknown
1987	El Chorrillo	30SXH9165	1.00	Unknown
1987	La Suerte	30SXH9166	0.01	Unknown
1989	El Chorrillo	30SXH9165	0.50	Unknown
1990	Cabezo del Pez	30SXH8969	0.02	Burning of MSW in illegal disposals
1990	La Colonia	30SXH8870	3.00	Unknown
1990	El Chorrillo	30SXH9165	2.00	Unknown
1991	La Torre	30SXH9272	0.02	Burning of agricultural residues
1991	Campo de tiro	30SXH8968	0.07	Unknown
1991	Las Colominas	30SXH9173	0.50	Unknown
1993	Jalonera	30SXH8973	0.07	Burning of MSW in illegal disposals
1994	Peña Rubia	30SXH9173	1.00	Burning of MSW in illegal disposals
1995	La Torre	30SXH9272	0.02	Burning of agricultural residues
1996	Lomas de Marco	30SXH9073	0.05	Unknown
1996	El Puntal	30SXH9470	1.60	Burning of agricultural residues
1998	Cabezo Gordo	30SXH8867	0.02	Burning of MSW in illegal disposals
1998	El Plano	30SXH8869	0.01	Unknown
1998	El Cuco	30SXH8770	0.01	Unknown

Source: Conselleria de Medio Ambiente, unpublished data.

in all towns with >5000 inhabitants should separate organic waste, paper, and glass in garbage disposal as of January 2001. The national government has recently started the Urban Residues National Plan 2000–2006, which includes a complete set of measures and funding instruments to reduce production of urban waste, increment recycling activities, and eliminate illegal rubbish dumps during the next six years (Ministerio de Medio Ambiente 2000).

Despite these legislative advances, the real situation in the study area is far from the conditions required by these laws. A great effort by local government and citizens must be made in the next years to implement an integrated waste management system that allows meeting the requirements imposed by recent laws.

Water Pollution Management

Despite the progress reached with the treatment of urban sewage, pollution by industry continues. There are several characteristics of local industries that make

Table 5. Main environmental activities during last decade in study area

Activity	Year	Sponsor[a]
Reforestation	1990–1999	G, P
Environmental education	1993	N
	1994	N
	1995	G
	1996	G
	1997	G, N
	1999	G
Forestry works	1993–1997	G
Cleaning of natural areas	1994	N
	1995	N
	1996	N, NG, G
Channeling of Vinalopó River and boundary cleaning	1994–1997	G
Vigilance and prevention of forest fires	1995	N
	1996	N
	1997	G, P
	1998	G, P
	1999	G, P
Placement of recycling containers	1995	G
	1997	G
Creation of a recreation area in El Plano	1996–1999	G
Creation of piping network to collect several isolated industrial effluents	1999	G

[a]G = government (national, local and regional), N = nongovernmental organization, NG = neighbors, and P = private organization.

Table 6. Recycling containers present in study area in 1999

Residue	Location of containers	Containers (*N*)	Inhabitants/container
Paper and carton	Streets	6	719
	City council	1	
	Schools	5	
Glass	Streets	6	1439
Small batteries	City council	1	2879
	Shops	2	
Dry batteries	City council	1	8639
Neon lamps	City council	1	1727
	Shops	4	

pollution difficult to control. First, more than 80% of factories have less than 15 employers, and the implementation of new production systems to reduce toxic effluents and the equipment to treat them cost more than many manufacturers can afford. In addition, many of the industries are located within the urban area and are not equipped with adequate piping systems to separate their effluents from the urban main sewer. Finally, industry is the main economic activity of the study area, and local government has not pressured manufacturers enough, with the aim to avoid social conflicts that would be generated if some factories close.

Even so, control of water pollution by industry must be a priority in local government environmental policy. To minimize the environmental impact of industrial activities and restore the Vinalopó River in the study area, the following measures are proposed:

Establish a monitoring program to control water quality. During the last decade samples of water have been collected irregularly by local authorities. The monitoring effort should be increased, and sampling should be done at least every four months. Together with this analytical control, nongovernmental organizations, volunteers, and citizen groups should establish an alternative monitoring system based on visual observations, which can be of great utility in detecting the presence of pollution by detergents, organic matter, and rubbish. In the last two years, the CAM (Mediterranean Saving Bank) Foundation supported a successful pilot monitoring program throughout the Vinalopó Basin developed by volunteers and nongovernmental organizations; it combined visual observations with water sampling for analytical measurements. The continuation of this program and the creation of a local one would improve existing control of water quality.

Identify industries that generate polluted effluents. This issue is a crucial task that has not yet been solved. Local government is trying to implement a monitoring system based on the construction of small chests in all the industries. Although this system is a straightforward way to detect contaminating industries, allowing local government employees to take samples without the knowledge of the manufacturer, at the moment it is failing. The reasons for this include insufficient information between manufacturers, lack of qualified staff in local government, pressure by local manufacturers, discussions between local politicians, economic constraints, and construction problems because of the location of many industries within the urban area. As an alternative, regular inspections by local government employees should be developed until these problems are solved.

Strengthen authority control on law observance. Both national (Real Decreto 1986/1338) and local (Boletín Oficial de la Provincia de Alicante, 7/12/1996) laws fix the allowable limits of pollutants in industrial effluents; however, these limits are often exceeded and none of the penalties in these legal documents have been applied. It is important to enforce observance of the law, and local authorities together with the Civil Guard should play a role in this task.

Restore degraded riparian areas. The Vinalopó River has played an important social, cultural, and recre-

Table 7. Government investment in environment during 1989–1999

Activity	Year	Investment (US $)	% of total investment	Funding[a]
Channeling of Vinalopó River	1994	573,000	4.12	N
	1997	40,000	0.29	R, L
	1999	906,000	6.51	R, L
Cleaning of Vinalopó River boundaries	1994	1,350	0.01	L
	1997	8,000	0.06	N
Creation of sewage and wastewater plant in Elda and piping of local wastewater effluent	1998	11,330,000	81.45	N
Creation of piping web that collects several isolated industrial effluents	1999	365,000	2.62	R, L
Prevention of forest fires	1997	13,300	0.09	R, L
	1998	16,000	0.11	R
	1999	6,700	0.05	R
Forestry works	1993	46,500	0.33	L
	1997	54,700	0.39	R
Environmental Education activities (conferences, expositions, informative sheets and books)	1995	1,350	0.01	R, L
	1997	2,000	0.01	L
	1999	2,350	0.02	R, L
Creation of recreation area in El Plano	1996	160,000	1.15	R,L
Reforestation activities	1990–1999	5,000	0.04	R, L
Collocation of recycling containers	1995–1997	4,500	0.03	R, L
Creation of a Environmental Education area in El Plano (in progress)	2000	166,500	1.20	R
Aconditioning of a local MSW disposal (in progress)	2000	75,000	0.54	R, L
Creation of recycling point (in execution)	2000	133,500	0.96	R, L

[a]N = national government, R = regional government and L = local government.

Source: Sax Town Council (unpublished data).

ational role for the inhabitants of the study area throughout the 20th century (Maestre 2000a). Together with the control of water pollution, is important to recover original habitat in those areas degraded by human activities. A restoration program cleaning up the border of the river and restoring riparian communities should be undertaken by local government with the help of nongovernmental organizations, volunteers, and citizen groups.

Revise the regulatory regime. All new industries should be required to build their own wastewater treatment systems. This requirement is not applicable to existing ones, although it would be desirable to extend this to all industries that produce toxic effluents. Some funding to help implement this process can be obtained through the regional government (Orden de 4/4/2000), which subsidizes industries to implement environmental management systems.

Land-Use Management

Land-use activities, such as housing in rural areas, road development, and infrastructure projects, have degraded natural habitats, promoted erosion, increased pollution, and modified local hydrology. Local land-use planning approved in 1997 (Ayuntamiento de Sax 1997) introduced several measures to avoid the negative impacts derived from the proliferation of second homes in rural areas, the development of new factories, and infrastructure projects. This document provides some degree of protection of forest lands by limiting cutting. However, it does not restrict the development of new roads, mines, houses, agricultural buildings, and new infrastructure in any part of the study area.

It would be desirable to modify current land-use planning with the aim of including more items on environmental management. The implementation of ecological land-use planning (Honachefsky 2000) is necessary as a further step to guarantee a more rational use of land. Some proposals that should be included in this plan are the following:

Create a GIS-based system to assess future land-use impacts. The use of geographic information systems (GIS) is a powerful tool to manage environmental issues (Muller 1997, Wright and Tanimoto 1998, Swetnam and others 1998, Payn and others 1999). The implementation of a GIS-based strategy, such as described in Dale and others (1998), would be very useful in the assessing future

impacts in the study area derived by changes in land use and infrastructure projects.

Management of agricultural areas. Agriculture occupies more than 58% of the study area, and there is a lack of information about the environmental impacts caused by the use of harmful chemicals and crop practices. Some preliminary data suggest that over 37 Mg/yr of chemical products are used in the study area (Maestre 2000a), but their contribution to soil and water pollution is still unknown. Further studies are needed to identify the main chemicals employed in the study area, the amount used, and if patterns of application are appropriate. Most valuable agricultural land should be protected effectively against the development of new roads and infrastructure works by the establishment of a specific protection category within land-use planning.

Control of erosion. Like most of southeastern Spain, the study area is within the high desertification risk zone on the United Nations World Desertification Map (Miller 1998). This means that the risk of erosion is great, and further studies are needed to quantify more accurately the erosion levels present in the study area. Regional and local authorities, with the help of nongovernmental organizations, volunteers, and citizen groups, should carry out the erosion control measures on old fields, areas of former sand extraction, and on the shoulders of roads that have started to erode. Economic funding provided by the European Union Common Agricultural Policy (CAP) for the forestation of former agricultural lands could be used to store native vegetation on abandoned fields (Gómez and Jiménez 1997). In this areas, the use of native shrubs such as kermes oak (*Quercus coccifera*) and mastic tree (*Pistacia lentiscus*) is of particular interest because of their ability to protect soil, withstand further disturbances, increase ecosystem resilience, and provide fruits for birds and small mammals (Cortina and Vallejo 1999, Vallejo and others 1999, Vilagrosa and others 1997). To restore road shoulders, the use of hydroseeding of native grass species, although costly, may be appropriate (Andrés and others 1996).

Control of housing in nonurban areas. During the last years, the number of houses built in rural areas has declined (Sax Town Council, unpublished data). However, their future development should be strictly controlled. To avoid the development of extensive urbanization in rural areas, current land-use planning requires that owners have a minimum plot of 10,000 m^2 to build a house outside the urban area (Ayuntamiento de Sax 1997). However, this does not limit housing expansion throughout the study area. The establishment of housing-free zones in the most valuable agricultural and ecological areas should be implemented.

Establishment of protected areas. The designation of protected areas has been identified as a key factor within natural habitat conservation (Primack 1993, Boersma and Parrish 1999, Schneider and Burnett 2000). The region contains no protected areas, despite the ecological importance of some sites (Table 8). In Spain, most environmental protection lies within the jurisdiction of regional governments. Between the different classes of protected areas that the Valencia Region Protected Areas Law (Ley 11/1994) reflects, the category of local natural area allows to local governments to manage natural areas of local interest that lie within their townships. Among the distinct natural areas that should receive protection, conservation of the Castillo de Sax is a priority. In less than 10 ha, this place includes more than 46% of the vascular plants present in the study area, including 60% of the total of native species and other plants of limited distribution (Maestre 2000a). It also has ten mammal species included on the Spanish Endangered Species List (Real Decreto 1990/439), and several historical monuments of great value, such as an Arab castle, a snow well from the 17th century, and archaeological ruins from the Bronze, Roman, and Middle Ages (Pérez 1998). This area also offers great possibilities for the development of environmental education programs and is threatened by the presence of illegal rubbish dumps, excessive visitor pressure, and infrastructure projects. The legal protection of this area, together with the establishment of a management plan in which local citizens and nongovernmental organizations should be involved, must rank within the priorities of local government in land-use policy.

Creation of Advisory Committee on Local Environmental Issues

Public participation plays an important role in the development of successful environmental management projects (Manogue 1980, Margerum and Born 1995, Gould and others 1996, White and Bayley 1999, Margerum 1999). Despite the efforts of some citizen groups to increase public participation in the study area, there is a lack of public influence in local decision-making (Maestre 2000a). The formation of an advisory committee has been proposed as an effective way to increase public participation (Vasser and others 1997). The creation of one advisory committee in the region was tried in 1997, but failed. It would be desirable to renew communication between local officials and all levels of the community with the aim of creating an advisory committee, which may be an important tool for decision-making concerning environmental issues. This consultative organ should include representation of (1)

Table 8. Areas of environmental interest in study area[a]

Area	Ecological values	Other values
Castillo de Sax (30SXH9068)	High vegetal diversity	Archaeological site
	Endemic vegetal taxa	Historic interest
	Habitats included in the 92/43 EEC Bill	Tourist place
	Protected animal species	Landscape
Sierra de la Argueña (30SXH9565)	Protected animal species	Traditional agriculture
	Well-conserved Mediterranean shrublands	Landscape
	Well-conserved forest	Fossil deposits
	Endemic vegetal taxa	Outdoor sports
La Torre (30SXH9272)	Protected animal species	Traditional agriculture
	Well-conserved forest	Recreational facilities
	Endemic vegetal taxa	Rural tourism
	Habitats included in the 92/43 EEC Bill	Archaeological site
	Well-conserved Mediterranean shrublands	Landscape
El Plano (30SXH)	Endemic vegetal taxa	Recreational facilities
	Habitats included in the 92/43 EEC Bill	Landscape
	Protected animal species	Outdoor sports
Cabreras (30SXH8768)	Well-conserved forest	Landscape
	Protected animal species	Outdoor sports
	Well-conserved Mediterranean shrublands	Touring

[a]UTM coordinates are in parentheses.

local government, (2) economic auditors, (3) nongovernmental organizations, (4) citizens, (5) manufacturers, and (6) scientists.

Regulation of Investments

There has been a biased flow of money towards wastewater treatment plants during the last decade. Once important advances have been made in the control of urban wastewater, the main resources in the future should be dedicated to integrated management of waste, the prevention of illegal dumping, and treatment of industrial wastewater. These points are crucial, and will require large investments by both local government and manufacturers.

Environmental educational programs must be increased, both in school and beyond, to inform local people of the main environmental problems and possible solutions (Jackobson and McDuff 1998). In this task, volunteers and nongovernmental organizations may play an important role, and their support by local authorities, regional government, and private companies must continue, as they play a leading role in nature conservation, education, and communication between politics and society (Perring 1989, Cutler 1995).

Conclusions

There is a clear relation between industrial development and environmental degradation in the region. At the heart of this deterioration is the rapid expansion since the 1960s of the population and the increase in manufacturing industries at the expense of agriculture. This development, combined with rapid expansion of the area dedicated to housing and factories, the proliferation of second homes in rural areas, and inadequate treatment of waste, wastewater, and industrial effluents, has accelerated the degradation of the environment.

To prevent further degradation and preserve the local environment, the establishment of an environmental management plan is needed. It includes important improvements in waste and wastewater management, land-use policy, and public participation in the decision-making process. The establishment of this plan will require significant increase of investment, together with major changes in industrial processes. However, industry is the mainstay of local economy, and introduction of management measures proposed would probably produce several social and economic disturbances. Despite this, unless industries considerably improve management of their residues and wastewater, serious damage will continue to be caused to the environment of the study area. Manufacturers could use funding opportunities provided by authorities, but the use of private investment needs to accompany such funds.

Environmental issues must rank among the most important problems facing local policy-makers in the next decade. The future development of the study area must take the conservation of its environment account more seriously and for sustainable development (Soussan 1992, Adams and Thomas, 1995, Munasinghe and Shearer 1995) to be achieved.

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