Covert Biological Weapons Attacks against Agricultural Targets: Assessing the Impact against U.S. Agriculture

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ESDP-2001-05
BCSIA-2001-9 **August 2001**

CITATION AND REPRODUCTION

This document appears as Discussion Paper 2001-9 of the Belfer Center for Science and International Affairs and as contribution ESDP-2001-05 of the Executive Session on Domestic Preparedness, a joint project of the Belfer Center and the Taubman Center for State and Local Government. Comments are welcome and may be directed to the author in care of the Executive Session on Domestic Session.

This paper may be cited as Jason Pate and Gavin Cameron. "Covert Biological Weapons Attacks against Agricultural Targets: Assessing the Impact the Impact against U.S. Agriculture." BCSIA Discussion Paper 2001-9, ESDP Discussion Paper ESDP-2001-05, John F. Kennedy School of Government, Harvard University, August 2001.

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ACKNOWLEDGMENTS

An early version of this paper was presented at the ISPAC International Conference, "Countering Terrorism Through Enhanced International Cooperation," held at Courmayeur Mont Blanc, Italy, September 22-24, 2000. The paper was then published in *Terrorism & Political Violence*, 13, no. 3 (Fall 2001). Our thanks are due to the editors and publishers of that journal for permitting this version of the article to be reproduced, and to Faith Stackhouse for providing excellent research throughout the paper.

This project is supported by Grant No. 1999-MU-CX-0008 awarded by the Office for State and Local Domestic Preparedness Support, Office of Justice Programs, U.S. Department of Justice. The Assistant Attorney General, Office of Justice Programs, coordinates the activities of the following program offices and bureaus: the Bureau of Justice Assistance, the Bureau of Justice Statistics, the National Institute of Justice, the Office of Juvenile Justice and Delinquency Prevention, and the Office for Victims of Crime. Points of view or opinions in this document are those of the author and do not necessarily represent the official position or policies of the U.S. Department of Justice.

INTRODUCTION

Since 1995, analysts, policymakers, and the news media in the United States have focused unprecedented attention on the threat of terrorism involving weapons of mass destruction (WMD), particularly chemical and biological weapons (CBW). The Aum Shinrikyo attack in Tokyo in March 1995 and the Oklahoma City bombing the following month significantly contributed to this phenomenon in two important ways. First, Aum proved that subnational groups could obtain CBW, previously only a theoretical possibility.[1] After the Tokyo incident terrorists using CBW appeared to be an evolving and dangerous threat that required creative new thinking in counter- and antiterrorism policy. Second, the Oklahoma City bombing brought the threat of terrorism to the American heartland. No longer was terrorism a foreign phenomenon characterized by media accounts of masked Islamic fundamentalists taking hostages, hijacking planes, or bombing far-away buildings. The terrorists in this case were Americans targeting Americans: not only had terrorism reached the center of the country, but the terrorist threat originated much closer to home.

In an effort to address this "new" terrorist threat, the United States has tripled spending for CBW counterterrorist programs since 1995. Threat analyses have focused on the vulnerability of American society to attacks involving CBW as well as the spread in the information era of the technologies and know-how associated with such weapons, and many government programs designed to address the CBW terrorist threat reflect this approach. In 1996, Congress passed the Defense Against Weapons of Mass Destruction Act (the Nunn-Lugar-Domenici Domestic Preparedness Program) in an effort to make the United States better prepared to respond to an attack involving CBW. This effort has been characterized by scenario development and training of the first-responder community, under the assumption that an attack would affect primarily civilians in urban areas.

More recently, the threat of a biological attack against an agricultural target, often labeled "agricultural terrorism", has been discussed, although programs to ensure preparedness for such an attack remain largely the purview of a limited part of the U.S. Department of Agriculture (USDA), which has begun to improve its capabilities to respond in the event of disease in animals or crops.[2] In an effort to address the potential threat of attacks against agricultural targets, USDA has developed a six-point strategy to ensure the security of U.S. agriculture, including terrorism prevention and deterrence, international cooperation,

[1] Although Aum was not the first subnational group to use a chemical or biological agent, the group's acquisition and use of sarin and VX nerve agents, agents thought to be restricted to state-level CW programs, was unprecedented.

[2] "The Threat of Biological Terrorism to U.S. Agriculture", U.S. Department of Agriculture, undated.

domestic consequence management planning, research on counterterrorism capabilities, protection of critical infrastructure, and protection of food supply.[3] This wide-ranging and somewhat vague list resembles many other agencies' counterterrorism plans. Interagency groups have proliferated, also characteristic of U.S. CBW counterterrorism planning in recent years. Several other U.S. agencies besides USDA now have some role in preparedness for agricultural terrorism, including the National Security Council and the Department of Justice.[4] USDA requested a total of $41.3 million for counterterrorism in Fiscal Year (FY) 2001, $39.8 million of which (or 96 percent) is devoted to defense against WMD.[5] In FY 2000, WMD defense accounted for $7.3 million of $12.3 million, or 59 percent of the total.[6] Clearly, USDA has focused significant resources on addressing this problem. For comparison, the Department of Health and Human Services (HHS), the agency responsible for public health, including the Centers for Disease Control and Prevention (CDC), requested $265.4 million for counterterrorism activities for FY 2001, all of which was WMD-related, representing a decrease in funding from $277.6 in FY 2000.[7] The HHS FY 1999 figure, however, was $173.1 million, indicating either that HHS was able to capitalize sooner on the attention given the WMD threat or that the threat was perceived as more pressing in HHS's jurisdiction.[8] The Department of Justice (DOJ) requested $254.7 million in WMD-related funding in FY 2001, an increase of $37.5 million over the previous year.[9] In the U.S. national security community, funding for WMD-related programs has tripled since 1998, but the figures remain a small portion (less than 10 percent) of the total for counterterrorism generally.[10] Other agencies' funding for WMD defense programs has also increased, but in no case has the proportion of WMD funding in the total counterterrorism budget been so great as in the case of USDA. That said, USDA's funding levels, seen as a proportion of the U.S. budget, trail those of other agencies dramatically in WMD-related appropriations, because the Domestic Preparedness Program until very recently has focused on preventing and mitigating attacks targeted directly at humans. The heightened focus on terrorism against agriculture represents a new stage, one with the object of protecting U.S. strategic assets, such as agriculture.

In addition, USDA has requested funding to upgrade a research facility at Plum Island, New York, to Biosafety Level 4, capable of and dedicated to the study of animal and plant pathogens, although local

[3] Statement by Floyd P. Horn, Administrator, Agricultural Research Service, U.S. Department of Agriculture, before the U. S. Senate Emerging Threats and Capabilities Subcommittee of the Armed Services Committee, October 27, 1999, p. 5.
[4] Ibid.
[5] "Federal Funding to Combat Terrorism, Including Defense against Weapons of Mass Destruction FY 1998-2001," available at http://cns.miis.edu/research/cbw/terfund.htm.
[6] Ibid.
[7] Ibid.
[8] Ibid.
[9] Ibid.

public opinion and congressional representatives have mixed views on the issue.[11] Building on these indicators of growing official attention to the threat of attacks against agricultural targets, including congressional hearings on the issue, news articles have begun to reflect concerns that U.S. agriculture is vulnerable to attack using biological weapons, and arguably this vulnerability, as well as the theoreticalease of carrying out such attacks covertly, makes agricultural targets particularly appealing to terrorists.[12] Terrorists may also find these types of targets appealing because they do not target humans directly and may therefore be more easily justified. Indeed, a recent influential US government report asserted that the "U.S. agricultural sector is especially vulnerable to agroterrorism" and that "a successful attack could result in local or regional economic destabilization" and affect international commerce.[13] The U.S. agricultural sector, including all elements directly or indirectly related to agriculture, represents about 13 percent of the U.S. gross national product and is enormous and diverse; few specific threat assessments of vulnerability exist.[14]

It would be extremely difficult for a terrorist group to perpetrate a significant biological attack against the agricultural economy in the United States, however, for several reasons. First, obtaining and effectively delivering a biological agent against an agricultural target is a task fraught with technical hurdles. Although some agricultural agents can be obtained relatively easily and crudely delivered, to cause a catastrophic incident would require a more sophisticated approach. Second, because crops and livestock in the United States are generally not concentrated, eliminating a segment of the agricultural economy would require a multipronged attack and a sophisticated understanding of the economy. Although not impossible, this type of attack presents significant obstacles. Third, the U.S. agricultural economy has in place networks and plans to respond to an attack once detected, and surveillance of crop and animal disease in the United States is extraordinarily sophisticated. Even if a terrorist group managed to deliver a biological agent effectively against a target, the effects of the attack would likely be severely limited by the U.S. response. Fourth, although a determined group could conceivably carry out a devastating attack, there is no evidence of terrorist groups with the motivation to carry out a catastrophic attack against U.S. agriculture. It is clear however that more research is required before an accurate assessment can be made of the threat terrorism poses to the U.S. agricultural economy.

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[10] Ibid.
[11] David Ruppe, "Battle Over Plum Island", available at *ABCNews.com*, accessed January 20, 2000.
[12] Steve Goldstein, "'Agroterror' Fears Awake; U.S. Crops Seen as Vulnerable," *The Arizona Republic*, June 26, 2000, p. A12; and "Experts Warn of "Agroterrorism" Threat," *Associated Press*, December 2, 1999).
[13] "First Annual Report to the President and the Congress of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction, 1: Assessing the Threat," December 15, 1999, p. 12, available at http://www.rand.org/organization/nsrd/terrpanel/ and accessed on June 23, 2000.
[14] Statement by Floyd P. Horn before the Emerging Threats and Capabilities Subcommittee, October 27, 1999, p. 3.

The purpose of this paper is to assess what economic impact an attack using biological weapons would have on the U.S. agricultural sector. There have been very few instances of what could be deemed "agricultural terrorism" in the United States; the empirical data is therefore quite limited. Although there have been some well-known cases of agricultural product contamination, these cases targeted people more directly rather than the crops or livestock themselves and were thus not examples of subnational actors seeking to eliminate a specific crop or portion of the agricultural base. Without a set of cases to examine, it is extremely difficult to predict accurately what an incident of agricultural terrorism would involve, how it would present itself, how it would be detected, and what its consequences would be.

By looking at natural outbreaks of disease in segments of the agricultural economy in the United States however, it may be possible to identify and quantify the actual impact of an attack against U.S. agriculture. These outbreaks, although they do not carry with them the same level of psychological impact that is normally associated with terrorism, do provide a baseline for economic analysis and estimates of disease impacts on local, regional, and national economies.

The paper discusses definitions of agricultural terrorism and talks about some theoretical reasons why U.S. agriculture may not be particularly vulnerable to an attack. The ideas proposed along these lines are similar to those in theories about the difficulty of perpetrating an effective attack using CBW against any target. After taking a look at the historical record of agricultural terrorism cases and making some observations, the paper reviews a number of naturally occurring outbreaks to provide a basis for determining the impact disease in the agricultural sector might have. To assess the vulnerability of the vast U.S. agricultural economy to terrorist attacks using biological weapons (BW), the paper then analyzes the diversity of U.S. agriculture and comments on the feasibility of attacking regionally focused crops. Finally, the paper draws some conclusions from the data.

DEFINITIONS

Before looking to natural outbreaks in an effort to understand what economic impact a subnational BW attack against an agricultural target would have, it is necessary and important to define the term "agricultural terrorism" in the context of the debate surrounding it. One key issue in arriving at such a definition is how to categorize covert BW attacks. Are all such attacks terrorism? In some cases, where there is a terrorist group or individual using BW against agriculture, the term "agricultural terrorism" would obviously apply. In others, the motivations for the attack are criminal in nature with no link to furtherance of an ideological goal. Even in such cases, the attack is likely to have a psychological impact that goes beyond the immediate effects of the attack, a subsequent terrorizing effect. For this reason, these

cases are covered in the analysis presented here even though they cannot by any reasonable definition be included as terrorism per se. We are speaking here of subnational attacks against agriculture; to provide as comprehensive analysis as the data allow, we use the term subnational BW attacks against agriculture to include all of these cases. Though cumbersome, this term allows for more accurate analysis. Although attacks using chemical or even conventional weapons against agricultural targets could be considered examples of subnational BW agricultural attacks, for the purposes of this study, subnational BW agricultural attacks refers to the use of disease against agricultural targets, including crops and livestock, in an effort to cause widespread damage to or destruction of the target. This is a separate issue from the use of agents to contaminate specific products; in those cases, the target is actually people, and the incidents look more like consumer product tampering. However, because of the paucity of incidents of actual agricultural terrorism, this paper provides an overview of product contamination cases for context. Because chemical destruction is by nature self-limiting, we have chosen to look specifically in this paper at disease, at attacks using a biological agent.

Although often-cited cases of subnational BW agricultural attacks have involved threats of contamination of specific products, causing significant economic losses through diminished consumer confidence, they did not threaten the loss of an entire segment of the agricultural sector. Although the diffusion, both geographically and typologically, of agricultural production across the United States makes a catastrophic attack on or the total elimination of a significant portion of the national agricultural economy highly unlikely, regional economies could be significantly affected. However, certain segments of the agricultural economy in the United States may be sufficiently concentrated or sufficiently unique that an attack against them could have major regional consequences.

COSTS

Although this paper deals overtly with the economics of subnational BW agricultural attacks, a range of costs, in the wider sense, would be associated with such an attack. If crops or livestock are destroyed, then obviously that has a financial impact on the grower or breeder. Depending on the scale of the attack, however, it might have an impact on consumers, both in confidence, in the case of product tampering, and in produce prices. Clearly, if a particular crop is in short supply, or if it has to be imported from a more remote region, then the price of that crop will rise. An example of this phenomenon attributable to natural causes occurred 1999 when frost decimated the California orange crop, so that oranges had to be shipped from Florida, resulting in a rise in orange prices. Such an occurrence also has a ripple effect: the increase in the price oranges adversely affected the Florida juice industry even though the frost had hit California. The increased costs were passed to the consumers of orange juice and table oranges. Equally, though, a

range of individuals and businesses are likely to suffer as a result of the secondary impact of subnational BW agricultural attacks. For example, if a crop is decimated, agricultural workers are likely to be seriously affected unless they can find alternative employment. In January 1999, for example, unemployment in Tulare County, California, hit 20 percent, largely as a result of the area's spoiled orange crops. A range of industries may depend on certain crops or livestock: a terrorist attack on cattle affects not only the farmer, but also the livestock shippers, stockyards, slaughterhouses, distributors, and so on. The economic impact of an incident depends not only on the scale of an attack, but also on the crop or livestock that is targeted. Where there are substitute goods for those that have been targeted, the economic impact can be reduced. Equally, some livestock or crops have more elastic supply than others, so that output can readily be expanded to fill a gap in the market. For example, because pigs have large litters and reach maturity relatively quickly, the supply of hogs is much more flexible than that of cattle.

Apart from the loss of immediate revenue from a subnational BW agricultural attack, there is also the risk of long-term loss of market share. If distributors, wholesalers, and retailers find acceptable and affordable alternative sources of agricultural produce to replace those affected by the attack, they may not return to their original supplier, even after the crisis has passed. This might be not only a consequence of subnational BW agricultural attacks, but conceivably a motive for them as well. Competitors in a particular market could see these attacks as a means of increasing their market share at the expense of their rivals.

Obviously, a range of other potential costs might also be incurred as a result of a subnational BW agricultural attack. Crops or livestock might need to be replaced. The expense of doing so could be particularly heavy if breeding stocks have to be replaced to replenish supplies of produce. Depending on the agent used to attack agriculture, the affected area will likely need to be decontaminated. Additional costs may include not only "cleaning up" the agent, but also the collection and destruction of infected crops or livestock. If dealing with a virulent and readily transmissible agent such as foot-and-mouth disease (FMD) or certain wind-borne plant pathogens, the need for collection and destruction may extend from those livestock or crops already affected to those in the vicinity, those that might be affected, due to the need to establish a *cordon sanitaire* to control the spread of the disease.

Finally, agricultural terrorism may generate political costs. Some of these costs apply to any act of terrorism: the loss of confidence and credibility stemming from a government's inability to protect the country. Specifically, however, terrorism involving BW attacks on agricultural may also result in a

heightened need for interagency cooperation, possibly at local, state, and national levels, and calls for increased action against further such attacks.

In summary, subnational BW agricultural attacks may involve a range of costs, both direct and indirect, overtly and hidden. Therefore, when discussing the economic impact of such attacks, it is important to be clear what costs are being incurred and by whom.

INCIDENTS INVOLVING SUBNATIONAL BW AGRICULTURAL ATTACKS

As of August 2, 2000, the Database of WMD Terrorism Incidents at the Center for Nonproliferation Studies, Monterey Institute, held twenty-one incidents that might be classified as subnational BW agricultural attacks.[15] This represents only a small fraction (2.5 percent) of the total number (853) of incidents contained in the Database. Clearly, in spite the attention that the threat of agricultural terrorism is now receiving, historically, such attacks have been relatively rare occurrences. Moreover, although high-profile concern over the potential threat is a relatively new phenomenon and has centered in the United States, the historical record suggests that acts of agricultural terrorism have been perpetrated worldwide for decades. Of the twenty-one incidents of subnational CBW agricultural attacks in the Database, five occurred in the United States, but four occurred in Israel, and there have been incidents in Canada, China, Sri Lanka, the Philippines, Australia, Uganda, and Kenya, as well as throughout Europe. The earliest incident in the Database occurred in Kenya in 1952, when members of the Mau-Mau, an anticolonialist group, inserted the latex of the African milk bush plant into cuts made in the skin of thirty-three steers, eight of which died.[16] Even within the United States, members of the Ku Klux Klan supposedly poisoned the water supply of cattle owned by a group of Black Muslims in Ashville, Alabama, in March 1970. A local veterinarian identified the poison as cyanide. The incident may have been part of a sustained campaign of intimidation by the Klan against the owners of the farm. The poison killed thirty cattle and sickened nine others.[17] Clearly, then, the threat of agricultural terrorism is neither new nor limited to the United States.

[15] The Monterey Institute WMD Terrorism Database is an open-source collection of incidents involving subnational actors and chemical, biological, radiological, and nuclear materials, 1900 to the present. The Database is available by subscription to qualifying organizations. For more information, contact Jason Pate at jpate@miis.edu.
[16] Seth Carus, "Bioterrorism and Biocrimes: The Illicit Use of Biological Agents in the 20th Century," National Defense University, Washington D.C., Working paper, August 1998 (March 1999 revision), p. 73.
[17] "Poison Is Suspected in Death of 30 Cows On a Muslim Farm," *New York Times*, March 16, 1970, p. 30. James Wooton, "Black Muslims Would Sell Farm to Klan," *New York Times*, March 17, 1970, p. 32. "Wallace Seeking More Policemen," *New York Times*, December 12, 1971, p. 50.

Agricultural attacks are not primarily a means of targeting people per se: it would be simply illogical to attempt to attack people by targeting agriculture. Subnational agricultural attacks are therefore predominantly a means of extortion, intimidation (as in the example of the alleged Ku Klux Klan attack described above), or economic punishment. Although their impact is primarily financial, agricultural attacks have obvious social consequences as well, that may be used as a tactic for political as well as criminal purposes. In fact, of the twenty-one cases of subnational BW agricultural attacks in the Database, only five were classified as criminally motivated. This is partly a consequence of the Database's inclusion criteria, but it is nevertheless extremely significant that sixteen incidents were classified as politically motivated; agricultural terrorism is a means of political as well as financial extortion. When people have been injured or even killed as a result of agricultural terrorism, it has generally been when the incident closely resembles consumer product tampering. In 1978, the Arab Revolutionary Council used liquid mercury to poison citrus fruit exports from Israel to Europe. Israeli orange exports were reduced by forty percent, and twelve people were injured when they ate contaminated oranges.[18] In this case though, despite the injuries, the primary target of the attack was the Israeli economy. A more serious case was uncovered in May 2000 when inspectors from the Israeli Agricultural Development Authority discovered that Palestinians had been Using counterfeit stamps on expired and salmonella-ridden eggs that were then sold throughout Israel. Although they had been operating the scheme for eighteen months, it is unclear how many contaminated eggs were sold or how many people were sickened as a result. In September 1999, two Israelis died of salmonella as a result of eating contaminated eggs. According to Israeli news sources, there may have been "widespread food poisoning in the IDF and among tourists" as a result of the Palestinians' actions.[19] Clearly, in this case, the intended impact was not only economic, but also disruption of the Israeli military and society, a direct and politically motivated attack on people. Palestinian groups, more than other terrorist organizations, appear to have used such attacks as one in a series of strategies. In each case, the actions of such Palestinian groups are examples of the product-tampering type of agricultural terrorism. In 1974 in Genoa, Italy, the "Revolutionary Command"

[18] Joseph Douglass Jr. and Neil C. Livingstone, *America the Vulnerable: The Threat of Chemical and Biological Warfare* (Lexington, Mass: Lexington Books, 1987) cited in Ron Purver, "Chemical and Biological Terrorism: The Threat According to the Open Literature," (Canadian Security Intelligence Service, unclassified, June 1995), pp. 87-8. Yonah Alexander, "Will Terrorists Use Chemical Weapons?*" JINSA Security Affairs* (June-July 1990), p.10 cited in Purver, "Chemical and Biological Terrorism," pp. 87-8.

[19] "Counterfeit stamps put on diseased eggs," *Ha"Aretz*, May 23, 2000, available on http://www3.haaretz.co.it/eng/scripts/print.asp?id=78775, accessed on June 23, 2000. "Warnings of contaminated eggs being sold with official stamp," *Israel Wire*, May 26, 2000, available on http://www.israelwire.com/new/00526/00052626.html, accessed on June 23, 2000. "Woman dies from salmonella", *Israel Wire*, September 13, 1999, available at http://www.israelwire.com/New/990913/99091328.html, accessed on June 23, 2000.

announced that it had "injected toxic substances into Israeli-produced grapefruit."[20] In 1979, the Arab Revolutionary Council threatened to contaminate a range of Israeli agricultural exports to Europe.[21] In April 1988, again in Italy, the Organization of Metropolitan Proletariat and Oppressed Peoples, acting in support of the Palestinian Intifada, claimed to have injected poison into Israeli grapefruit. Grapefruit contaminated with a non-harmful agent were discovered in Naples and Rome, and the Italian government then withdrew all Israeli grapefruit from sale.[22] Interestingly, Israeli individuals or groups have targeted Palestinian agriculture too, but such attacks have been directed against crops rather than exports. Therefore, they have had a more direct, although possibly less widespread impact than that achieved by Palestinian undermining of consumer confidence in Israeli fruit. In October 1997, settlers from Gosh Etzion sprayed a chemical on grapevines in two Palestinian villages south of Bethlehem. The settlers supposedly destroyed hundreds of vines and up to 17,000 metric tons of grapes.[23] In June 2000, settlers from Efrat released sewer water onto Palestinian fields in Khaddar, near Bethlehem. Farmers estimated their losses at around $5,000.[24] Although the settlers were undoubtedly pursuing a campaign to drive Palestinian farmers from the land, it is unclear whether they sought to do so by poisoning crops with sewage or by simply flooding the fields with the water.

Elsewhere in the world, agriculture has been targeted for a range of political objectives. In 1977, Ugandan dissidents threatened to poison the country's coffee and tea crops in an effort to severely affect Ugandan foreign exchange, thus undermining the economy.[25] The LTTE (Tamil Tigers) threatened to use biological weapons to attack Sri Lankan crops in the mid-1980s.[26] In January 1984, Pater Vivian Wardrop threatened to Use FMD to attack livestock in Queensland, Australia, unless prison reforms were undertaken.[27] In none of these cases was there any indication that an attack had actually been perpetrated or that an agent for use against agriculture had been successfully acquired.

[20] The RAND-St. Andrews Terrorism Chronology: Chemical/Biological Incidents, 1968-1995, RAND Corporation, Santa Monica, CA.
[21] Ibid.
[22] Ibid.
[23] Shabatai Zvi, "Israeli Settlers Destroy 17,000 Tons of Grapes," *Al-Ayyam*, October 23,1997, available at http://www.hebron.com/article04-10-23-97.html, accessed on February 17, 2000.
[24] "Settlers pump sewerage water into Palestinian groves", *Palestine Information Network*, June 21, 2000, available at http://www.palestine-info.net/daily_news/index.htm, accessed on June 21, 2000. Also available at *Palestine Times*, http://www.ptimes.com/current/news.html, accessed on July 5, 2000.
[25] RAND-St. Andrews Terrorism Chronology.
[26] Carus, "Bioterrorism and Biocrimes."
[27] Purver, "Chemical and Biological Terrorism," p. 35; Tony Duboudin, "Murderer in court over virus threat," *The Times*, February 22, 1984, p.5; *Reuters*, December 5, 1984.

Forms of subnational agricultural attacks have been used as a means of settling personal scores. In the mid-1990s, a farmer in China used rat poison to kill twelve of his neighbors' water buffalo, along with four of his neighbors, supposedly because they were better off than he.[28] In 1997, Brian W. 'Skip" Lea, of Berlin, Wisconsin, used the fungicide folpet and the illegal pesticide chlordane to contaminate products manufactured by National By-Products, a supplier for Purina Mills animal feed that he regarded as a business competitor.[29]

A number of cases worldwide and the majority of cases in the United States, reflect the targeting of exports or products rather than agriculture per se. In the 1980s, Huk terrorists poisoned Dole pineapples in the Philippines that were meant for export. However, the contaminated pineapples were discovered and destroyed, before any harm was done.[30] In September 1997, an ex-Kurdistan Workers Party member claimed that the group planned to target Turkish vegetable exports.[31] In July 1986, threats from the Azanian Peoples Liberation Front, an anti-apartheid group, were published in the Canadian press that South African fruit would be poisoned with a toxic chemical.[32] Although no poisoned fruit was discovered, two Canadian supermarket chains ceased sales of all South African fruit.[33] The South African fruit sales ceased because of the poisoning threat at the time with no clear indication from the two supermarkets when sales would resume.[34] In November 1994, "the David Group" sprayed graffiti on railcars containing grain in Thunder Bay, Canada. Subsequent tests gave no indication, however, that the grain itself had been contaminated.[35] Within the United States, exports have also been a target: in January 2000 an e-mail message spread to internet users that warned, Costa Rican bananas were contaminated with necrotizing fasciitis, a flesh-eating bacteria.[36] The e-mail message was signed "Manheim Research

[28] "The Poisoned World—1998," University Sains Malaysia (1998), available at http://prn.U.S.m.my/diary/text298.html, accessed March 29, 1999.
[29] Gretchen Schuldt, "Man indicted on charges of tainting animal feed; Berlin plant contaminated with toxic pesticide in 1996," *Milwaukee Journal Sentinel*, September 15, 1999, p.1. Richard P. Jones, "Product Recalled in Four States; Animal Feed Tainted in Act of Sabotage," *Milwaukee Journal Sentinel*, January 4, 1997, p.1. "MDA Investigates Possible Feed Contamination", *PR Newswire*, January 6, 1997.
[30] Purver, Ron. "Chemical and Biological Terrorism: The Threat According to the Open Literature" June 1995. CSIS/SCRS.
www.csis-scrs.gc.ca/eng/miscdocs/biblio_e.html
[31] Shyam Bhatla Naxos and Leonard Dayla, "Poison bomber offers secrets for sanctuary," *The Observer*, September 28, 1997, available at http://www.byegm.gov.tr , accessed on May 21, 1998.
[32] Purver, Ron. (1995)
[33] "Quebec's largest food distributor removes S. African fruit," *Reuters*, July 11, 1986. Michael Babad, "Threats halt sales of S. African fruit at Canadian stores," *United Press International*, July 15, 1986. Michael Babad, "Canadian stores stop selling South African fruit," *United Press International*, July 16, 1986.
[34] "Canadian Food Distributor Removes South African Fruit". 11 July 1986. Reuters North European.
[35] "Rail car graffiti not linked to shadowy group (David Organization)," *Canadian Press Newswire*, November 7, 1994.
[36] Emery, David. "The Great Banana Scare of 2000". 23 February 2000.
http://urbanlegends.a…gends/library/weekly/aa022300a.htm

Institute Center for Disease Control Atlanta Georgia," which is a false organization according to the Centers for Disease Control.[37] No basis was discovered for the threat, and it is doubtful whether it is possible, even theoretically, to contract the disease as a consequence of eating food.[38] Clearly, these cases were targeted at potential consumers of the product.

More interesting was the 1989 case of the Breeders, a previously unknown group that threatened to spread Medfly through California if aerial spraying of pesticides continued in the state. The Medfly infestation in California at that time was unusually large and had a number of characteristics that led investigators to conclude a deliberate infestation was being conducted. No one was ever caught for promoting the spread of the Medfly, however.[39] The case had a number of noteworthy aspects, particularly in that the motivation for the action was environmentalism. Although causing economic damage seems the most likely political reason to perpetrate an act of agricultural terrorism, the Breeders case shows that some single-issue groups might be similarly interested in such a tactic. Protesters concerned with genetically modified foods, as well as environmentalists, seem plausible candidates to consider an act of agricultural terrorism or agro-sabotage. The Breeders used a biological means, Medfly, to attack crops in California. By contrast, most attacks have either been hoaxes or relied on chemical agents to attack agriculture. It is biological, not chemical, weapons however that can potentially have the most widespread effects on agriculture.

Of the agents used or threatened in the incidents of subnational agricultural attacks contained in the Database, eight cases involved threats to poison or contaminate crops or agricultural products with unspecified agents. In none of these cases was an attack actually launched, and all eight were simple hoaxes, threats, or plots. Six incidents in the Database involved a specific chemical agent directed against agriculture and each involved the use of the agent: mercury, cyanide, rat poison, pesticide, fungicide, and an unnamed chemical. None of these incidents could be classified as sophisticated or involving high-end, or warfare, agents. Of the biological incidents in the Database, there were threats to use FMD, necrotizing fasciitis, and an unnamed biological agent. Of these, the threat to use FMD notable because potential use

[37] Emery, David. 23 February 2000.
[38] "Banana Fits", Urban Legends Reference Pages: Toxin du jour (Banana Fits), available at http://www.snopes.com/toxins/bananas.htm, accessed on July 27, 2000. "False Internet Report about Bananas," National Center for Infectious Diseases, available at http://www.cdc.gov/ncidod/banana.htm, accessed on May 31, 2000. "E-mail at UC Riverside Helped Spread Hoax About Bananas," *Los Angeles Times*, February 16, 2000, p. A18.
[39] John Johnson, "Female Medfly Found in Sun Valley Close to Area Targeted Earlier," *Los Angeles Times* January 4, 1990, p. B3. Ashley Dunn, "Officials Advertise to Contact Mystery Group Claiming Medfly Releases," *Los Angeles Times*, February 10, 1990, p. B3. Stephanie Chavez and Richard Simon, "Mystery Letter Puts a Strange Twist on Latest Medfly Crisis," *Los Angeles Times*, December 3, 1988, p. B1 (Orange County Edition).

of the disease on agriculture elicits considerable alarm and concern among U.S. officials and agricultural experts. It is the agricultural equivalent of a threat to use smallpox on a human population, with the difference that FMD is more readily available than is smallpox. Of the biological agents actually used, one was simply sewer water, another was salmonella in eggs, another a plant toxin from the African milk bush, and the last Medfly. Of these, perhaps only the Breeders incident could be considered significant for this study, as it involved the use of a biological agent in a way that could credibly have had widespread impact on agriculture.

It is useful to examine the economic impact of these incidents of agricultural terrorism from the Database. In twelve cases, no costs could be identified beyond the cost of harassment from the threats. In four cases, the perpetrators were able to kill animals, and in two of these four, people were killed as well. In only five cases is it possible to attribute financial costs to the activities. In one case, 17,000 metric tons of grapes were destroyed. In another, 300 pounds of feed were halted from distribution, but it is unclear whether Purina destroyed the feed or simply tested it for contamination. In a third, Palestinian farmers lost an estimated $5,000. In a fourth case, two supermarket chains in Canada stopped importing South African fruit, but reports gave no estimate of losses in currency. In the most significant case, Israeli orange exports were reduced by 40 percent, but again, reports gave no estimate of costs incurred. In two of the more significant cases, the incident looked more like product tampering than an attack against agriculture. In the other cases, costs were extremely limited and minimal. The historical record therefore suggests that it is difficult to achieve significant damage against agricultural targets, with the possible exception of product tampering.

NATURALLY OCCURRING OUTBREAKS OF DISEASE

One means of determining the costs associated with potential subnational BW agricultural attacks would be to examine the impact of naturally occurring outbreaks of disease, particularly within the United States. Historically, both livestock and crops have been affected by a range of catastrophic diseases. Clearly, though, the impact of a particular outbreak of a disease is dependent on a range of factors: the characteristics of the disease, where it occurs, and the measures taken to deal with it.

At the time of writing, a major outbreak of Foot and Mouth Disease (FMD) is occurring in the United Kingdom and has apparently spread to France, the Netherlands and Ireland. Affecting ungulates, cloven-hoofed animals such as cattle, pigs, and sheep, the viral infection has resulted in widespread import bans on livestock dairy and meat products from European Union countries. The disease is extremely infectious and can be spread through either direct or indirect (e.g., by dirty straw or on human clothes) contact with

an infected animal. The British outbreak originated in a single pig herd in north-east England, where animals ate swill containing infected meat imported illegally from East Asia (FMD is endemic in areas of Africa, the Middle East, and Asia). As the origin of the British outbreak shows, the FMD virus can survive processing, explaining the ban not only of live animals from affected countries, but also of many animal products as well.

Between February 20 and May 14, 2001, 1,595[40] separate cases of FMD were reported in Britain, and a much smaller number of possible cases had been reported in France, the Netherlands, and Ireland. Although the disease has a relatively low mortality rate around 5 percent of affected animals, mostly those that are young or old, it has a major economic impact. The meat and milk producing capacity of affected animals drastically declines, and there is an increased incidence of miscarriages in animals that have suffered the disease. Within Britain, compensation is available, so it is more economical for a farmer to slaughter the animal than to keep it. More importantly though, recovered animals may still be viral carriers, presenting a continued threat of infection, increasing the incentive to kill such animals.[41]

Although vaccines are available to counter the disease, these should ideally be administered before an animal is exposed to FMD. This is complicated further as there are seven major strains of the disease and several subtypes, limiting the scope of a vaccination to be effective against all varieties of the disease. The "killed" vaccines offer protection for just six to nine months, so animals must be repeated immunized. More important still is the need to sell meat to countries free of FMD. A vaccinated animal cannot be distinguished from one that has had the disease, nor does vaccination prevent an animal from acting as a carrier. Vaccination, therefore, is an expensive option, particularly in countries where the disease is not endemic, and also had implications for trade. Consequently, the more common response has been to destroy every cloven-hoofed animal on affected farms. Britain has already slaughtered 2,657,000 animals and plans to slaughter 75,000 more;[42] European countries have also slaughtered thousands of animals that may have come into contact with British livestock.

As well as incurring import bans, the outbreak of FMD has restricted movement of livestock within Britain. Markets have closed, and only a small number of animals from unaffected herds are being moved to slaughterhouses, under tightly controlled conditions. Since culled animals from affected herds must be

[40] "Foot and Mouth Outbreak: Special Report," *BBC News Online*, available at http://news.bbc.co.uk/hi/english/in_depth/uk/2001/foot_and_mouth/default.stm, accessed on May 14, 2001.
[41] "Foot-and-mouth disease: The costs and cures," Business News Special, *The Economist*, March 31, 2001, available at http://www.economist.com/printedition/displayStory.cfm?Story_ID=549904, accessed on April 2, 2001.

burned, rather than sold for meat, the restricted number of animals being slaughtered for food has resulted in a shortage that has had to be satisfied by importing meat from outside the UK, at an increased cost to consumers.

As of May 14, 2001, it was still too early to estimate accurately the economic costs to farmers and the wider agricultural sector, beyond that it will be devastating to both. Even those farms that are unaffected stand to suffer huge losses because the disease compelled all livestock markets to be shut, so most farmers have had no income, only expenses, for the past two months. Moreover, the economic prospects for such farmers are grim: their animals are now mostly past the optimum time to ship them off to slaughter, and when the markets finally do open, the price of meat will plummet because every farmer is in the same situation and will flood the market. Moreover, while there will be compensation for farms where animals are slaughtered as a direct consequence of FMD (either through infection or prevention), the compensation for indirectly affected farms is less certain. Even the money for slaughtered animals is unlikely to be sufficient to return farms to pre-disease levels. The government money is based on stock valuation, rather than being compensation for lost income. Once the outbreak is over, the cost of new animals for replacing herds and flocks is expected to be very high due to the relative scarcity of breeding stock.

The FMD outbreak has had significant political implications: the British government felt obliged to postpone a national election, widely anticipated to be called for May, to June, along with local elections. The government's handling of the crisis has be a source of political debate, and the government department responsible for agriculture, the Ministry of Agriculture, Fisheries and Food (MAFF), is itself under pressure, being accused of bungling the prevention and control of the disease.

However, it is hard to suggest that the outbreak presents a strategic threat to the UK economy: agriculture and even the associated loss of tourism are not significant enough. Farming currently represents 0.9 percent of UK GDP and employs 1.5 percent of the UK workforce. The FMD epidemic is likely to reduce the value of the agricultural sector still further, as some farmers decide that their compensation does not permit a return to the occupation that offered economically marginal returns, even before the outbreak. However, the economically more significant impact of the disease will be on tourism. Although FMD only very rarely affects humans (when it presents itself as flu-like symptoms), tourist bookings for holidays in the UK have been severely affected by the disease outbreak. A report by accountants

[42] "Foot and Mouth Outbreak: Special Report," *BBC News Online*, available at http://news.bbc.co.uk/hi/english/in_depth/uk/2001/foot_and_mouth/default.stm, accessed on May 14, 2001.

PricewaterhouseCoopers (PWC) on the cost of the outbreak suggested that although the cost to UK agriculture would be between £500m and £1.6 billion, the total cost of the crisis for Britain in 2001 could be between £2.5 billion and £8 billion, or between 0.3 percent and 0.8 percent of GDP.[43] By the end of April, the Centre for Economic and Business Research estimated that the epidemic would cost farmers £3.6 billion, and the British Tourist Authority estimated £2.5 billion of overseas tourist revenue will be lost by the end of the year.[44] Clearly, a major disease outbreak, such as FMD, has the potential to be catastrophic on an individual farm level; be significant to the agricultural sector; but may not be devastating to the economy as a whole. The same distinction could apply in the U.S. In 1999, the sector of the economy directly related to agriculture represented 1.3 percent of U.S. GDP[45] and in 2000 employed 2.6 percent of the U.S. workforce.[46]

In the Netherlands in 1997, five million pigs had to be slaughtered as a result of swine fever. Since the disease, though harmless to humans, is highly lethal to pigs and extremely contagious, entire herds with affected pigs have to be killed to contain its spread. Due to restrictions on transportation and sale of pigs, necessary to control the disease spread, the Dutch government had to impose breeding bans, and 1.5 million piglets had to be slaughtered to relieve the pressure on overcrowded sties. The cost of compensation for the cull and cleanup of affected farms is estimated at $2 billion. Of this sum, the Dutch government contributed $900 million, and the European Union (EU) contributed $1.1 billion from the EU agricultural fund. Moreover, pig breeding usually contributes about $2.25 billion to Dutch exports; the disease knocked a half point off the country's GDP for the year.[47]

A 1999 dioxin (a highly carcinogenic substance) contamination in Belgium cost Belgian food producers and farmers hundreds of millions of dollars. The incident arose from contaminated feed and led to bans of Belgian eggs, poultry, and also beef, pork, and some dairy products across the EU. It is believed that the original contamination was at Verkest, a company providing animal fats to animal feed manufacturers. The impact continued to spread: nine Belgian, one Dutch, and one French feed manufacturer were supplied with contaminated products, leading to bans on all EU chicken and pork in the United States,

[43] "Foot-and-mouth disease: The costs and cures," Business News Special, *The Economist*, March 31, 2001, available at http://www.economist.com/printedition/displayStory.cfm?Story_ID=549904, accessed on April 2, 2001.
[44] "After foot and mouth," *The Economist*, May 3, 2001, available at http://www.economist.com/printedition/displayStory.cfm?Story_ID=611386, accessed on May 14, 2001.
[45] "Gross Domestic Product by Industry data," U.S. Bureau of Economic Analysis, available at http://www.bea.doc.gov/bea/dn2/gposhr.htm#1993-99, accessed on April 9, 2001.
[46] "Comparative Civilian Labor Force Statistics, Ten Countries, 1959-2000," U.S. Bureau of Labor Statistics, available at http://www.bls.gov/flsdata.htm, accessed on April 9, 2001.
[47] Roel Janssen, "Swine Fever strikes," *Europe*, No. 371, November 1997, p. 43.

Japan, and Brazil. By September 1999, estimates of the cost of the incident to Belgian farmers varied at between $750 million and $1.5 billion, and the Belgian government estimated that it had cost the country around $900 million in lost tax revenue, chemical testing, and veterinary bills.[48]

When FMD struck Taiwan in 1997, over four million pigs had to be slaughtered. Before the outbreak, the swine industry represented nearly 60 percent of Taiwan's livestock products. After the outbreak, pork prices collapsed, and it was estimated that damage to the Taiwanese economy might include $3 billion of lost sales, the jeopardizing of 50,000 jobs, and a half point slowdown in the country's economic growth.

Within the United States, the economic consequences of naturally occurring outbreaks have been less catastrophic than overseas. In 1999, the Mexican fruit fly threatened agriculture across California, when it was discovered in San Diego County and Fallbrook County. The fly attacks more than 250 species of fruits, nuts, and vegetables, laying eggs in ripening fruit and thus spoiling it for sale and consumption. The agricultural economy in San Diego County alone is worth $1.2 billion, but it is difficult to determine the effects of subsequent bans on fruit exports from the county by the Australian, New Zealand, Taiwanese, and Japanese governments. Mediterranean fruit flies were discovered in Riverside County, and guava flies were found in Fresno County. According to the California Department of Food and Agriculture, the state's worldwide fruit exports were valued at about $2 billion in 1997, and 1997 combined fruit, nut, and vegetable production was almost 39 million tons, or more than half of total U.S. production.[49] Within the state, 132,000 jobs and $13 billion depend directly or indirectly on fruit farming. However, thanks to a rigorous program of quarantine and eradication, the damage to Californian agriculture was a mere fraction of these figures.

In 1994, late blight, the fungal disease that caused the Irish potato famine in the 1840s, caused $100 million damage in the United States. The costs of attempting to suppress the late blight within the country equaled the direct losses. The majority of seed potatoes come from a single region, Europe, so the late blight developed into a worldwide problem, with outbreaks in the Middle East, South America, Asia, and Africa as well as Europe and North America. In 1997, the International Potato Center in Lima, Peru, estimated losses worldwide from late blight were about $3 billion annually. In 1995, growers in Washington and Oregon alone lost $30 million. In 1994, a single New York grower lost $1 million, despite extensive use of pesticides, as marketable yields fell by 80 percent.

[48] Dick Leonard, "Scandals damage farmers' influence," *Europe*, No. 388, September 1999, p. 44. "Wrap-Up," *Chemical Week*, September 22, 1999, p. 24.
[49] "California Agriculture," California Department of Farms and Agriculture, available at http://www.cdfa.ca.gov/statistics, accessed on April 12, 2001.

One of the means employed to control the worldwide spread of pathogens is export controls. The World Trade Organization has "phytosanitary" rules that permit even a minor disease outbreak to compel the cessation of a crop's export. This can be seen in the example of the fruit flies in California, or in the case of karnal bunt in Arizona. In the latter example, a relatively mild but highly infectious pathogen was discovered in Arizona wheat. In one day, thirty-two countries banned U.S. wheat imports. It cost the United States hundreds of millions of dollars to eradicate the fungal pest and threatened the country's $5 billion of annual wheat exports.[50]

Differentiating between naturally occurring outbreaks of disease and those caused purposefully by subnational entities is extremely difficult and may be impossible if no group or individual comes forward to claim responsibility for the outbreak. Epidemiological evidence may suggest intentional spread of disease, for example, the appearance of a strain of disease not endemic to the region, or the occurrence of the disease at several nonproximal sites simultaneously. Even this type of information, however, may not be completely reliable. The outbreak of West Nile virus in the northeastern United States that began in September 1999 is such an example, being a naturally occurring outbreak of an exotic, non-indigenous, disease, never previously seen in the United States.[51] In addition, if it were discovered that a particular outbreak had been intentionally caused, would it be in the public's best interests to make that information widely available? Doing so could create panic and incidentally assist the goals of the perpetrator. Naturally occurring outbreaks continue to have economic impacts, but thus far, subnational attacks against agricultural targets have been limited in scope and sophistication. Technical obstacles to effective acquisition, maintenance, and delivery of microorganisms partially explain the limited scope of such attacks, but a more telling explanation is that there is little evidence that subnational groups are interested in this type of attack.

It is widely acknowledged that usable agricultural pathogens are likely to be more easily acquired than are their human equivalents. Dissemination of these agents may also be extremely straightforward, in some cases, such as that of some rusts or FMD, which supposedly require no more than swabbing an infected animal or crop and transferring the sample to a healthy animal or crop elsewhere. The theory holds that these highly infectious diseases would then spread naturally within their new host population. However, rigorous surveillance, quarantine, and eradication programs are likely to help curtail the spread of such diseases, and crop pathogens are generally vulnerable to environmental factors such as light, heat, and wind. Even with frequent transport of agricultural goods across the country, it is reasonable to hope that

[50] Deborah Mackenzie, "Run, Radish, Run," *New Scientist*, December 18, 1999, pp. 36-9.

outbreaks initiated or spread by such methods might be contained within a region. In such circumstances, the attack need not be catastrophic. To achieve widespread effect in all but the most localized crops (such as almonds), multiple attacks would likely be necessary. Discussion of such an approach is beyond the scope of this paper, but it clearly increases the quantities of agent required and the likelihood of being apprehended.

DIVERSITY OF U.S. AGRICULTURE

Part of the reason the United States has been able to avoid some of the most catastrophic consequences of agricultural pestilence has been the diversity of the national agricultural economy.[52] In 1997 the market value of agricultural products sold in the United States was more than $208 billion. Although some states clearly had disproportionate shares of the total, it was widely distributed across the states. California was the leading agricultural state, with products valued at $25.2 billion, or 12.1 percent of the U.S. total; Texas was second with $13.4 billion, followed by Iowa ($12.8 billion), Nebraska ($10 billion), and Illinois ($9 billion). The top five states accounted for 34 percent of the U.S. total. However, 27 states, spread across the country, had agricultural products valued at more than $3 billion; 20 states had more than $4 billion of business, and 9 had $6 billion.

A similarly diverse geographical pattern can be seen among individual agricultural products, particularly major crops and livestock. Of the leading states, measured by cash receipts in 1997, Texas produced about 16 percent of U.S. cattle and calves and about 22.5 percent of U.S. cotton; California about 17.2 percent of U.S. dairy products and 14.7 percent of the country's hay; Iowa about 18.5 percent of U.S. corn, 22.4 percent of the country's hogs, and 17.9 percent of its soybeans; Georgia about 16.1 percent of U.S. broilers; and Kansas about 16.8 percent of U.S. wheat. Clearly, although there are some regional concentrations, such as cattle and corn in the Midwest, the scale of production and geographical distances involved offer some level of protection against catastrophic attacks.

Some other crops are far more concentrated and thus potentially substantially more vulnerable to a major attack. Using 1997 cash receipts figures, within the United States, 92.2 percent of grapes, 47 percent of tomatoes, 33.8 percent of oranges, 77.8 percent of lettuce, 100 percent of almonds, and 75.5 percent of

[51] Jennifer Steinhauer, "Outbreak of Virus in New York Much Broader Than Suspected," *New York Times*, September 28, 1999, p. A1.
[52] The information in this section was obtained from http://www.usda.gov and e-mail exchanges with Jim Tippett, State Statistician for the California Department of Agriculture.

strawberries were grown in California; 41.3 percent of tobacco in North Carolina; 53.5 percent of apples in Washington; 38.9 percent of peanuts in Georgia; 43.3 percent of rice in Arkansas; and 65.7 percent of oranges in Florida.

Even within individual states, crops may be further concentrated, making them even more vulnerable to attack. Three adjacent counties in California—Fresno, Madera, and Tulare—produced 55.1 percent of all U.S. grapes in 1997. Another striking example is lettuce. California cultivated 77.8 percent of U.S. lettuce in 1997, and 57 percent of the national acreage for lettuce production was in six bordering counties in that state: Santa Cruz, Monterey, San Benito, Fresno, San Luis Obispo, and Santa Barbara. Strawberry production provides another impressive illustration. A little over 41 percent of Californian strawberry production, which comprises over 75 percent of total U.S. production, was in two contiguous counties (Santa Cruz and Monterey), and another 33 percent of Californian production was in two nearby counties (Santa Barbara and Ventura).

In addition to these specific concentrations, it is important to note that a few counties spread over many square miles in the relatively compact San Joaquin Valley produce most of these crops. A disease that could affect several crops would have even greater impact on regional economies and aggregate production, thereby increasing the apparent vulnerability of certain sectors of the U.S. agricultural economy.

This geographical diversity of agriculture in the United States can be slightly misleading: although spread over several states, 70 percent of U.S. beef cattle is raised in an area with a 200 mile radius. Moreover, the concentration of animals on individual farms can also magnify the impact of an attack. Large poultry farms may have hundreds of thousands of birds; dairy herds can have thousands of cattle. Some animals, such as pigs and poultry, are often raised intensively and in close quarters. In such cases, even where a disease does not compel that an entire farm be slaughtered, the spread of the disease in such confined conditions may be rapid and extensive. Intensive farming, using large-scale and automated feeding, also increases the scope for attacks that use animal feed as the means of delivery. By contaminating the feed on such a farm, an attacker could legitimately hope to reach a high proportion of the animals.[53]

A similar phenomenon is observable in arable farming in the United States. It is common practice even for large farms to focus on one or two crops, rather than grow a range of different ones. It is therefore entirely possible to threaten thousands of acres of farmland with a single pathogen, because all the fields

are planted with the same crop. In such circumstances, even effective surveillance might be a challenge: on large farms, production methods such as spraying and harvesting are highly automated, so it might be weeks before there is an appreciation of the problem. In the meantime, the pathogen may have been widely disseminated by the wind and by insect, bird, or animal vectors.[54] The danger is compounded by the dependence of U.S. agriculture on a few regions for seeds. The Idaho valley provides most of the seed in the country. This greatly increases the opportunities for contaminating seeds and causing a "sleeper" outbreak of disease, capable of blighting crops across the United States.

In summary, the U.S. agricultural sector, as a whole, appears to be sufficiently diverse and vast as to be invulnerable to a catastrophic subnational BW attack with a significant economic impact. That said, certain portions of the agricultural economy might nevertheless be concentrated or organized in such a way that a sophisticated attack could have significant economic consequences at the regional, state, or local level.

CONCLUSION

Although agriculture throughout the world, including within the United States, is extremely vulnerable to attack, because such an attack would be relatively easy to perpetrate, achieving widespread impact from such an attack would be significantly more difficult. In reality, however, there appear to have been relatively few such attacks worldwide that have even sought catastrophic consequences. Rather than seeking to eradicate a crop or type of animal or poultry from a country's agricultural economy, most attackers have focused on damaging consumer confidence. This has meant that such attacks have been much closer to examples of product tampering than to the devastating strikes that have been the focus of a growing number of government reports, academic articles, and newspaper columns. The economic impact of such attacks is, potentially, enormous: within the United States, agriculture is an industry worth hundreds of billions of dollars and, directly or indirectly, employing millions of people. The willingness and ability of an attacker to jeopardize more than a fraction of that however appears limited. Moreover, the size of the United States and the range of agriculture within the country make it likely that even a major attack would be highly damaging rather than crippling to the country's economy. In addition, although the relative ease of releasing of BW agents against agriculture compared to that of BW agents against human targets implies that BW attacks against agriculture could be quite effective, the potential

[53] Corrie Brown, "Agricultural terrorism: A cause for concern," *The Monitor*, Vol. 5, Nos. 1-2, pp. 6-8.
[54] Mackenzie, "Run, Radish, Run," pp. 36-9.

ease of delivery may be offset by these limiting factors. Effective delivery would at the very least require a sophisticated, multi-pronged attack to achieve major effects, one capable also of overcoming the environmental barriers to effective dissemination.

Historically, most attacks against agriculture worldwide have been directed at consumer confidence and could more legitimately be described as credible threats than as genuine attacks. The number of actions directed against agriculture per se has been limited, and none appears to have occurred on the scale presently being envisaged. However, relatively little is known or understood about the threat of subnational BW agricultural attacks. Although the potential vulnerability to attack could be enormous and could have economically disastrous impacts on individual farms and possibly on specific segments of the agricultural economy, the agricultural economy as a whole, as well as the entire U.S. economy, are unlikely to be significantly affected. However, there is currently a gap between what has actually occurred in previous incidents and this perceived danger. Further research needs to be undertaken to ascertain whether there is a genuine danger and whether the terrorist threat has evolved to the point that terrorists now see agriculture as a worthwhile target. Alternatively, this perceived danger may simply be the latest example of vulnerability-driven, rather than intent-driven, threat assessments. In either case, it is important that more work be undertaken to ascertain the scope of the problem, and determine the best means of minimizing the danger.

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