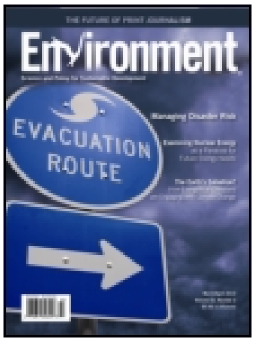


Routledge
Taylor & Francis Group

Environment: Science and Policy for Sustainable Development

ISSN: 0013-9157 (Print) 1939-9154 (Online) Journal homepage: http://www.tandfonline.com/loi/venv20

Sheepfarming after Chernobyl: A Case Study in Communicating Scientific Information

Brian Wynne

To cite this article: Brian Wynne (1989) Sheepfarming after Chernobyl: A Case Study in Communicating Scientific Information, Environment: Science and Policy for Sustainable Development, 31:2, 10-39, DOI: 10.1080/00139157.1989.9928930

To link to this article: http://dx.doi.org/10.1080/00139157.1989.9928930

Published online: 08 Jul 2010.

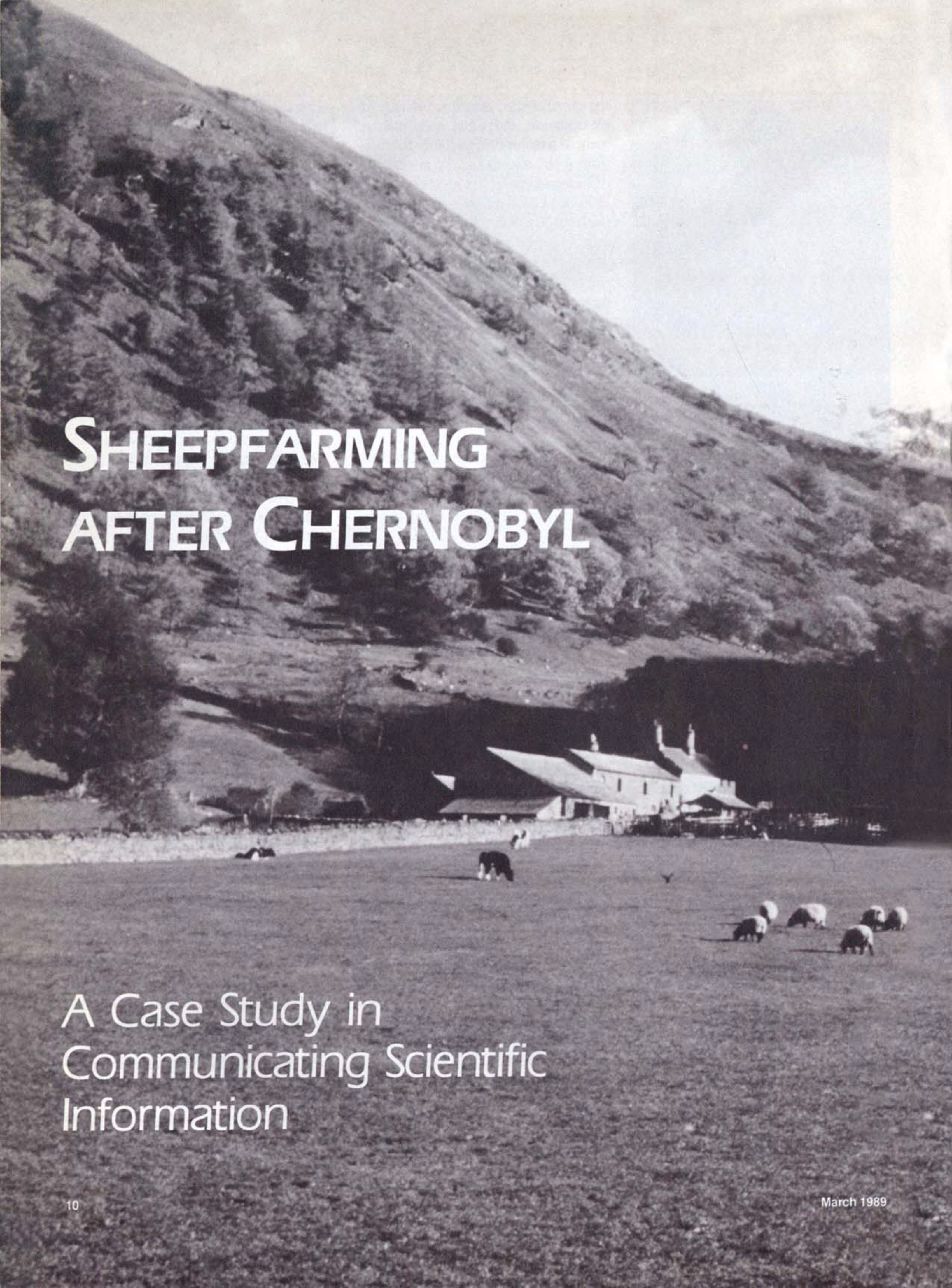

SHEEPFARMING
AFTER CHERNOBYL
A Case Study in
Communicating Scientific
Information

PHOTO BY PETER WILLIAMS

By Brian Wynne

The Chernobyl nuclear accident and the resulting international radioactive fallout provoked unprecedented confusion, demands for information, and economic and social dislocations that extended far beyond the Ukraine. The radioactive cloud also exposed stark discrepancies among national approaches to radioactive contamination and public health.[1]

Problems of communication and credibility have pervaded the disjointed actions surrounding the Chernobyl accident. The accident dramatically underlined a problem already gaining more general recognition:[2] the difficulty of communicating technical knowledge about risks or lack of risks. Scientists and government officials find themselves rationalizing real and considerable effects, the products of diverse interventions that are often based solely on abstract scientific justifications.[3]

The perceived credibility of scientists and governments greatly influences the effectiveness of communicating complex hazard information to lay people. This article identifies some factors affecting credibility by describing a case study of one group—the hill sheep farmers of Cumbria in the Lake District of northern England, 150 of whom are still restricted from selling their sheep freely.

In addition to receiving some of the highest levels of Chernobyl fallout in Western Europe, the English Lake District is a good study choice because its restricted sheep farming area is very close to the huge Sellafield nuclear fuels reprocessing complex. Sellafield's management and radioactive discharges have been widely criticized since the early 1970s. Many of the farmers have relatives and neighbors who work at Sellafield, and most can remember the 1957 fire in one of its nuclear reactors—the largest reactor accident in the world before Chernobyl.

The bleak mountains and narrow, deep-cut valleys of the English Lake District are economically marginal for cultivation but can support sheep farming in its difficult climate and terrain. Contrary to initial scientific belief, the radioactive cesium from Chernobyl was not immobilized in the soil. Instead, it re-

---

BRIAN WYNNE is Reader in Science Studies and Director of the Centre for Science Studies and Science Policy at the University of Lancaster. His book, *Risk Management and Hazardous Wastes: Implementation and the Dialectics of Credibility*, was published in 1987.

After the Chernobyl fallout reached England, Cumbrian farmers gathered sheep and lambs into the valleys for radiocesium testing. (Photo: Peter Williams)

mained active far longer than expected, resulting in persistently high levels of cesium in sheep and annual resurgency effects.[4] Following reassurances from experts—first, that there would be no problem, then that unexpected restrictions would last only a few weeks—these experts now decline to predict how long the restrictions might continue.[5] (For additional information about European governments' reactions to the Chernobyl accident and European levels of contamination, see "Chernobyl: An Early Report," by C. Hohenemser, M. Deicher, A. Ernst, H. Hofsäss, G. Lindner, and E. Recknagel in *Environment*, June 1986; and "Shifting Public Perceptions of Nuclear Risk: Chernobyl's Other Legacy," by Christoph Hohenemser and Ortwin Renn, *Environment*, April 1988.)

Responses of the Lake District sheep farmers to Chernobyl radiation were critically affected by scientific advice:

- political decisions to ban sheep sales after high levels of cesium 137 and 134 had been found in sheep from this area;
- forecasts about the likely length and scope of the ban, which critically affected farmers' decisions;
- official assurances about the origins of the contamination, given local suspicions that Sellafield might be implicated;
- numerous revisions in the restrictions in light of changes in scientific and other knowledge;
- rules for compensation, designed to alleviate financial losses resulting from the restrictions, but which only some farmers received.

Perhaps unsurprisingly, the issue of compensation was the focus of the most explicit conflict between farmers and officials: 65 unresolved claims from Cumbria are still being fought. However, the experts' lack of credibility with the farmers on the other points undoubtedly fueled the fires of complaint and incredulity over compensation.

Abstract scientific knowledge may seem universal, but in the real world, it is always integrated with supplementary assumptions that render it culture-bound and parochial. The validity of this supplementary knowledge crucially affects the overall credibility of "science" or "experts." Furthermore, the mode of communication itself conveys a set of tacit cultural and social assumptions or prescriptions. Efforts to communicate that ignore this fuller social dimension are likely to be ineffectual or even counterproductive.

These general conclusions drawn from the lapses in scientific information and communication in Cumbria are supported by descriptions of specific British responses to the Chernobyl fallout, the particular impacts on the Cumbrian sheep farmers, their interactions with various scientists and officials, and their own accounts of the experience.

Chernobyl Fallout

The main cloud of radioactive contamination from Chernobyl passed over the United Kingdom on 2 and 3 May 1986. Virtually no precipitation disturbed the cloud on its circuitous, 6-day, 4,000 kilometer journey until heavy thunderstorms on 2 May rained radioactive particles across the United Kingdom. The Cumbrian fells suffered unusually high levels of rainfall—as much as 20 millimeters in 24 hours;[6] the North Wales fells (where sheep restrictions were also introduced and remain) experienced heavy rain as well, although less than in Cumbria.

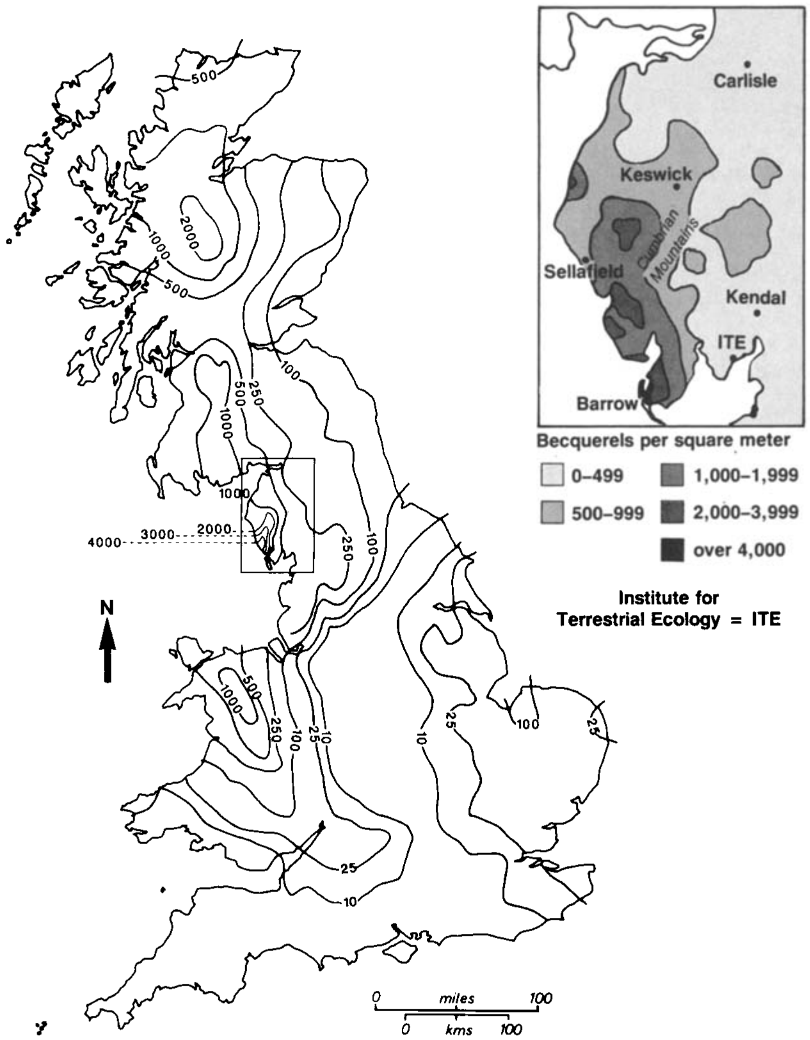
Rainfall was the major factor affecting local deposition of radioactivity, especially radioactive cesium. One millimeter of rain can deposit as much radioactive cesium as 24 hours' dry deposition so that 20 millimeters of rain in one day deposits the equivalent of roughly 20 days' deposition in drier areas. Furthermore, because rainwater encounters uneven terrain, rivulets and puddles can create large differences in radioactivity even over distances as short as one meter. Thus, actual levels of contamination varied markedly over small distances, and the variability of radioactive deposition did not necessarily correspond with the differences in amounts of rainfall. This variability was not fully appreciated at the time.

In the United Kingdom, 27 existing radiation-in-air monitoring stations provided immediate emergency-management data.[7] Within a few weeks, a series of about 300 direct measurements of radiocesium (radioactive cesium) deposited on vegetation allowed scientists at the Institute for Terrestrial Ecology (ITE) on the southern edge of Cumbria to estimate contamination contours in England, Scotland, and Wales.[8] The fallout map (see Figure 1 on this page) indicates that the Cumbrian hills, especially the southwestern part near Sellafield, received the highest radiocesium fallout in the United Kingdom, over 4,000 becquerels per square meter. (A becquerel is a unit of radioactive decay equal to one disintegration per second.) The inset to Figure 1 maps the fallout in Cumbria itself. Another map of radiocesium deposition calculated months later from rainfall data, rather than deposits in vegetation, produced a different picture, with southwestern Scotland receiving over 20,000 becquerels per square meter of cesium and the Cumbrian and North Wales fells about 10,000 becquerels per square meter. An unrecognized "hot spot" in the Yorkshire pennines was also identified retrospectively by this method.[9]

These maps, however, were produced after the first few weeks of confusion and anxiety. In the beginning, the government issued only bland assurances. A farming journalist described the experience:

The whole two-year event was characterised by great reluctance on the part of MAFF [Ministry of Agriculture, Fisheries and Food]—and indeed other government departments—to inform. . . . We had to wait for four weeks for the first press release and seven weeks for the first briefing. It was incredible—the silence was deafening.[10]

FIGURE 1. Contour map of Great Britain shows cesium 137 deposition on vegetation from the Chernobyl accident in becquerels per square meter. Inset map shows cesium 137 vegetation deposition in northwest England, May 1986.



SOURCE: Institute for Terrestrial Ecology, Grange-over-Sands, Cumbria, United Kingdom.

Punctuating the silence, however, were repeated government dismissals of the whole event. On 6 May, Secretary of State for the Environment Kenneth Baker asssured Parliament that "the effects of the cloud have already been assessed and none represents a risk to health in the United Kingdom." Levels of radioactivity were "nowhere near the levels at which there is any hazard to health." He stressed that the cloud was moving away with levels falling rapidly and that there would thus be a steady decline of already insignificant, if raised, levels of radioactive contamination.[11]

John Dunster, head of the official government advisory National Radiological Protection Board (NRPB), was more circumspect, forecasting on 11 May that the Chernobyl disaster might lead to "a few tens" of extra cancers over the next 50 years in the United Kingdom. However, he also avowed that "if the cloud does not come back the whole thing will be over in a week or ten days."[12] Baker announced on 13 May that "the incident may be regarded as over for this country by the end of the week, although its traces will remain."[13]

The very same day, however, the Ministry of Agriculture, Fisheries and Food (MAFF) found samples of lamb meat taken from the Cumbrian fells recording levels of more than 1,500 becquerels per kilogram of cesium 137. This was 50 percent greater than the United Kingdom and European Economic Community (EEC) "action level" (level of radi-

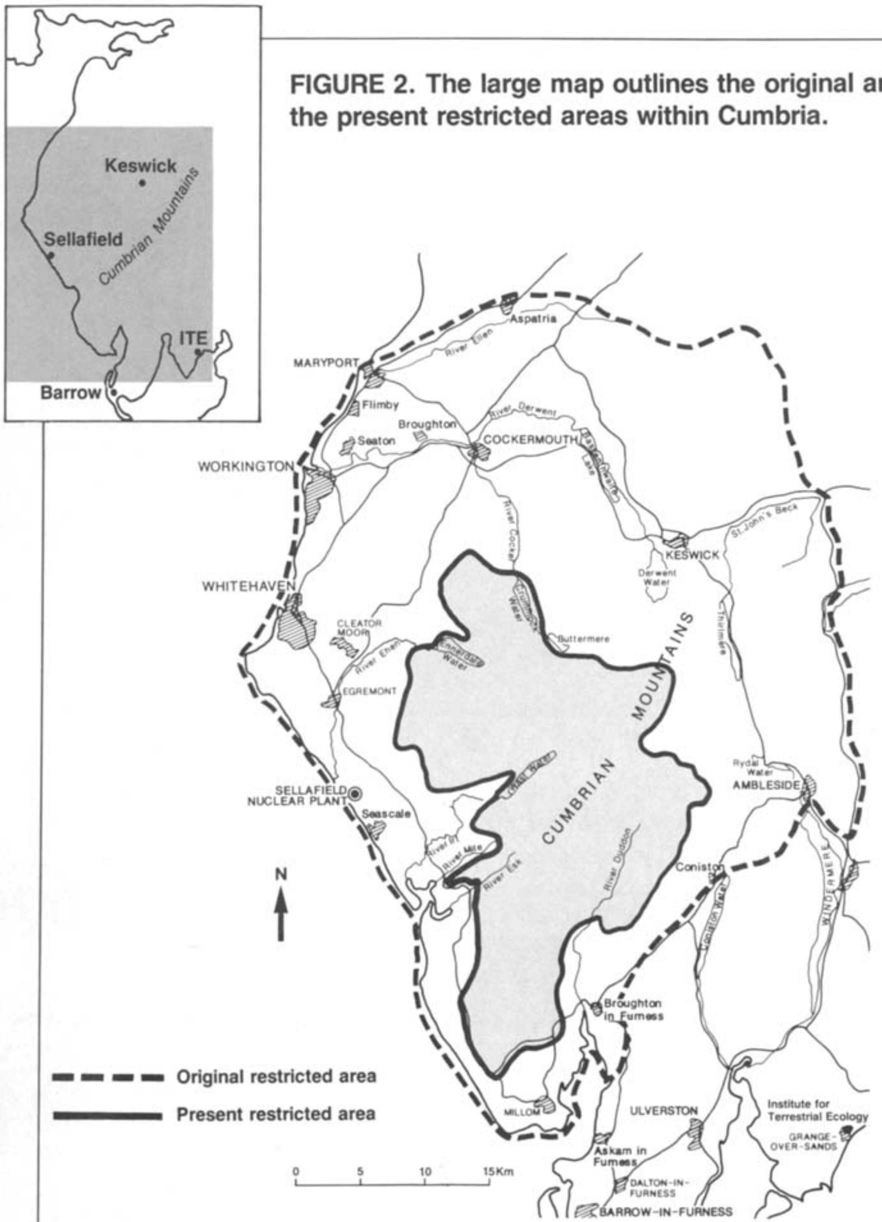


FIGURE 2. The large map outlines the original and the present restricted areas within Cumbria.

SOURCE: U.K. Ministry of Agriculture, Fisheries and Food, Divisional Office, Eden Bridge House, Lowther Street, Carlisle, Cumbria, United Kingdom.

oactivity requiring official intervention) of 1,000 becquerels per kilogram. Nevertheless, official pronouncements continued to claim that contamination was decaying from already insignificant levels. The Department of the Environment (DoE), which had taken over the government coordination of information, even discontinued its daily bulletins on radioactivity levels on 16 May, reasoning that levels were now insignificant.

On 30 May, MAFF announced their findings of "higher readings" of radiocesium in hill sheep and lambs but asserted that "these levels do not warrant any specific action at present,"[14] on the assumption that hill lambs were not yet ready to be sold and their high levels would soon decrease.

On 20 June, however, in complete contradiction of previous advice to the public, Secretary of State for Agriculture Michael Jopling announced an immediate ban on the movement and slaughter of sheep in designated parts of Cumbria and North Wales. Even this utterly unexpected intervention was laced with reassurances that the ban would affect virtually no one in practice, because radiation would fall to acceptable levels before lambs were ready for market. The ban was imposed for only three weeks, based on this assumption of declining radiation:

Monitoring results present a satisfactory picture overall and there is no reason for anyone to be concerned about the safety of food in the shops. However the monitoring of young unfinished lambs not yet ready for market in certain areas of Cumbria and North Wales indicates higher levels of radiocaesium than in the rest of the country. . . . these levels will diminish before the animals are marketed . . .[15]

However, levels of radiation in sheep increased rather than decreased. On 24 July, the ban in Cumbria was extended indefinitely. (See the box on page 15 for a timetable of key official responses to the radiation contamination.)

The areas restricted on 20 June contained over 4 million sheep and nearly 7,000 farms. Four days later, parts of Scotland were added to the restricted region. The Cumbrian restricted region was whittled down from 1,670 farms to 150 farms by the end of September 1986 (see Figure 2 on this page). This area remains restricted. In June 1987, some farms in North Wales and Scotland that had been freed of restriction were rerestricted, and some farms in Scotland and Northern Ireland were restricted for the first time. At the height of the bans, about one-fifth of the sheep population in the United Kingdom, or 4 million sheep, were restricted from sale or slaughter. Nationally, about 800 farms and over 1 million sheep were still restricted as of March 1988.[16]

The Bureaucratic Labyrinth

Throughout the aftermath of the Chernobyl accident, farmers felt betrayed by bureaucrats and scientists. Four interrelated aspects of this betrayal stand out:

- scientists ignored local variations in radioactive fallout effects and in farming procedures that were central to farmers' experiences;
- experts were evidently ignorant of local farming realities and neglected local knowledge;

- bureaucrats critically interfered with the usual informal and flexible decision-making style of hill farmers, imposing an unrealistic degree of formalization and requiring inflexible prior commitments to marketing a set number of lambs at preselected markets; and

- government officials expressed a level of certainty in official statements that simply did not ring true with the farmers, who were used to adapting to uncertain and unpredictable forces rather than trying to control them.

The expected rate of decay of radioactive contamination in sheep was a critical factor in the whole episode. Official statements from several organizations during the seven weeks between the accident and the initial restriction order on 20 June conveyed the expert view that radioactivity levels in all media would continue to decrease steadily. The 20 June MAFF statement explained that new, clean grass replacing contaminated grass would stop lambs from ingesting radioactive cesium so that, with a biological half-life of cesium in lambs of about 25 days, 21 days would see levels in meat roughly halved.[17]

However, monitoring showed no decrease in levels of cesium, and some lambs began testing at even higher levels than they had before. The 21-day ban was therefore extended indefinitely. Farmers became desperate because their limited pastures could not sustain the contaminated lambs. Sale of spring lambs provides hill sheep farmers with their only significant yearly income. The sheep are allowed to produce more lambs than the poor pastureland can support for very long, so the lambs must be sold before they start to overgraze. Because spring lambs are taken to market starting in August, the restrictions prevented hundreds of thousands of radioactively contaminated lambs from leaving the hills at a time when the grazing had become utterly inadequate. Hillfarmers feared there might be slaughter of all contaminated sheep, not just the unsaleable lambs, which would have meant total disaster for the long-term breeding cycle in which lambs are tied through their mothers to specific areas of the immense, unfenced fells.

TIMETABLE OF OFFICIAL REACTIONS TO RADIATION CONTAMINATION IN CUMBRIA

DATE	EVENT
1951	Windscale (later Sellafield) reprocessing plant and nuclear reactors begin operation.
1957	Windscale reactor fire emits radioactivity, resulting in a 200 square mile milk ban.
1983	Raised incidence of childhood leukemias is reported near Sellafield.
1984	Sellafield operators are prosecuted for illegally exceeding authorized levels of discharge and polluting a local beach.
26 April 1986	Chernobyl accident.
2, 3 May 1986	Radioactive cloud crosses the United Kingdom. Heavy rain falls over Cumbria and North Wales.
6 May 1986	Secretary of State for the Environment Kenneth Baker states there is no risk to health.
11 May 1986	National Radiological Protection Board (NRPB) head John Dunster claims the effects of Chernobyl will be over in a week or two.
13 May 1986	Cumbrian lamb samples tested for cesium show levels in excess of 1,500 becquerels per kilogram of tissue.
30 May 1986	Ministry of Agriculture, Fisheries and Food (MAFF) notes "higher readings" of cesium but assures that no action is warranted.
20 June 1986	Three-week ban on movement and slaughter of sheep in Cumbria and North Wales is established.
24 July 1986	Three-week ban is extended indefinitely. Compensation is announced for over-fat sheep (i.e., lambs kept too long from being sold).
13 August 1986	Marked sheep could be sold and moved but not slaughtered. Compensation is announced for marked sheep.
September 1986	MAFF announces 28 September deadline for compensation for marked sheep.
30 September 1986	The restricted region is whittled down (see Figure 2 on page 14).
28 April 1987	British government announces that the restrictions may continue through a second lambing and marketing season.
June 1987	Previously unrecognized radiation hotspot is discovered in Yorkshire. Opposition Labour spokesman David Clark alleges contamination of food chain by lambs prior to 20 June 1986 ban.
January 1988	Government papers reveal extent of cover-up of 1957 Windscale fire. House of Commons announces inquiry into government response to Chernobyl emergency.
July 1988	House of Commons Select Committee Reports' main criticism is of government communications.
Fall 1988	Scottish Universities' Reactor Research Centre's aerial grid survey by helicopter for radiocesium shows some areas of Scotland with up to 40 times the official MAFF figures. Levels around Sellafield register at about 300,000 becquerels per square meter, roughly 10 times the highest recorded level of Chernobyl deposits.

Although the initial scientific wisdom was clearly incorrect, MAFF, expecting all restrictions to be lifted, still advised farmers to hold their sheep a little longer rather than sell them short as contaminated.[18] Despite contradictory evidence, the scientists still believed firmly that radioactive contamination in hill sheep would soon decline, and their advice to farmers was founded on this belief. The policy of short-lived restrictions was based on the assumption that, after the initially contaminated grass was consumed, radiocesium would be immobil-

(continued on page 33)

Sheepfarming after Chernobyl

(continued from page 15)

ized in soil, not incorporated into the new growth of grass.[19] However, this model for cesium distribution originated in research on lowland, clay mineral soils. The upland soils were mainly acidic, with high organic content in which cesium remained chemically mobile and available for root uptake into vegetation. Because scientists failed to take into account the special geological and vegetal conditions in Cumbria, their flawed advice continued to oppose the farmers' personal experience of continuing high levels of radiocesium.

Moreover, in advising the farmers to hang on to their lambs a little longer, the experts appeared not to understand the consequences for the lambs' physical condition, which is critical to their market price. Pinpointing the optimum moment for marketing lambs forms the centerpiece of sheep farming expertise. The critical elements of the decision are flexibility and adaptability to the unexpected. Following variable winter conditions, several hundred lambs born over a period of six weeks from mid-April until the end of May will fatten to market readiness at different times from August to October. Usually, therefore, the farmer selects a few ready lambs the day before market and takes them for sale. Timing of the sales is critical because lambs rapidly go out of condition and lose market value if allowed to become overfat or underfed. This decision process requires highly flexible judgments: whether to take any lambs at all; if lambs are taken, how many and which ones; and to which of several nearby markets to take them. Complex craft judgments of trends in prices, rates of finishing of other lambs, pasture conditions, disease buildup, condition of breeding ewes for mating for next year's lamb crop, need for money, and many other dynamic factors partly or fully beyond the control of the farmer enter into these decisions. It is an informal but highly refined process of expert judgment. The nature of this process runs completely counter to the rigidity of the bureaucratic method for dealing with the crisis: Sell the lambs later.

In response to the overgrazing problem, on 13 August 1986 the government permitted farmers to sell and move contaminated sheep from restricted areas if they were marked with blue paint.[20] All sheep in the restricted regions had to be tested for contamination. Sheep testing below the action level (1,000 becquerels per kilogram) could be sold without restriction; sheep testing above the action level could be painted and sold at a loss. Slaughtering the marked sheep for market was forbidden until the original area was derestricted. Although it was possible to lower contamination levels beneath the limit by grazing sheep in the valleys instead of on the highly contaminated fells, the sparse valley grass was needed for winter hay and silage crops; once grazed on, the grass grows back quite slowly.

When the technical experts realized that heavy contamination mainly affected the high fells, they advised the farmers to keep the sheep in the valleys,

In this grazing experiment, sheep were confined to pens on ground sprayed with bentonite, in an unsuccessful effort to immobilize radiocesium. (Photo: ITE—Nick Beresford)

a wildly unrealistic suggestion, as the hill farmers pithily pointed out.[21] Experts followed with statements like: When the sheep were given imported feed "such as straw," then they would soon register clean. A typical reaction was:

[The experts] don't understand our way of life. They think you stand at the fell bottom and wave a handkerchief and all the sheep come running. . . . I've never heard of a sheep that would even look at straw as fodder. When you hear things like that it makes your hair stand on end. You just wonder, what the hell are these blokes talking about? [22]

Furthermore, gathering sheep beforehand from the fell requires an arduous day's work on foot simply to get them back to the farm. A full gather on some of the larger farms takes 10 separate days. If low clouds on the morning of a gather affect visibility, as is common, the gather must be postponed until visibility improves. All this is coordinated with neighbors in a mutual aid system. In these circumstances, flexible decision-making is essential, and a deep natural skepticism is induced toward decision-making systems based on a belief in control and certainty.

Inevitably, the Chernobyl restrictions destroyed much of this flexibility and undermined the farmers' autonomy and sense of identity in managing familiar uncertainties by the complex dynamics of forecasting and adaptation. The restrictions require farmers to notify the local MAFF office in Carlisle at least five days in advance of their intention to sell a certain number of sheep and to identify the market. The farmer must give notice in order to schedule the monitoring session and must wait with the sheep on the appointed day. Gathering, sorting, and managing sheep for the many tests required by MAFF and others took more time and interruption than officials recognized. The lambs sometimes needed to be gathered and returned to the fells two or three times before they passed a monitoring session, a source of further frustration.

Although the farmers accepted the need for restrictions, they could not accept the experts' apparent ignorance of the effects of their approach on the normally flexible and informal system of hill farm management. This experience of expert knowledge being out of touch with practical reality and thus of no validity was often repeated with diverse concrete illustrations in interviews. Many local practices and judgments important to hill farming were unknown to the experts, who assumed that scientific knowledge could be applied without adjusting to local circumstances.

Compensation Conflicts

Three particular points of conflict over compensation illustrate the cultural divide separating farmers and officials. First, when farmers began to assess their losses and make claims during the winter of 1986–87, MAFF told them to produce full documentation and quantification. They were told they should have kept a detailed diary of such costs ever since the crisis first erupted. Many farmers angrily replied that during those early weeks the very same ministry experts had been reassuring them that the restrictions would not last long enough to affect anybody.

Second, the initial compensation offered was to make up the market loss suffered on blue-marked, radiation-blighted sheep. However, in September 1986 the government announced that this would be discontinued. Sales after 28 September would be assumed not to have been forced by grazing shortage and therefore losses on these sales would not be eligible. Quite apart from the fact that many farmers did not hear of this deadline until it was too late, the officially claimed notice period did not consider the time needed to gather, sort, and get sheep to market and the farmers' lack of total control over scheduling this. Furthermore, the effect on prices of the rush to sell created by the deadline was not officially acknowledged. Also unrecognized was the effect of the whole crisis on the price of unmarked sheep, and so no compensation was offered. Moreover, this lowered price for unmarked sheep was the yardstick for compensation. The government was now contradicting its previous advice to hang on to sheep in the confident scientific expectation of imminent derestriction. To bewildered farmers, this switch was easy to read as a deliberate trap, and many did.

When market losses were estimated for compensation, payments for marked sheep were calculated as an average for that market. This averaging incensed farmers, who felt that their own sheep should be judged for the price they would have gained as healthy sheep in a normal market. This judgment epitomizes the kind of individual, expert decisions that are central to the farmers' daily practice. To farmers, this type of judgment was reliable as a decision rule. To administrators, however, the criteria had to be standardized and "objective." This amounted to saying government did not trust the farmers.

Third, many of the farmers' costs were intrinsically very difficult to document and quantify: Extra time was spent waiting for monitors to come to the farms and laboriously gathering and handling sheep to comply with the restrictions. Extra handling and unsettlement also worsened the animals' condition and thus affected their value; these effects were very obvious to farmers but invisible to inexperienced bureaucrats. Eventually, the farmers were awarded a payment for each head of sheep handled but not before the experts had solidly established themselves as unrealistic and arrogant.

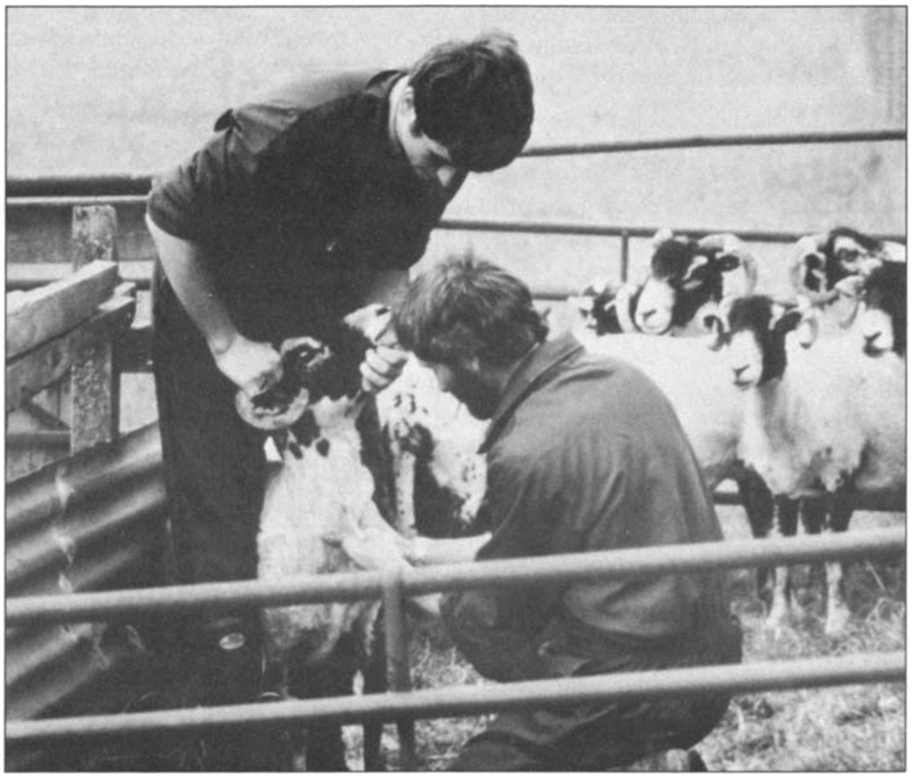
Thus came the typical farmers' lament that the experts "can't understand. They think a farm is a farm and a ewe is a ewe. They think we stamp them off a production line or something,"[23] was often elaborated with detailed explanations of variations in conditions and of resultant optimal husbandry practices even between neighboring farms—variations and decision factors that were obvious to the specialist farmer but invisible to the outside expert.

The very nature of the documentation task contradicts the farmers' experience. Restricted hill farmers fill out administrative forms for each sheep movement and sale and provide auctioneers with copies. As the restrictions developed and the rules altered, the forms and procedures also changed, and government agencies showered farmers with instructions and advice. The barrage of written advice was intended to help, but it was alien to people accustomed to dealing with everything personally and informally. Farmers depended heavily on practical help from their local farmers' union official, local MAFF officials, and local auctioneers, all of whom they knew and trusted individually. Indeed, filling out forms was often totally entrusted to these officials, the explanatory documents being consigned to the kitchen fire. In effect and completely without prior design, these informally defined local mediators rescued the official information process from disaster.

The Sellafield Factor

The Sellafield nuclear reprocessing plant in Cumbria complicates public perceptions of hazards and expert credibility. The plant was established as a military plutonium factory called Windscale (the name was later changed to Sellafield) in 1951, only a few miles from the hill farms now beset by radioactive contamination.[24] Its own radioactive emissions have been a source of controversy since the mid-1970s and have provoked repeated allegations of damage to local public health and the environment. (For more information about British policies of environmental regulation, see Timothy O'Riordan's article, "The Politics of Environmental Regulation in Great Britain," in the October 1988 issue of *Environment*.) In particular, in 1983, a consistently raised incidence of childhood cancers over the past 25 years was identified within a 15-mile radius of Sellafield, although no causal link to the plant could be established. Thus, well before 1986, considerable anxiety about the plant's discharges and management already existed. In addition, in 1957, the site suffered the world's worst nuclear reactor accident prior to Chernobyl, when a military reactor caught fire and burned for three days, emitting an estimated 70,000 curies of radioactivity (a curie is the radioactive decay rate of one gram of radium). Milk from 200 square miles of farmland had to be thrown away for several weeks afterwards because of iodine 131 fallout, but full monitoring data in the environment were never released and may never have been collected.

Because of the remarkable coincidence of large Chernobyl depositions around such a huge nuclear site, the suspicion arose that contamination on the fells had always been high from Sellafield's



Adult sheep and lambs were monitored for cesium contamination. At one point, farmers feared that slaughter of all contaminated sheep, as well as lambs, would be ordered. (Photo: ITE—Brenda Howard)

routine discharges or the 1957 fire but had simply not been monitored or admitted before the Chernobyl emergency. Such concerns were widely expressed by residents after Chernobyl but denied by the experts,[25] who stated unequivocally that the isotope ratios of cesium 137 and 134 in Sellafield discharges could be distinguished from the fresher Chernobyl discharge. Because the half-life of cesium 137 is about 30 times that of cesium 134, the ratio of cesium 137 to 134 increases with time. The Chernobyl fallout ratio was about 2 or 3 to 1, whereas the ratio of the remaining isotopes from the Sellafield fire was about 12 to 1.

To the farmers, this distinction was highly theoretical. Interviews with the farmers revealed a widespread belief that contamination from Sellafield had existed unrecognized since well before 1986. Farmers believed for several reasons that Sellafield radiation contributed to their high levels of contamination. First, the isotope ratio distinction could not be demonstrated to them. They were simply asked to believe the same experts who had shown themselves to be equally confident but wrong about the rate of decline of the contamination. The false certainty of the scientists was frequently cited as a sign of their lack of credibility. Second, the farmers were well aware of the fantastic variability of contamination over very small distances on their own farms; yet, they saw these variations processed in public scientific statements into average figures with no variability or uncertainty. If these measurements could be so misrepresented, perhaps the isotope ratios could also be more variable than what the experts would publicly acknowledge.

When on 30 September 1986 the initial ban over nearly the whole county was reduced to a much smaller crescent around the Sellafield plant (see Figure 2 on page 14), farmers felt confirmed in their judgment that background radiation from Sellafield was raising their levels of contamination. One farmer close to Sellafield, relating the distribution of post-Chernobyl monitoring data on his own farm to his own experience, noted that the highest readings of contamination regularly came from just that place where vapor clouds from the plant usually hit the fell side.[26] Another farmer remembered walking on deposited ash on the same mountains in the wake of the 1957 fire, whereas the scientists said there was no contamination of the fells from that fire.

The farmers' skepticism about Sellafield's claimed innocence was consolidated when requests for radioactive monitoring data from the fell tops and from hill sheep before Chernobyl were diverted to avoid the embarrassing official admission that little or no such data had actually been gathered before Chernobyl.[27] The farmers thus drew their own conclusions about expert credibility from the official maneuvering to cover up this important gap. Government technical officials thus appeared doubly incompetent, since the scientific ignorance about radioactive cesium in the local environment could have been dispelled by proper research in the area after the 1957 fire. Whether such research had been overlooked or was being covered up, neither explanation benefited the experts' credibility. Moreover, a survey reported in March 1988 that half the contamination on the fells was from Chernobyl and half was from Sellafield and nuclear weapons' testing fallout, combined.[28]

The Cumbrians' reactions to Sellafield and Chernobyl strikingly substantiate the point that lay people define and judge a risk according to their experience of those institutions supposedly "in control" of hazardous processes, not just according to the physical parameters of the processes alone.[29] Furthermore, this institutional basis of judgment has a dauntingly long reach through time and across social issues. Entirely separate issues to experts—the 1957 Windscale fire; the control and justification of Sellafield's routine discharges; and the Chernobyl accident—become the same issue to members of the public, who experienced the same social structures and relationships of dependency, perceived scientific arrogance and unrealism, secrecy, and official unwillingness to admit uncertainty or error.

Communication and Decisions

Fieldwork has revealed a cultural chasm underlying the failure of expert communication about radioactivity and sheep restrictions. Eventually, farmers adapted to the restrictions, and experts overcame some of their ignorance of hill farming and its local environment. This pragmatic adaptation provides no basis for transferring the benefits of experience to other situations, however. Moreover, a deep mistrust of scientists and central government officials persists among the hill farmers. In some respects, this distrust has been exacerbated as farmers' experience increases. For example, the complications and untidiness of the scientific method used in post-Chernobyl field research on their own farms constrasts greatly with the professed certainty of official scientific knowledge, which recognizes no doubts.[30]

Communication is not just an appendage to decisionmaking that provides post-hoc explanation and justification. The allocations of authority and power inherent in routine decisionmaking communicate built-in assumptions about what kinds of experience and social groups are worth prior status and which are marginal. If a communication program ignores this social and historical context, it is likely to be self-contradictory, unrelated to rooted experiences and concerns, and thus ineffective. Effective communication between technical experts and lay people thus requires them to restructure their regular social relationships.

In the sheep farmers' case, for example, critical to the scientific experts' lack of credibility was their inability to recognize that the farmers held extensive informal knowledge about sheep habits, the local physical environment, and farming practices and decisionmaking, all of which needed to be integrated with more abstract and formal scientific knowledge to create an effective response framework to the Chernobyl fallout. Nor did the experts recognize the cultural and practical incompatibility of hill farming with a bureaucratic model in which everything is assumed to be subject to standard rules, control, deterministic planning, and formal evidence.

In addition, a deeply embedded scientific assumption—amounting to a general stereotype—about lay people is that they cannot handle uncertainty and risk and thus need to have technical information "simplified."[31] In the United Kingdom this stereotype is amplified by the strongly paternalistic political culture in which the government's role is to reassure people. In Cumbria, the scientists' tendency to understate uncertainty (supposedly for public benefit) backfired and damaged the credibility of scientific information because the idiom of certainty and standardization did not accord with the normal experience of the lay public.

Although hill farmers may be more accustomed to uncertainty and risk than are other communities, evidence suggests that scientists misconstrue the lay population's fear of hazards. For example, technical experts in the European chemical industry were horrified at the requirement in the 1982 Seveso Directive to inform the surrounding public, many of whom were long-time residents, that they live near a major hazard chemical plant.[32] However, contrary to the industry's fearful expectation of public disquiet on being informed of such hazards, the universal experience was that people had already understood that a hazard existed and therefore did not react. The experts' assumption that, in blissful ignorance of the risks, lay people expected a risk-free environment was shown to be a fiction.

Although the degree of uncertainty and variability expressed in scientific information communicated to the public should not be limited automatically on some untested assumption as to the public's needs and capabilities, automatic adoption of an alternative model of a public thirsting for uncertainty and variability could be equally false and ineffectual. The social relations of routine decisionmaking and communication should allow negotiation between experts and the public to determine the appropriate levels of uncertainty and disaggregation in each particular case. This negotiation would result in an intercultural understanding about the expectations for knowledge or information: for example, how conclusive or how universal it is.[33] In Cumbria, some hill farmers eventually managed to communicate with scientists who visited their farms repeatedly to do research and often stayed for several days as guests and engaged in more informal conversation about the scientific research process. This serendipitous and limited interaction improved the credibility of these scientists and of their associated institutions, even though such encounters revealed scientific uncertainty. The Institute for Terrestrial Ecology was most fortunate in this respect because, as a locally based institution, it had the closest such practical contact. Through the farmers' informal grapevine, it subsequently gained a reputation as being plainspeaking, open about uncertainty, independent, and trustworthy.

The scientific expertise administered by MAFF was more centralized, hierarchically structured, and geographically and culturally remote. Although the farmers treated all scientists and experts with skepticism, they quickly learned to distinguish and evaluate the different institutional affiliations; special contempt was reserved for MAFF.

The situation was rescued only by the mediation of local MAFF officials who were personally known and trusted by the farmers. However, these officials were not scientists, so the negotiation of an effective communications framework—with expression of accurate scientific knowledge in socially appropriate terms, and assimilation of local knowledge with the existing scientific knowledge—was crippled. The dominant MAFF view assumed a "deficit" (i.e., inadequate) model of communication and public understanding of science, in which a universally valid body of scientific knowledge is diluted, distorted, and often undermined by the lay public and media. MAFF officials did not appreciate that science may also be parochial (the assumption about cesium immobilization by clay soils, for example) and that it may need to be supplemented by special knowledge, perhaps expressed in a nonscientific idiom.

A less centralized organization of scientific expertise in the ministry would have aided the two-way information exchange as well as the intercultural negotiation of what was expected (for example, the appropriate degree of uncertainty) from science. The necessity of reorganizing the routine social structure of decisionmaking is ignored in current conceptions of risk communication.[34] Of course, it may be argued in any particular case that reorganization of routine decisionmaking—that is, of power and social control—is an unacceptable price to pay for better communication of technical hazard information. However, if the aim is genuinely to develop effective and authentic communication rather than to achieve short-term goals of public quiescence, it is probably the going price. Furthermore, the achievement of such short-term goals is increasingly attended by long-term disorientation and instability in public reactions to expertise.[35] It may therefore be a price worth paying.

ACKNOWLEDGMENTS

The fieldwork was performed by Peter and Jean Williams, without whose diligent, sensitive, and good-humored work the project would have been stillborn. The patience and hospitality of the hill farmers, officials, and scientists whom we interviewed is gratefully acknowledged. I am grateful to Nick Beresford and Brenda Howard of the Institute for Terrestrial Ecology for valuable background discussions as well as some photographs. The research forms part of a wider study in public interpretation of science and technology funded by the Science Policy Support Group of the U.K. Economic and Social Research Council.

NOTES

1. See, for example, Christopher Flavin, "Reassessing Nuclear Power: The Fallout from Chernobyl," Worldwatch Paper 75 (Washington, D.C.: Worldwatch Institute, March 1987); Anneli Salo and James Daglish, "Response to an Accident in Theory and in Practice," *Environment International* 14(1988):21-38; Nicola Loprieno, "Radiation Knows No Frontiers," *European Environmental Review* 1(1986):2-9; and Organization for Economic Cooperation and Development, Nuclear Energy Agency, *The Radiological Impact of the Chernobyl Accident in OECD Countries* (Paris: OECD NEA, 1987).

2. Harry Otway, P. Haastrup, W. Cannell, G. Gianitsopoulos, and M. Paruccini, *An Analysis of the Print Media in Europe Following the Chernobyl Accident*, EUR-11043 EN (Ispra, Italy: Joint Research Centre of the Commission of the European Community, 1987); Harry Otway, "Risk Communication, Experts and Democracy," *Risk Analysis* 7(1987):125-29; J. Clarence Davies, Vincent Covello, and Fred Allen, eds., *Risk Communication* (Washington, D.C.: The Conservation Foundation, 1987); Harold Sharlin, "EDB: A Case Study in Communicating Risk," *Risk Analysis* 6(1986):61-68; and Thomas Belton, Robert Roundy, and Neil Weinstein, "Urban Fishermen: Managing the Risks of Toxic Exposure," *Environment*, November 1986, 18-37.

3. Robert Paine, "Accidents, Ideologies and Routines: 'Chernobyl' over Norway," *Anthropology Today* 2(1987):7-10; and Hilary Beach, "Conceptions of Risk, Dilemmas of Policy: Nuclear Fallout in Swedish Lapland" (Paper presented to the Twelfth International Congress of Anthropological and Ethnological Sciences, Zagreb, Yugoslavia, 1988).

4. Brenda Howard, Institute for Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands, Cumbria, England, personal communication, November 1988.

5. See, for example, Ministry of Agriculture, Fisheries and Food (MAFF) evidence to the U.K. House of Commons Select Committee Report, *Chernobyl: The Government's Response, Minutes of Evidence, vol. II* (London: H.M. Stationery Office, July 1988); and MAFF letters to farmers, 21 March 1988 and 12 December 1988. When a report from the Welsh Country Landowners' Association suggesting a ban of at least 30 years was widely publicized, MAFF's criticism of it was notable for its lack of specific commitment to a shorter duration: MAFF press release, London, 8 February 1988. MAFF press releases and circulars may be obtained from Food Science Division, MAFF, Great Westminster House, Horseferry Road, London SW1P 2AE, United Kingdom.

6. F. B. Smith, "The Environmental Consequences of the Chernobyl Nuclear Reactor Accident" (Bracknell, U.K.: U.K. Meteorological Office, May 1987, mimeographed), p. 18.

7. For a compilation of such data, see the U.K. National Radiological Protection Board (NRPB), *A Compilation of Early Papers by Members of NRPB Staff about the Reactor Accident at Chernobyl on 26th April 1986*, NRPB-M139 (Chilton, United Kingdom: NRPB, 1986); and Martin Morrey et al., "A Preliminary Assessment of the Radiological Impact of the Chernobyl Reactor Accident on the Population of the European Community" (Chilton, United Kingdom: NRPB, January 1987). For a critical view of how the early scientific information was handled in the United Kingdom, see David Webster, "How Ministers Misled Britain about Chernobyl," *New Scientist*, 9 October 1986, 43-45.

8. This initial map was first published in Stuart Allen, "Radiation: A Guide to a Contaminated Countryside," *Guardian*, 25 July 1986. More detailed versions were published later, as more data came in. ITE recorded only radiocesium contamination of vegetation. Thus, areas of thin vegetation such as the Cumbrian fell-tops would show lower readings for a given level of radiocesium deposition, and the soil would be expected to contain higher levels. The ITE map thus underestimates the actual contamination available for uptake by vegetation and sheep. This partly explains the discrepancy between the ITE figures and those of Smith (note 6 above). The Ministry of Agriculture, Fisheries and Food (MAFF) aerial radiometric survey of 1988 confirms suspicions of higher, previously unmeasured levels of radiocesium in the soil of the fell areas; readings of up to 100,000 becquerels per square meter were recorded, levels an order of magnitude higher than Smith's findings. The aerial survey recorded radiocesium signals to a depth of 30 centimeters and so includes a record of the combined contamination from Chernobyl fallout, weapons testing fallout, and Sellafield/Windscale emissions. The survey also found even higher radiocesium levels at certain points along the coast known to be contaminated by Sellafield's marine discharges. The new radiation figures are published in MAFF, *Aerial Radiometric Survey in West Cumbria 1988*, available from MAFF publications, Lion House, Wilowburn Trading Estate, Alnwick, Northumberland, NE66 2PF, United Kingdom.

9. F. B. Smith and M. Clark, "Deposition of Radionuclides from the Chernobyl Cloud," *Nature* 322(1986):690-91; and Smith, note 6 above. The latter paper exposed a high-deposition area in Yorkshire that had not been communicated to MAFF and that had thus escaped close monitoring. This fueled allegations

that sheep above the contamination limits had gotten into the food chain.

10. Martin Oliver, editor of *Farming News*, House of Commons Select Committee Report, vol. II, 25 May 1988, 227, note 5 above.

11. U.K. *Hansard Parliamentary Debates* (Commons), 6th ser., vol. 97 (1986), col. 20.

12. U.K. National Radiological Protection Board press release, 11 May 1986, available from NRPB, Chilton, Didcot, OXON, OX11 ORQ, United Kingdom.

13. Parliamentary Debates, note 11 above, col. 182.

14. MAFF press release, London, 30 May 1986, note 5 above.

15. MAFF press release and circular letter accompanying ministerial statement to Parliament, London, 20 June 1986, note 5 above.

16. In spring 1988 the restrictions covered 69 farms and 640,000 sheep in Scotland; 416 farms and 300,000 sheep in Wales; 123 farms and 27,335 sheep in Northern Ireland, and 150 farms and 90,000 sheep in Cumbria. This data is available from the U.K. House of Commons Select Committee Report, Minutes of Evidence, note 5 above.

17. MAFF press release, note 15 above.

18. MAFF advisory letters of 13 and 18 August 1986, for example, told farmers that since "levels were continuing to fall" they "should consider very carefully" whether they wished to mark and release their sheep rather than wait a little more.

19. Brenda J. Howard et al., "A Comparison of Caesium-137 and -134 Activity in Sheep Remaining on Upland Areas Contaminated by Chernobyl Fallout with those Removed to Less Active Lowland Pasture," *Journal of the Society for Radiological Protection* 7(1987):71-73; and Brenda J. Howard and Nick A. Beresford, "Chernobyl Radiocaesium in an Upland Sheep Farm Ecosystem," *British Veterinary Journal*, forthcoming.

20. MAFF press release and circular, 13 August 1986, note 5 above.

21. Public meetings attended by the author.

22. Hill farm interview, October 1987.

23. Hill farm interview, February 1987.

24. For an account of Sellafield's (previously Windscale) history and debate over a major expansion there, see Brian Wynne, *Rationality and Ritual: The Windscale Inquiry and Nuclear Decisions in Britian* (Lancaster, U.K.: British Society for the History of Science, 1982).

25. See, for example, Allen, note 8 above.

26. Hill farm interview, November 1987.

27. For example, demands for such pre-Chernobyl data by farmers to MAFF scientists at a public meeting in Broughton, a local market town, in February 1987 were met by references to a very thick MAFF document, which only contained post-Chernobyl monitoring data.

28. "Chernobyl II," *Farmer's Weekly*, 11 March 1988, 76. See also "Chernobyl I," *Farmer's Weekly*, 4 March 1988.

29. See, for example, Brian Wynne, "Technology, Risk and Participation: The Social Treatment of Uncertainty," in Jobst Conrad, ed., *Society, Technology and Risk* (London: Academic Press, 1980).

30. Brian Wynne, "Public Understanding of Science: From Content to Process," *Newsletter* of the European Association for Studies of Science and Technology (EASST), February 1987, 3-8; and Robin Millar and Brian Wynne, "Public Understanding of Science: From Contents to Processes," *International Journal of Science Education* 10(1988), forthcoming.

31. For example, The Royal Society of London, *The Public Understanding of Science* (London: Royal Society of London, 1985).

32. Brian Wynne, *Implementation of Article 8 of the Directive EEC/501/82: A Study of Public Information* (Brussels: Commission of the European Communities, Directorate-General XI, 1987); and Alison Jupp, "Public Information About Major Hazards" (M.Sc. diss., University of Manchester, 1987).

33. Robert Paine, "Making the Invisible 'Visible': Coming to Terms With Chernobyl and Its Experts" (Unpublished draft, Memorial University of Newfoundland, 1988).

34. The conventional approach that does not adequately recognize the social context of perception and communication is illustrated in the literature reviewed by Vincent Covello, Detlov von Winterfeldt, and Paul Slovic, "Risk Communication: A Review of the Literature," *Risk Abstracts* 3(1986):171-82. A more sociological literature is emerging: for example, Alonzo Plough and Sheldon Krimsky, "The Emergence of Risk Communication Studies: Social and Political Context," *Science, Technology and Human Values* 67(1987):3-10; and Branden Johnson, "Accounting for Social Context of Risk Communication," *Science and Technology Studies* 5(1987):103-11.

35. For example, The Royal Society, note 31 above. For some interpretation, see Brian Wynne, ed., *Risk Management and Hazardous Wastes: Implementation and the Dialectics of Credibility* (London, Berlin, New York: Springer Verlag, 1987), especially chapter 11, "Risk Perception, Decision Analysis and the Public Acceptance Problem"; and Brian Wynne, "Frameworks of Rationality in Risk Management: Towards the Testing of Naive Sociology," in Jennifer Brown, ed., *Environmental Threats: Social Sciences Approaches to Public Risk Perceptions* (London: Belhaven Press, 1989).