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Traditional Ecological Knowledge Trends in the Transition to a Market Economy: Empirical Study in the Doñana Natural Areas

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Abstract: *Researchers and conservation managers largely agree on the relevance of traditional ecological knowledge for natural resource management in indigenous communities, but its prevalence and role as societies modernize are contested. We analyzed the transmission of traditional knowledge among rural local people in communities linked to protected areas in Doñana, southwestern Spain. We studied changes in knowledge related to local practices in agriculture and livestock farming among 198 informants from three generations that cover the period in which the area transited from an economy strongly dependent on local ecosystem services to a market economy with intensified production systems. Our results suggest an abrupt loss of traditional agricultural knowledge related to rapid transformations and intensification of agricultural systems, but maintenance of knowledge of traditional livestock farming, an activity allowed in the protected areas that maintains strong links with local cultural identity. Our results demonstrate the potential of protected areas in protecting remaining bodies of traditional ecological knowledge in developed country settings. Nevertheless, we note that strict protection in cultural-landscape-dominated areas can disrupt transmission of traditional knowledge if local resource users and related practices are excluded from ecosystem management.*

Key words: intensification, market integration, natural protected areas, resource management, resilience, Spain, traditional ecological knowledge

Tendencias del Conocimiento Ecológico Tradicional en la Transición a una Economía de Mercado: Estudio Empírico en Áreas Naturales en Doñana

Resumen: *En gran medida, investigadores y gestores de la conservación están de acuerdo en la relevancia del conocimiento ecológico tradicional para el manejo de recursos naturales en comunidades indígenas, pero su prevalencia y papel son cuestionados a medida que las sociedades se modernizan. Analizamos la transmisión de conocimiento tradicional entre habitantes locales en comunidades vinculadas con espacios protegidos en Doñana, suroeste de España. Estudiamos cambios en el conocimiento relacionado con prácticas locales agrícolas de agricultura y ganadería en 198 informantes de tres generaciones que cubren el período en que el área transitó de una economía fuertemente dependiente de los servicios ecosistémicos locales a una economía de mercado con sistemas de producción intensiva. Nuestros resultados sugieren una pérdida abrupta del conocimiento ecológico tradicional relacionado con rápidas transformaciones e intensificación de los sistemas agrícolas, pero mantenimiento del conocimiento de la ganadería tradicional, una actividad permitida en las espacios protegidos que mantiene fuertes vínculos con la identidad cultural local. Nuestros resultados demuestran el potencial de las espacios protegidos para proteger los remanentes del conocimiento*

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ecológico tradicional en países desarrollados. Sin embargo, señalamos que la protección estricta en áreas con paisajes culturales dominantes puede afectar la transmisión del conocimiento tradicional sí los usuarios de recursos locales y las prácticas relacionadas son excluidas del manejo del ecosistema.

Palabras Clave: áreas naturales protegidas, conocimiento ecológico tradicional, España, intensificación, integración de mercados, manejo de recursos, resiliencia

Introduction

Traditional ecological knowledge (TEK) has been defined as "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relation of living beings (including humans) with one another and with their environment" (Berkes et al. 2000: 1252). Since the 1980s a growing literature within environmental sciences, ecological anthropology, and resilience theory has stressed the potential role of traditional knowledge for nature conservation and sustainable natural resource management (e.g., Gadgil et al. 1993; Toledo 2002; Ballard & Huntsinger 2006; Berkes & Turner 2006). We contribute to this line of research by examining changes in traditional knowledge and practices for building resilience in resource-management systems.

First used as a descriptive tool within ecological science (Holling 1973), in the last decade resilience has become a leading concept for sustainability analysis in coupled social-ecological systems (Adger et al. 2005; Folke 2006; Perrings 2006). *Resilience* has been defined as the capacity of social-ecological systems to absorb recurrent disturbance to retain essential structures, processes, and feedbacks (Adger et al. 2005). It refers to the shock-absorbing capability of social and ecological systems and reflects their capacity to self-organize, learn, and adapt. Resilience theory conceives traditional knowledge as a dynamic body of knowledge, evolving through a combination of long-term ecological understanding and learning from crises and mistakes (Olsson & Folke 2001; Berkes 2004; Berkes & Turner 2006). From this viewpoint, traditional knowledge is thought to increase the capacity of social-ecological systems to deal with crises and maintain resource flows in changing and uncertain conditions (e.g., Berkes et al. 2000; Folke et al. 2003; Olsson et al. 2004).

The role of traditional knowledge in building resilience to disturbance can be especially critical for communities that rely on ecosystem services as primary sources of provisioning or income (Berkes & Turner 2006). Researchers seem to agree on the importance of traditional knowledge for traditional societies (Klubnikin et al. 2000; Armitate 2003; Godoy et al. 2005; Reyes-García et al. 2007*a*), but its role in societies with modern production systems and lifestyles is contested (Cox 2000). With a few significant exceptions (e.g., Olsson & Folke 2001; Reiff et al. 2003; Sandhu & Heinrich 2005), most previous research on TEK has focused on indigenous communities of developing countries. Consequently, there is a significant knowledge gap concerning the extent to which traditional knowledge still exists in developed countries. This gap hampers researchers' ability to explore the potential contribution of traditional knowledge to ecosystem management and conservation in such settings.

We contribute to efforts to fill this gap by analyzing empirical information on TEK in eight rural communities of the Doñana natural areas, southwestern Spain. Given our focus on resilience, we studied TEK as embodied in a sample of information and management practices used to cope with natural disturbances and climate variability. Our measure of TEK encompasses both knowledge and practices because previous research suggests that both dimensions do not necessarily overlap (Reyes-García et al. 2007*b*).We analyzed changes in the level of traditional knowledge held across three generations of resource users as the society made a transition over time from an economy that was strongly dependent on local ecosystem services for household provisioning to a market-integrated economy. We then analyzed the variables associated with intergenerational changes in traditional knowledge. Finally, we discuss perspectives of TEK in contemporary societies and the challenges involved in the preservation of TEK in developed-country settings.

The Doñana Case Study

Study Area

The Doñana region (hereafter Doñana) is in Andalusia, southwestern Spain. Doñana consists of a large system of marshes, dunes, and beaches associated with the coastal dynamic of the mouth of the Guadalquivir River. As in recent studies (Martín-López et al. 2007), we considered Doñana a coupled social-ecological system (sensu Folke et al. 2003) in which the biophysical system (i.e., the dune-coastal-wetland system) and human culture and livelihoods are linked (Fig. 1).

At the beginning of the twentieth century the Doñana marshlands were relatively untransformed because of failure of various attempts at reclamation in the 19th century (González-Arteaga 1993; Corominas 1995). Due to this lack of transformation, the Doñana marshland is now the largest wetland in western Europe (García-Novo & Marín-Cabrera 2005) and a unique biodiversity spot that is refuge to many endemic and endangered species

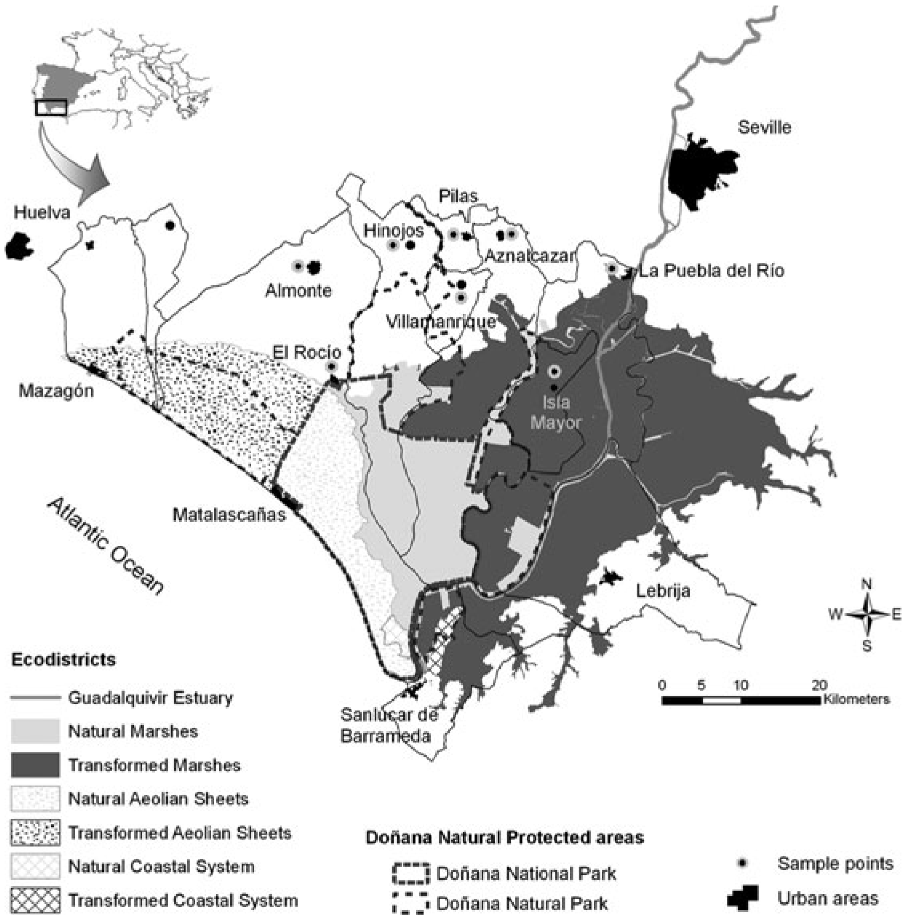

Figure 1. The Doñana area. The map shows the four main ecosystems of Doñana at ecodistrict scale and their degree of current transformation, the main protected areas, and sample points where the data were gathered.

(Fernández-Delgado 2005). Of the approximately 2200 km^2 of Doñana, about 50% are protected by a national park (declared in 1969) and a natural park (declared in 1980). These parks were unified in 2005 as the Doñana Natural Area. Parts of Doñana were designated a UNESCO biosphere reserve in 1980, a Ramsar site in 1982, a special protection area for birds in 1988, and a natural World Heritage site in 1995.

Traditional Knowledge and Human-Nature Coevolution

As with most Mediterranean landscapes (Grove & Rackham 2001), Doñana reflects a secular process of human landscape transformation and resource use (Ojeda 1992). Doñana has been pointed out as the possible location of the ancient Tartessos (Schulten 2006); evidence of cattle farming in the Guadalquivir Estuary can be traced for at least two thousand years (Butzer 1988), and there is evidence of controlled use of fire in Doñana since the 13th century (Clemente & Siljeström 1987). Thus, although human pressure was low until the second half of the 20th century, the ecosystems of Doñana have been largely shaped by centuries of natural resource use and large-scale management, representing cultural landscapes rather than pristine nature. Agriculture has historically been the subsistence base of the region, with an emphasis on cereals, grapevines, and orchards. The sandy soils extending along the coast have been used by local inhabitants for grazing, pond fishing, and agroforestry, and by the aristocracy as a hunting reserve (Ojeda 1992). The marshlands were inhabited by scattered settlements of shepherds and gamekeepers and were mainly used for livestock farming (González-Arteaga 1993). Resource management activities were mainly carried out by local inhabitants relying on traditional knowledge systems until economic development policies were launched in Doñana in the 20th century.

Decline of Traditional Resource Management

Until about 1950 the economy of Doñana was largely dependent on local ecosystem services. Natural disturbances such as droughts, pests, and plagues were the primary challenge for resource-flow continuity in Doñana and sometimes led to economic crises and famines (Flores-Cala 2005). Given the lack of technology and isolation of the region, TEK may have played a critical role in coping with disturbances in management of natural resources.

Wetland conversion to monocultures started in the late 1920s with reclamation of marshlands for rice crops (González-Arteaga 1993) and continued into the 1930s with cultivation of 12,000 ha of *Eucalyptus* spp. and 14,000 ha of *Pinus pinea* in the sandy soils (Sousa & García-Murillo 2003). In the 1960s and 1970s, traditional practices for ecosystem management declined abruptly due to economic development and conservation policies prohibiting resource use. Development policies in Doñana were launched in the general context of fast economic growth that was related to the transition of Spain toward a market economy. This period entailed an acceleration of land-use change and intensification of resource use. The marshlands outside the national park were converted to intensive agriculture (e.g., Ojeda 1987; González-Arteaga 1993; Sousa & García-Murillo 2003). Abandonment of traditional farming and growing land demand for intensive farming led to increased landscape fragmentation, loss of connectivity, and changes in stream networks (García-Novo et al. 2007). Because of the unique biodiversity of the area, in parallel with development policies, a strict conservation policy was implemented for the remaining unconverted ecosystems. The national park was fenced, free access was forbidden, and use was restricted to tourism, research, and a few nonintensive uses, such as cattle range breeding. The rapidity of the transformation process and its delay relative to most of the rest of western European rural areas make Doñana an ideal area to study changes in traditional knowledge with the modernization of society.

Methods

Background Information

This research was part of the 2005 Doñana Ecological Restoration Project launched by the Spanish Ministry of the Environment. Data were collected in villages surrounding the Doñana National Park and Natural Park (Fig. 1) through semistructured interviews and focus groups and a survey.

Between September 2007 and March 2008, we gathered background information through semistructured interviews and focus groups with key informants. We drew on the experience of researchers working on the Doñana Ecological Restoration Project and then used snowball sampling to select key informants (Bernard 2005), defined here as local inhabitants with long-term experience in resource use in the area. Key informants included six men with life-long experience with agriculture in the area and five men with life-long experience with livestock farming. All key informants were over 65 years of age and native to the study site. We collected information on practices to cope with natural disturbances and climate variability in traditional agriculture and livestock farming in the two main economic activities that entail natural resource management in the area.

Survey

We constructed a survey to collect information on sociodemographic characteristics of informants and their level of TEK. To ensure variability, we pretested the survey with 13 informants. Data were collected from 198 adult men, between 19 and 90 years of age, in eight villages from seven municipalities of the Doñana region (Fig. 1). We focused on men because local gender division of labor traditionally assigns agriculture and livestock farming to men. We obtained a list of meeting places for farmers and shepherds from staff of the local agency, Fundación Doñana 21, and conducted face-to-face surveys in each of the listed places with any local man with direct experience in agriculture or livestock farming willing to participate.

We followed Kristensen and Lykke (2003) and Reyes-García et al. (2007*a*) and proxied individual TEK with the informant's score in a set of questions on TEK. To select the questions, we drew on information from key informants and focus groups. We included 11 questions, three on practices, five on knowledge, and three on local vocabulary and proverbs. Five questions related to agriculture, and six related to livestock farming. For example, to proxy informant's knowledge on management practices we asked, "We have been told by elders in this region that in the old times farmers used to bury chickpea and broad bean plants. Do you know why people would do that?" To proxy informant's knowledge in local vocabulary and proverbs we gave informants the first words of a local proverb and asked them to complete it.

Because we wanted to analyze intergenerational changes in knowledge, we used the information obtained in semistructured interviews with key informants as the reference point. With this approach, we assumed that the consensual knowledge of elders proxies for adaptive management. We then coded individual responses as correct (2) if they completely matched the consensual response from key informants, partially correct (1) if they partially matched key informants' responses, and incorrect (0) if they did not match the information provided by key informants.

We used Chronbach's alpha test to analyze the intercorrelation between answers to TEK questions. Questions on agriculture ($\alpha = 0.7227$) and livestock farming ($\alpha = 0.7295$) were highly correlated, indicating that each set of questions reflected an underlying factor. Thus, we added five questions on agriculture and a question on local weather to generate a score of traditional agricultural knowledge (from 0 to 12) and five questions on livestock farming and the question on local weather to generate a score of traditional livestock farming knowledge (range: 0–12). Our overall TEK score was the sum of all the questions.

We used the year of the survey (2008) and the participant's reported year of birth to create three dummy variables for age classes: young (born between 1960 and 1990), middle (born between 1940 and 1959), and old (born 1939 or before). The variables for age classes took the value of 1 if the person was born in the indicated class and 0 otherwise.

We ran three Poisson multiple regression models in which we used the participant's scores for agricultural, livestock farming, and overall TEK as outcome variables, and age and age-class dummy variables as explanatory variables. By including age and age-class variables in the same regression, we separated changes in knowledge related to age from intergenerational changes unrelated to the acquisition of knowledge that comes with age (Godoy et al. 2009). Controls included level of education, main economic activity, involvement in economic activities other than the main one, and village of residency. We clustered respondents by main activity to control for fixed-effects related to intragroup correlation.

Results

Descriptive Statistics

Both agricultural and livestock farming traditional knowledge showed an intergenerational decline (Table 1). For example, the mean traditional agricultural knowledge score decreased by 15.9% between the old (mean [SD] = 7.63 [2.97]) and the middle (mean = 5.72 [2.72]) age classes and by 25.1% between the middle and the young (mean = 2.70 [2.32]) age classes. In other words, there was a decline of about 40% in scores of traditional agricultural knowledge between the old and young age classes. In a similar, but less pronounced trend, knowledge of traditional livestock farming declined by 16.5% between the old and middle age classes and by 5.65% between the middle and young age classes. Mean scores in our overall measure of traditional knowledge declined by about 32% between the old and young age classes.

On average, informants in our sample were 55 years old, had low levels of education (46% of the sample had not completed the primary school), and most were agriculturists (Table 2).

Multivariate Regression Analysis

There were significant intergenerational losses of TEK (Table 3). For the three scores analyzed (traditional agricultural knowledge, traditional livestock farming knowledge, and traditional ecological knowledge), participants in the old age class had significantly higher knowledge than those in the middle age class, and participants in the young age class had significantly lower scores than those in the middle age class. On a 12-point scale, on average, participants born before 1939 scored 0.27 points higher ($p < 0.001$) in traditional agricultural knowledge, 0.20 points higher ($p < 0.003$) in traditional livestock farming knowledge, and 0.23 points higher ($p < 0.001$) in TEK than their peers born between 1940 and 1959. For the same three scores, participants born in 1960 and after scored 0.67 ($p < 0.001$), 0.15 ($p = 0.10$), and 0.39 ($p < 0.001$) points lower than those born between 1940 and 1959.

Once we controlled for age and age-class effects, the associations between age class and TEK lost statistical significance, except in two cases. First, after controlling for age effects, the traditional agricultural knowledge of the young age class was 0.24 points lower ($p = 0.06$) than that of the middle age class. Second, traditional livestock farming knowledge of the young age class was 0.15 points higher ($p = 0.02$) than that of the middle age class. In the three regressions, the coefficient for the age variable was small (0.014–0.018), but statistically significant ($p < 0.05$), which implies that each additional year of age increased traditional knowledge by only about 0.015 points.

Discussion

Data Interpretation

Our results suggest that changes in traditional knowledge are uneven relative to the resource-management activities we analyzed (agriculture and livestock farming).

We found a significant and nonlinear decline of traditional agricultural knowledge. The decline was larger from the middle to the young age class than from the old to the middle age class. These results suggest a

Table 1. Traditional ecological knowledge (score range in parentheses) of adult men ($n = 198$) in villages surrounding the Doñana National Park, Spain, by generation of birth.

		Traditional agricultural knowledge (0–12)		*Traditional livestock farming knowledge (0–12)*		*Traditional ecological knowledge (0–24)*	
Generation	n	*mean*	*SD*	*mean*	*SD*	*mean*	*SD*
Old	47	7.63	2.97	6.61	3.67	14.25	5.67
Middle	77	5.70	2.72	4.63	3.18	10.33	4.59
Young	74	2.70	2.32	3.95	3.10	6.66	4.14

Table 2. Descriptive statistics of variables used in regression analysis ($n = 198$) of traditional ecological knowledge of adult men in villages surrounding the Doñana National Park, Spain.

Variable	*Definition*	*Mean*	*SD*
Outcome			
traditional agricultural knowledge	sum of individual scores in 6 questions on traditional agricultural knowledge (0–12)	5.04	3.28
traditional livestock farming knowledge	sum of individual scores in 6 questions on traditional livestock farming knowledge (0–12)	4.85	3.41
traditional knowledge	sum of traditional agricultural knowledge and traditional livestock farming knowledge (0–24)	9.89	5.52
Explanatory variables			
age	age (years)	54.83	17.39
age classes	year of birth ≤ 1939 (old) (%)	23.62	
	year of birth 1940–1959 (middle) (%)	39.20	
	year of birth 1960–1990 (young) (%)	37.19	
Control variables			
education	maximum level of formal education completed		
	no school or incomplete primary school	46.73	
	completed primary school	27.14	
	completed secondary school	4.52	
	completed education beyond secondary school	21.61	
main economic activity	self-reported main economic activity of the participant through his life history		
	agriculture	48.74	
	livestock farming	5.03	
	other	46.23	
diversity of activities	self-reported number of economic activities (agriculture, livestock farming, other) performed by the participant during his life		
	one activity	29.15	
	two activities	38.19	
	three activities	32.66	

Table 3. Intergenerational changes in traditional knowledge among adults ($n = 198$) living in villages surrounding the Doñana National Park, Spain (multiple regression).[a]

Explanatory variable	*Dependent variable*					
	traditional agricultural knowledge		*traditional livestock farming knowledge*		*traditional ecological knowledge*	
Age class[b]						
pd	0.270*** (0.027)	−0.007 (0.058)	0.200*** (0.06)	−0.019 (0.152)	0.233*** (0.043)	−0.016 (0.043)
young	−0.671*** (0.103)	−0.0249* (0.132)	−0.152* (0.094)	0.156** (0.066)	−0.397*** (0.074)	−0.031 (0.042)
age	^	0.018*** (0.005)	^	0.014** (0.006)	^	0.016*** (0.001)
Control variable						
education	0.013 (0.022)	0.033* (0.017)	−0.117* (0.067)	−0.096 (0.066)	−0.051* (0.029)	−0.031 (0.028)
diversity of activities	0.152** (0.074)	0.159** (0.077)	0.143*** (0.013)	0.147*** (0.010)	0.148*** (0.039)	0.154*** (0.037)
Main economic activity[c]						
agriculture	0.316*** (0.016)	0.295*** (0.015)	0.027 (0.058)	0.012 (0.060)	0.171*** (0.042)	0.152*** (0.039)
livestock farming	0.062 (0.086)	0.110* (0.063)	0.242* (0.127)	0.279** (0.140)	0.192* (0.109)	0.234** (0.104)

[a] *Significance: ***, ≤1%; **, ≤5%; * ≤10%. Poisson regressions with robust standard errors used when probability of exceeding χ^2 value in Breusch-Pagan test was ≤10%. Numbers in parenthesis are robust strandard errors (^, variable intentionally left out). Regressions include a set of village dummies and a constant (not shown).*
[b] *The category of reference is "middle" (see Table 2).*
[c] *The category of reference is "other activities" (see Table 2).*

knowledge loss related to the transformation of agricultural systems in Doñana. If one accepts that professionalization does not typically take place before a person reaches 15–20 years of age, the young generation of agriculturalists, who reflect the largest traditional agricultural knowledge loss, started on their professions in the mid-1970s. This was the period during which agriculture in Doñana underwent rapid changes related to market integration. Land-use change resulted mainly from agricultural expansion to natural or seminatural ecosystems. Of the approximately 1000 km^2 of natural marshes existing in 1956, about 700 km^2 had been drained by 1988. Of these, 300 km^2 were converted to highly mechanized rice fields (González-Arteaga 1993; Corominas 1995). Since the mid-1980s, 51 km^2 of strawberry crops have been established around the northwestern limit of Doñana. The Plan Almonte-Marismas led to the establishment between 1971 and 1990 of 98 km^2 of irrigated crops; these crops required management techniques unfamiliar to the local farmers (Corominas 1995). Intensification resulted from the increasing amount of pesticide, fertilizer, fuel, and machinery inputs that in many cases acted as substitutes for traditional management practices. For instance, the use of pesticides and fertilizers discouraged traditional practices to prevent pest outbreaks and oxygenate the soil, and the possibility of pumping underground water discouraged the selection of drought-adapted species and diversification of crops to buffer droughts. Market integration took place as agriculture lost its subsistence character and transformed to cash crops for national and international markets.

We advance two nonexclusive potential explanations for the persistence of traditional livestock farming knowledge. First, the modernization processes that have affected Doñana since the 1960s had a relatively small effect on traditional livestock farming compared with agriculture. Free-range livestock breeding in the marshes, one of the few uses allowed in the national park, continues to be largely carried out in an extensive regime with autochthonous cattle varieties. Second, livestock farming retains strong links with local culture, identity, and institutions. Cattle farming has lost economic importance in the area, but is maintained as a tradition and a complementary source of income. Previous anthropological work suggests that horse farming is rooted in a strong cultural tradition and constitutes a central symbol of the local identity (Murphy 1987; González-Faraco 1991; Murphy & González-Faraco 2006). Free-range horse breeding, however, remains largely at the margin of markets, and horse sales are usually limited to a week-long cattle fair that takes place every year following the so-called mare draw, *Saca de yeguas*, probably the most significant nonreligious cultural event in Doñana. For example, González-Faraco (1991) referred to the "surprising phenomenon" that free-range horse breeding in the marshes was increasingly popular at a time when such activity represented a residual economic factor alien to the rapid transition of Doñana to modernity, and stresses the cultural meaning of this activity as a symbol of local identity. Because traditional livestock breeding helps define local identity and is deeply embedded in cultural and religious practices that are widely celebrated (e.g., Saca de yeguas and the Pilgrimage of el Rocío), traditional livestock farming knowledge persists in Doñana even when its economic role has become residual.

Decline of Traditional Knowledge in the Developed World

Traditional knowledge and practices seem to be declining in many parts of the world due to complex factors (Turner & Turner 2008). Reasons behind this loss include the compounding influences of acculturation and loss of local languages (Gross et al. 1979; Benz et al. 2000), changes in land use (Kingsbury 2001; Gray et al. 2008), transition to market economies (Godoy et al. 2005), loss of access to traditional resources due to conservation programs, and more generally, industrialization and globalization forces (Turner & Turner 2008). Whereas most research on TEK loss centers on indigenous communities, most reasons for this loss also affect many rural areas in developed countries. Lack of attention to TEK in developed countries may rest on the untested assumptions that traditional knowledge is residual and no longer relevant as societies modernize. Nevertheless, the scant research on the topic suggests that significant bodies of TEK still persist in both rural (Olsson & Folke 2001; Pieroni et al. 2004) and urban (Andersson et al. 2007; Pieroni et al. 2007) communities in developed countries.

Moreover, because the primary holders of TEK in developed countries are elders and intergenerational transmission is limited, the remaining TEK is likely to continue to decline in coming years. The loss of this empirical knowledge slowly accumulated throughout centuries can be irreversible in the short and medium terms. Even if the economic role of traditional knowledge is constrained in the context of highly mechanized productive systems operating in developed countries, protection of remaining TEK can be an investment in human capital assets for sustainability. As the ecological crisis intensifies, traditional knowledge that is undervalued today can gain relevance as an asset on which to draw for future transformations. Research and programs for the conservation of TEK should expand from its almost exclusive focus on indigenous communities to incorporate rural societies in developed countries, where much of the remaining traditional knowledge, often held by elders, is likely to decline abruptly in the near future.

Perspectives for Traditional Knowledge in Contemporary Society

The recognition of market integration as a driver of traditional knowledge loss is well established in the literature

(Godoy et al. 2005; Lu 2007). Nevertheless, results of recent research suggest that TEK does not vanish inexorably as economic development unfolds (Reyes-García et al. 2007*c*). For instance, Godoy et al. (1998) found that market integration through the sale of crops and wage labor is associated with declining traditional knowledge, whereas market integration through the sale of forest products is associated with increased TEK. In developed countries, emerging agroecological movements and increased demand for organic food appear as potential niches for traditional production systems. Nevertheless, the shrinking economic role of the agricultural sector in developed countries and the intensification of resource use leave little space in the near term for economic activities that maintain living TEK systems. Except in the rare cases where TEK is intertwined with solid cultural systems and institutions (e.g., livestock farming in Doñana), the remaining TEK for resource use in market economies is likely to keep declining if ways are not found to adapt to the emerging economic and sociopolitical junctures.

Efforts to renew and restore traditional knowledge systems must recognize the cumulative effects of the driving factors reviewed above. Nevertheless, to think that such factors are likely to be reversed in the short term would be naive. We argue that in the short term, environmental policy is probably one of the few ways to protect remaining TEK pools in the developed world. The declining economic role of TEK can be partially counterbalanced by confirming its role as a tool for biodiversity conservation and sustainable resource use. An important step could be the reallocation of conservation funds currently used for enforcement and payments to resource users for "not producing" to payments for traditional production. Agroenvironmental measures in European agricultural policy provide an example of a possible mechanism for the articulation of such allocations.

Trends in global environmental policy point toward an increasing recognition of TEK as reflected in the 1992 Rio de Janeiro Conference (CBD Article 8j) and the 1999 Budapest Conference of UNESCO. Similarly, the relevance assigned to traditional knowledge by the Millennium Ecosystem Assessment (Reid et al. 2006) and the mainstreaming trends of resilience theory in the sustainability sciences open up new opportunities for the acknowledgment of TEK as a valuable policy input. Nevertheless, as the recognition of TEK slowly builds, significant bodies of the remaining TEK in developed countries are likely to keep declining because their economic role in market economies will vanish. Because they are partially buffered from market and development pressures, protected areas in cultural landscapes can be a powerful tool for the protection of TEK in the short term. Conservation policies to protect and restore TEK should adopt human-in-nature perspective (e.g., Man and Biosphere) that use nature-protection categories that allow traditional resource use and that empower local resource users as active stakeholders in ecosystem management. In regions dominated by cultural landscapes, the exclusion of humans and traditional resource use in natural protected areas disrupts long processes of storing and transmission of TEK systems that have great value for sustainable ecosystem management and biodiversity conservation.

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