III. Industry Studies:

Private-Sector Traceability Systems Balance Private Costs and Benefits

In this section, we examine the development of traceability systems in three food sectors in the United States: fresh produce, grains and oilseeds, and cattle/beef. We describe the breadth, depth, and precision of each sector's traceability system and examine the influence that varying costs and benefits have had in the development of traceability in these sectors. We find that traceability systems are rapidly developing as traceability benefits increase in value and as technology drives down the cost of creating and managing information. We also find that the dynamic balancing of benefits and costs has led to wide variation in the development of traceability systems in the three food sectors.

Fresh Produce

The development of traceability systems in the fresh produce industry has been greatly influenced by the characteristics of the product. Perishability of and quality variation in fresh fruit and vegetables necessitate the boxing and identification of quality attributes early in the supply chain, either in the field or packinghouse. This has facilitated tracing capability for a number of objectives, including marketing, food safety, supply management, and differentiation of new quality attributes.

The history of traceability in the produce industry dates back to the early part of the 20th century. The development of refrigerated railcars in the late 1800s allowed produce from the West and other distant areas to be shipped to the major eastern population centers. As a result, local spot market produce sales with face-to-face transactions where both buyer and seller could verify the quality at the same time became less common. Instead, transactions over long distances became the norm (Dimitri, 2001). Problems began to arise due to the high perishability and fragility of most produce: produce quality could change substantially in transit. When produce deteriorated, it was not clear where the responsibility lay—the grower, shipper, transportation firm, intermediaries, or buyer. When delivered quality was less than expected, buyers demanded price adjustments. These long-distance transactions also introduced more intermediaries into the marketing chain. Buyers and sellers needed a system to verify quality at various points in the marketing chain and establish their legal rights in the case of a disputed transaction.

In response to these problems, produce growers urged Congress to provide legislation to regulate marketing practices for their industry, and in 1930 Congress passed the Perishable Agricultural Commodities Act (PACA). One part of the Act focused on recordkeeping requirements in produce transactions for shippers selling on behalf of growers—the most common marketing arrangement for fresh produce. The recordkeeping system provides growers with a paper trail to ensure they receive the proper price for their produce. A shipper must assign a lot number, or other positive identification, to all loads received so as to segregate and track produce from different growers from receipt of the product until the first sale. PACA regulations for shipper recordkeeping establish the first link in the fresh produce traceability system at the shipper level.

More recently, the impetus for further developing traceability systems for produce has come from the industry's concerns about food safety. In the event of a foodborne illness outbreak, damage can be limited if the contaminated product can be identified quickly, allowing other noncontaminated product to be marketed. In the mid-1990s a series of well-publicized outbreaks, traced back to microbial contamination of produce, raised public awareness of potential problems. In response, FDA developed voluntary guidelines for good agricultural practices (GAPs) for reducing the potential for microbial contamination of produce. One part of the guidelines focuses on improving traceability. Some retailers now want their produce growers to comply with GAPs and to provide third-party audits to verify compliance. Some farmers voluntarily provide these audits already. Third-party audits reduce the asymmetric information inherent in a transaction where food safety attributes are not obvious. But this new concern requires more traceback information than required by PACA. In a food safety crisis, retailers and the food service industry are concerned about identifying the shipper of a contaminated product but shippers and growers require more precision to uncover the source of the contamination problem and resolve it. Some have begun to track information on exactly where a product comes from—down to a part of a field in some cases.

The costs of establishing and maintaining traceability systems are generally lower for perishable produce than for other commodities because of the way produce is packaged. Most fresh produce is sold in small well-marked containers (generally boxes), as opposed to bulk sales, because much of it is easily damaged and must be protected during shipment. Containers are so small that they generally contain produce from only one grower. Compare this to the nut or dried bean industry, where the products can be stored in silos without damage until they are packed. In these industries, which are not covered by PACA since they are not considered perishable, product from more than one supplier may be mixed together in a silo.

Because produce is packed in boxes, the industry can easily segregate products with different characteristics of concern to buyers. Segregating various types of products has always been important to the produce industry. Unlike grains or meat, fresh produce is a consumer-ready product. Size and appearance matter. For some commodities, variety is also important. For example, a large Washington apple shipper today could be selling over 3,000 distinct apple products that vary by variety, grade, size, packaging, and other characteristics. Segregation is a necessity. The variation in products is also increasing. In 1987, the typical U.S. supermarket carried 173 produce items. By 2001, the number had grown to 350. The well-established ability to segregate and trace fruit and vegetables has allowed the produce industry to adjust relatively easily to new products with different characteristics such as organic or no-pesticide-residue items.

Tracing Produce Through the Marketing Chain

Figure 4 presents a diagram of the marketing chain for produce. In 2002, U.S. growers produced fruit and vegetables (both fresh and processed) worth $24.5 billion (see table 2). In general, growers can market their produce through shippers, sell it directly to consumers at farmers' markets and roadside stands, or sell it to processors. Shippers may sell directly to retailers and the food

Figure 4
Tracing fresh produce through the food marketing system

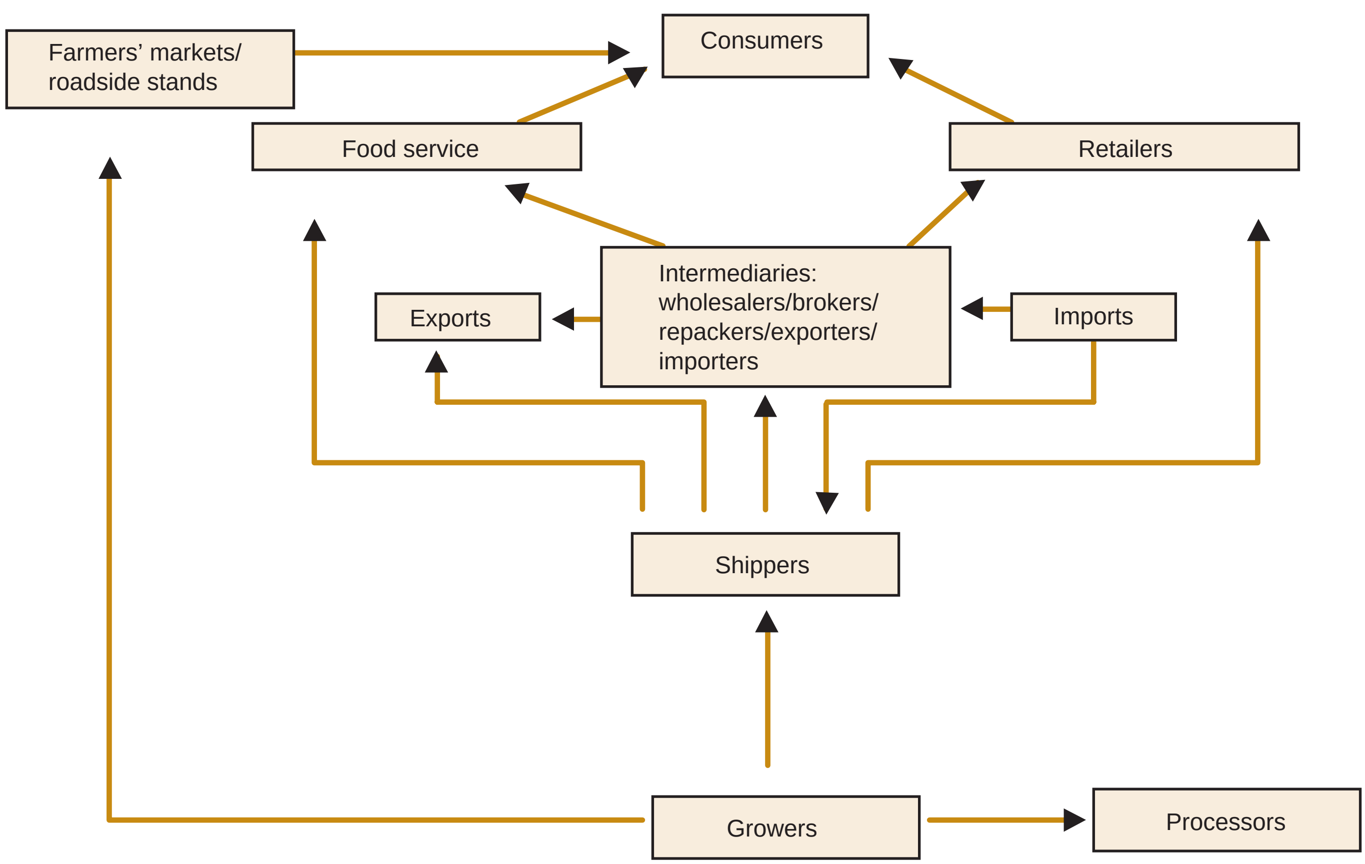


Table 2—U.S. fruit and vegetable industry, 2002

		Production		Imports	Exports
		$ billion	*million tons*	*$ billion*	*$ billion*
Vegetables[1]		13.7	21.4	3.3	1.8
	Fresh		3.0		
	Processed		18.4		
Fruit[2]		10.8	35.6	3.6	2.1
	Fresh		10.9		
	Processed		24.7		

[1] Vegetable trade numbers include fresh and frozen vegetables.
[2] Fruit production numbers contain information for 2002 for the noncitrus industry and the 2001/2002 season for the citrus industry. Fruit imports include fresh and frozen but exports include just fresh.

Sources: Noncitrus Fruits and Nuts, NASS; Citrus Fruits, NASS; Vegetables, NASS; Potatoes, NASS; and FATUS, ERS.

service industry (restaurants, hospitals, military institutions, schools, etc.) or to a range of market intermediaries who in turn sell to retailers and the food service industry. In 1997, 48 percent of fresh produce consumed in the United States was purchased at retail and 50 percent at food service establishments (Kaufman et al., 2000).

Direct sales to consumers are small, accounting for only about 2 percent of final fresh produce consumption in 1997. On the other hand, processing is an important part of the produce industry. In 2002, 86 percent of vegetables and 69 percent of fruit produced in the United States, by weight, went to processing. Trade is also important for the fresh produce industry. In 2002, fresh imports totaled 28 percent of the value of fruit and vegetable production, and the export share was 16 percent. Shippers and market intermediaries both import produce directly from foreign suppliers. Shippers may also sell directly to the export market or to intermediaries who then sell to that market.

This chapter focuses on fresh produce that is marketed by shippers. Fresh produce is more difficult to trace than a processed fruit or vegetable. A processed product, like a can of tomatoes in a consumer's cupboard, carries a wealth of traceback information embedded in its label and its product code printed on the bottom of the can (see box, "Traceability for Processed Fruit and Vegetables"). A fresh tomato on a consumer's countertop may display no identifying information at all. This chapter discusses how the produce industry provides traceability in a challenging environment.

The Grower to Shipper Link—Including Exports and Imports

The traceability chain begins with the grower to shipper link. Growers and shippers generally make marketing agreements before production begins. Growers want to be sure that someone is committed to selling their produce on their behalf. The shipper may want growers to follow specific practices since any problems traced back to the grower would damage the shipper's reputation too. The shipper markets the grower's produce and returns the proceeds to the grower after deducting the agreed-upon fees.

Typically, shippers market for growers and are covered by PACA regulations requiring produce to be identified by lot and accounted for until the first sale. PACA does not require a lot number to be marked on a box although many shippers do so. Also, PACA does not specify the size of a lot, it just requires that it be adequate to provide correct payment to growers. Lots can vary depending on the needs of the shipper and grower. At one end of the spectrum, a lot could be one grower's entire production of a particular crop over the length of a season. But identifying lots by smaller production units can be an important business tool. For example, a grower with several apple orchards may want each to be a separate lot to be able to compare yields with different production practices. From a food safety perspective, it is also important to narrow down where a contaminated product comes from and limit potential losses. If all contaminated product comes from a lot representing one orchard, a grower may be able to continue marketing from the others. On the other hand, there are diminishing benefits to precision. No one traces apples back to a particular tree. So far, there is no reason to do so. The costs would be high, and the benefits, compared to just being able to trace back to an orchard block (or part of one), would appear to be negligible, if not zero. Most things that would affect apples would generally affect more than one tree. So if an apple from a particular block had a problem, the entire block would be treated to be sure the problem was resolved.

Traceability for Processed Fruit and Vegetables

There is a critical difference in traceability between fresh and processed fruit and vegetables. Each processed item a consumer buys is generally individually identified unlike fresh produce. For example, when the consumer gets a fresh tomato home, he may not know where it came from, but a canned tomato product will be labeled and almost always has a product code. Processed products often have consumer-recognized brand names that are also helpful in a traceback situation even if the can or other container is no longer available.

Produce for processing is usually contracted for in advance with very specific requirements for varieties, production practices, and harvest time. The processor may harvest the product and take it directly to the processing facility. Like the fresh shipper, the processor records information about the grower and field for all arrivals. Each load is processed and the time noted by the processor. PACA rules apply for fresh-cut produce like bagged salads and frozen produce, but canned fruit and vegetables are generally exempt.

For canned tomatoes, for example, the recordkeeping challenge is to link the fresh tomatoes coming in to the canned tomatoes going out. Product codes are an important component of traceability. In the canned-tomato case, a product code would generally be inkjet printed or embossed on the bottom of the can. Then a firm would be able to say that the finished product with a certain range of product codes corresponds to fresh tomatoes processed at a certain time that came from a particular grower.

FDA provides guidelines for product codes that would aid a firm with a potential recall situation, but there are no requirements to use product codes. However, the benefits of product codes are so great that most firms use some kind of product code. A typical product code might contain information such as firm, plant, line, date, and time. If there is a recall, FDA needs to know which product is a problem. If firms cannot identify particular product codes that are contaminated, FDA would have no alternative but to recall all the firm's products. Firms want to keep any potential recall as small as possible, which requires more precise identification information. A firm would have to balance the costs of more precise information with the cost of a potential recall to determine the appropriate amount of information.

PACA also does not specify the form of the recordkeeping or accounting system. Some systems are quite sophisticated and others less so, depending on the firm's capabilities and needs. A large company may have a state-of-the-art computer system. In some cases, retailers require their suppliers to use specific computer software to aid invoicing or electronic ordering and other procurement activities. A smaller company may have a less complex system. Some firms do not need much information. If they sell produce for just a few growers or sell to a limited number of buyers, a simple system may be adequate.

PACA establishes the depth of traceability in the fresh produce industry—generally produce can be traced back to the individual grower. But there are some exceptions. For example, growers may agree to pool their produce and receive an average price for the pooled product. In this case, traceback would be less precise, going back to a small group of growers rather than the actual grower. If produce is sold and then repacked by another shipper or market intermediary, PACA laws would not apply, and the origin of the produce could be lost if careful records were not kept. However, in a traceback situation, a repacker could identify the sources of the different items packed on a particular day and narrow the search to several growers.

Shippers who do not sell on behalf of growers are not covered by PACA requirements to identify produce by lot. These include vertically integrated grower/shippers who market only their own production. However, most grower/shippers market for at least a few other growers. Produce purchased by shippers instead of marketed for growers would also not be covered. Both of these groups are probably quite small. But the general business benefits of a traceability system are so great that most firms likely maintain a level of traceability even if not required to do so.

At harvest time, growers send their produce for the fresh market to shippers. Some fruit and vegetables are harvested and transported to a central packinghouse or shed for cleaning, grading, and boxing. Apples, citrus, stone fruit, tomatoes, and potatoes are examples of crops that are shed-packed. When a grower brings in a load of fruit or vegetables to a central packinghouse, the packing line is cleared of all other loads. The grower's whole load then goes through the packing line all at once or, in the case of storable products, like apples or potatoes, the produce may first go into storage until packing at a later date. Information about how much is graded into different qualities and sizes, including culls, is recorded for each lot. The shipper may also collect other data on the lot such as specific field or orchard, pickers, harvest date, etc. This information facilitates payment to the grower, operations management, and, if necessary, traceback. The shipper packs and labels the cartons, usually with an ink jet printer.

Other fruit and vegetables are packed in the field. For example, lettuce, berries, broccoli, and melons are typically harvested, wrapped, and boxed in the field. The shipper uses stickers on each box, or on each pallet of boxes, that generally identify the grower, packing crew, and date. Handheld ink jet printers are available for use in field packing but are used infrequently because they are expensive.

Containers are printed with various types of information relevant to different people along the marketing chain. Pallets of boxes may also be labeled. Because fresh produce is not transformed before it gets to the consumer (unlike grains and livestock), it is easy to add stickers, tags, and other special labels to the produce to appeal directly to consumers. Each of these methods of identifying produce is discussed below. The exact type of information provided will depend on various laws that apply and the needs of the shipper and buyer.

Information on Boxes PACA does not require any information on boxes, just that everything printed on the box be true. In practice, boxes provide a wealth of information, some required by law and some voluntary. Typically, States require that certain information be included on a box. For example, California State law requires each produce box to identify the commodity and variety, responsible party (entity, town, and State), and quantity (weight, count, or size).

Although not required, most shippers voluntarily mark boxes with lot numbers. It is easier to look up records by lot number than to have to search through other records to identify a particular grower's product. FDA would like to see growers also add lot information to invoices to help speed up traceback in a food safety outbreak (FDA, 1998). If a shipper is selling only for himself and a neighbor and can keep the boxes separate, there would be no need for lot numbers on boxes. Recordkeeping alone could indicate whose boxes were sold to which buyer.

In addition to ensuring proper payment, the traceability system that identifies boxes by lot can also be important for general business operations because not all produce is of equal quality. For example, if someone liked a particular purchase and wanted more from the same grower, a shipper would need to know whose product, identified by lot number, was sent. Alternatively, if a product does not hold up well and a buyer complains, a shipper wants to know which grower's product was involved. The shipper may dock the price for that load, decide to not ship for that grower again, or ship only to nearby markets. Similarly, if produce is exported but fails phytosanitary inspections because of the presence of pests, an exporter might request no more loads from the lot with problems.

Labeling on boxes is important for marketing. Produce growers and shippers are always looking for ways to distinguish their product and raise its price above that of an undifferentiated commodity. Currently there are several characteristics that consumers are particularly concerned about. If organic produce is to be marketed as such, it must be marked to verify that production practices meet USDA's organic standards. Similarly, produce with no pesticide residues can be marked with a third-party certifying seal to verify its status.

Marketing orders, which allow producers to collectively regulate certain marketing activities for an industry, may also require additional label information. A marketing order may require that shippers market only produce of a certain quality or size. Quality standards can bolster a product's reputation, which benefits all growers in the order. Restriction of supply can also raise the price for all producers. This type of program can involve additional mandatory markings on boxes to ensure that the marketing order can regulate the program by identifying producers who are not complying and undermining the integrity of the program.

In the case of California peaches, the marketing order requires positive lot identification (PLI) which means that each box of peaches is inspected by a USDA inspector to verify that the quality meets the marketing order specifications. The size of the lot is specified in the marketing order and is not necessarily the same lot used by shippers to comply with PACA. Some marketing orders require additional information. The California peach marketing order also requires that each box be marked with the packinghouse number and date. The additional information allows the shipper to identify whose product was packed at that location and time.

Marketing orders can also be used to provide more precision in traceback. In addition to individual grower efforts to improve traceback capabilities, grower organizations have become more concerned about the reputation of their crops for food safety. Several grower organizations have developed systems to strengthen traceability, which encourages grower responsibility and reduces the free-rider problem in developing a positive industry reputation—a public good. In the case of an outbreak, a grower organization that encourages traceback can prove to the public that their product is not responsible for the problem. Or, when the industry is responsible for the outbreak, the problem grower or growers can be identified and damage can be limited to that group. The California cantaloupe industry has developed a more precise traceback system to deal with potential food safety issues (see box, “Cantaloupe Industry’s Response to Food Safety Problems”).

Another set of mandatory labels relates to products exported to other countries. Produce that is grown or treated for export may be required to bear a mark from USDA’s Animal and Plant Health Inspection Service verifying that the product meets certain phytosanitary provisions. Foreign countries requiring the phytosanitary provisions would not accept a box without the correct markings. In the case of Washington apples, only those that have passed a cold treatment process may be exported to Mexico, and boxes must be marked with the number of the registered treatment facility.

Shippers may also import produce directly to market with their domestic production as a means to extend their marketing season or provide more variety in product offerings. Almost all imported produce, like domestic produce, is marketed on behalf of the foreign growers so the transactions are also covered by PACA. Typically, the produce is packed and labeled in the foreign country to comply with U.S. labeling requirements, but it may be repacked in the United States as well. The only additional labeling requirement for a box of imported fresh produce is that it show a country-of-origin label. For produce in consumer-ready containers, such as raspberries in plastic boxes, grapes in bags, and shrink-wrapped greenhouse cucumbers, each container must be labeled with the country of origin.

Information on Pallet Tags After initial packing, boxes are formed into pallets, and a pallet tag with a barcode is sometimes attached. The number of shippers using pallet tags is increasing. Pallet tags are for internal accounting and logistics; they are not required by law. The tags reflect shipper needs. A typical pallet tag might indicate the date packed, packing shift, grower, lot number, variety, grade, style of pack, and size. Pallet tags allow staff moving pallets in cold storage with forklifts to easily find the exact product they are looking for without having to read the small print on the boxes. Scannable pallet tags are also used to verify that orders contain the correct products. Pallet tags are also useful in narrowing the scope of a quality or food safety problem beyond just the lot. If the only problem products in a lot were on a pallet shipped to one distribution center, the focus of the investigation would concentrate on contamination sometime after the pallet left the shipper. If the only problem pallets from the lot were packed during a particular shift at the packinghouse, some kind of postharvest contamination might be suspected. While there are voluntary Universal Code Council standards for pallet tags, very few U.S. produce firms use them. Most barcodes are internal systems that can be read only by the shipper. Pallet tags are discussed again below.

Cantaloupe Industry’s Response to Food Safety Problems

Beginning in 2000, the California Cantaloupe Advisory Board (a marketing order for California cantaloupe grown north of Bakersfield) began requiring additional traceback information on cantaloupe boxes as part of the State marketing order (this program was voluntary in 1999). This was not a very difficult process. California cantaloupe is field-packed and the Board had already contracted with the California Department of Food and Agriculture to inspect cantaloupe during harvest for quality control and apply an inspection sticker to every box (growers pay the Board a per-box fee for this service). Cantaloupe from this area cannot be sold without the sticker identifying the county and shipper.

The new program requires information on the packing date, field, and packing crew which allows a grower to trace a problem back to a particular part of a field. This would allow a grower to determine if contamination perhaps originated with a sanitation problem with a particular packing crew or was more widespread and perhaps originated with irrigation water. Some growers had already been providing this additional information on a voluntary basis. Adding this additional traceback information to the box was neither particularly costly nor complicated. It did take some administrative changes, however. To be able to require traceback, the members of the Board had to propose a change to the marketing order and vote on it. The original marketing order covered grades and quality standards.

The new marketing order specifically approves “such grade and quality standards of cantaloupes as necessary, including the marking or certification of cantaloupes or their shipping containers to expedite and implement industry practices related to food safety” (California Department of Food and Agriculture, 2003). If a foodborne illness outbreak were to occur, this program would allow the industry to immediately confirm or deny that the problem is due to California cantaloupe and help growers pinpoint the source of the problem. This may be the only grower-organized program for produce in the United States that requires such detailed traceback information on each box. To date, the system has not been necessary for a food safety outbreak.

Information on Individual Produce Items By the time fresh produce reaches retailer shelves, many products have lost their identity. A bin of loose potatoes is completely anonymous unless displayed in its shipping box. But some products do retain at least some of their identity—potatoes packed in bags, bagged salads, berries in plastic consumer-ready containers, and items, such as bananas, that are marked with stickers emblazoned with their brands. The trends toward more fresh-cut produce, consumer-ready packaging, and branded products ensure a continued increase in the information available to consumers when selecting fresh produce. In 1997, 19 percent of retail produce sales were branded products, compared with only 7 percent in 1987 (Kaufman et al., 2000).

Retailers often request that fruit and vegetables sold loose (as opposed to those in consumer-ready packages like a bag of carrots) carry stickers with the product's price-look-up (PLU) code. Stickers work relatively well for some products such as large tomatoes and apples. Stickers do not adhere as well to other products with a rough texture such as cantaloupe. Some products, such as chili peppers, are too small to use stickers although they could be packaged instead of being sold loose and then a sticker could be applied. The primary motivation for PLU codes on loose produce is to ensure that the retail cashier rings up the right price code for each item and charges the right price—identification of the item, not traceability *per se*. Shippers charge for this service. Some shippers use stickers with their company, brand name, or additional product attributes, as well as the PLU code. This can also convey useful information to the savvy consumer. For example, greenhouse tomatoes sold loose in bins usually have stickers with the firm name applied. Consumers may prefer one firm's tomatoes to another's. Such information could prove useful in a food safety traceback situation, if consumers paid attention to it.

Since the only product information for produce sold loose that actually reaches the consumer is the PLU sticker, there is some interest in trying to put more traceability information on it. Retailers want scannable PLU stickers to reduce labor costs and cash register keying errors. With reduced space symbology (RSS), additional information such as a shipper code, and perhaps even lot, could be incorporated into a barcode. There are, however, constraints to sticker size and the amount of information that can be included. The newest stickers also require newer scanning machines; that requirement could delay retail adoption of RSS.

The Shipper to Retailer or Food Service Establishment Link—Direct Sales and Intermediate Sales

Shippers sell produce to a wide range of final commercial customers—retailers and food service establishments—and market intermediaries. If a shipper sells directly to a retailer or a food service buyer (an increasing trend in the industry), traceability can be straightforward since PACA requires recordkeeping to the first buyer. Recent research shows that shippers' share of sales made directly to retailers and mass merchandisers increased between 1994 and 1999. For example, 63 percent of total grape sales and 54 percent of orange sales were direct sales in 1999, up from 60 percent and 48 percent, respectively, in 1994 (Calvin et al., 2001).

While the shipper has a wealth of information about the product, only a limited amount of information is forwarded to commercial buyers in accounting records. Information on the box and pallet is generally not entered into the buyer's database since it is not in a standardized machine-readable form. The commercial buyer creates a new tracking system. The link between the shipper and buyer databases is the purchase order number for each transaction. If the buyer calls up about an order and has the purchase order number, the shipper can access all his records about the product including lot and pallet numbers.

As a commercial buyer receives each load, information is entered into the firm's data system that tracks the entry and eventual disposition of the product. For example, a large retailer might have a central warehouse that receives produce from shippers and then distributes produce in smaller volume to its local stores. The more sophisticated distribution centers add new internal pallet tags specific to the retailer's tracing system. For example, it would link to information on the purchase order number, the date of receipt for use in rotation of the stock, and information on storage location in the warehouse. The pallets received from the shipper may be broken down and then reformed into mixed pallets (a pallet of different products and/or different suppliers) to be shipped off to a local retail store or food service firm. The outgoing pallets also need pallet tags. These outgoing tags do not, however, link individual boxes back to their purchase order number, so the commercial buyer does not necessarily know which suppliers' product went where. In a traceback, commercial buyers would look through their records to see what they had in stock in the warehouse during the relevant time period, identify the purchase order numbers associated with that product, and contact the shippers. If there is only one supplier, there is no problem. If there are two or more, traceback becomes more difficult.

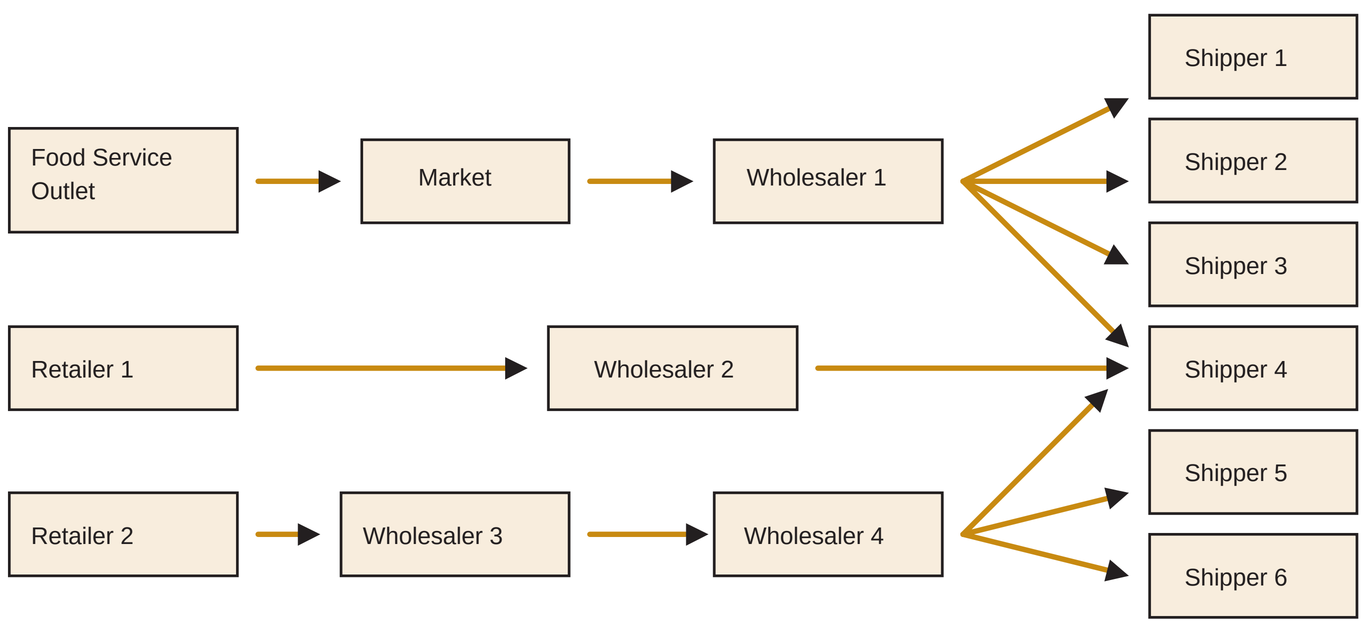
In foodborne illness cases where there is more than one supplier, multiple outbreaks may provide additional information to identify the source of contamination. Consider a hypothetical example of a traceback where multiple outbreaks would help to pinpoint the most likely source of contaminated product (see figure 5). Looking at just the Food Service Outlet or just Retailer 2, both of which received produce from multiple sources, would provide insufficient information to allow FDA to determine the source of contamination. Looking at both together, however, shows that Shipper 4 is likely to be the source of the problem. If FDA had information only on Retailer 1, which received produce from just one shipper, that information alone would be sufficient to identify the probable source.

Better traceback requires a system that maps out the exact path a box of produce follows through the distribution center. If there were a standardized machine-readable data system, the shipper's pallet tag could be read as the pallet entered the system and linked to the buyer's pallet tag to carry data such as shipper pallet and lot number. Similarly, as boxes left the buyer in new mixed pallets, the lot information on the box could be tracked to record exactly where that box went. If such a system were in place, a food safety problem in a particular store could be uniquely linked back to the distribution center and the original shipper's pallet, lot, and purchase order.

There is growing recognition in the industry of the potential efficiency gains from developing a traceability system that is standardized across individuals up and down the marketing chain. The U.S. Produce Marketing Association and the Canadian Produce Marketing Association are collaborating to develop a strategy for adopting the UCC.EAN standardized barcode system. Bolstering the shipper-commercial buyer link involves standardized machine-readable information on pallet tags and boxes (*The Packer*, 2003).

In a more complicated transaction, produce may also pass through other hands, including one or more intermediaries such as brokers, wholesalers, repackers, terminal markets, or exporters before reaching the final point of consumer sale. These indirect sales can sometimes pose traceability challenges. Nearly all firms in the produce marketing chain require a PACA license which imposes recordkeeping requirements, but each layer of transaction adds another chance for human error, and a different tracking system may be used at each stage in the marketing chain. Traceability depends on the recordkeeping standards of the market intermediaries. Many of these intermediaries are large companies with sophisticated traceability systems that track incoming and outgoing shipments in the same way that large retailers do. Some are smaller firms and may have less comprehensive systems. As produce passes through many hands, the information on the box becomes potentially more important for identifying its source.

Figure 5
Hypothetical traceback scenario with multiple outbreaks



A standardized traceability system up and down the marketing chain would make traceback for sales with intermediate buyers much easier. If the last commercial buyer could identify the lot, pallet, and shipper immediately, FDA could avoid the delay of having investigators wade through information on several transactions to determine the original shipper.

Certain types of markets can also pose problems for tracing. Terminal wholesale markets, for example, serve a number of types of buyers: large retailers or food service firms that need to make an emergency purchase to fill in a sudden hole in their supplies, small firms that rely on the terminal market for their main purchases, and sidewalk food stands. The last category, although probably a very small share of sales, can pose a particular problem for tracing sales because they are often cash transactions that are not necessarily well documented.

Likewise, certain types of market intermediaries (repacking operations for example) can present traceability difficulties. Frequently, tomatoes are sold and shipped from their production regions to repackers or wholesalers who ripen, resort, and repackage for uniform color and then sell to local retailers and food service buyers. On any day, repackers may use tomatoes from several different sources to create a new box of tomatoes. In a traceback situation, a repacker might be unable to identify the exact grower but could at least identify a small group of growers whose tomatoes could have been in the box.

Shippers also sell fresh produce to the food service industry, either directly to the food service firms or their specialized warehouses, or via wholesalers and other intermediaries. Big fast food companies are particularly concerned about food safety and will often deal directly with a shipper to ensure the product meets their exact production standards, which could be specified in a contract. For tomatoes, fast food firms might use an integrated shipper/repacker (one that is repacking only with its own tomatoes), which maintains a higher level of traceability than an unaffiliated repacker. But the food service industry also consists of many small restaurants with small produce purchases. These firms are probably buying from wholesalers or other intermediaries.

To the Consumer

The final step in produce traceability is from the last commercial buyer—generally the retailer or food service institution—to the consumer. This can be a weak link in traceability. Many consumers might be uneasy about the idea of retailers' keeping records of what they buy. But this information is important for traceback, particularly for a food safety problem.

Many observable quality issues can be resolved if a consumer returns produce in poor condition to the retailer. For example, if a consumer brings in a package of bagged lettuce that has spoiled before its sell-by date, traceback would also be a routine process since all the information is printed on the bag. Even a head of lettuce may have a plastic sleeve with the shipper name or a twist tie with a firm name to identify its origin. Traceback for a food safety problem is more problematic. Food with microbial contamination generally looks fine. Even testing cannot always pick up contamination problems because microbial contamination is often sporadic and present at low levels. By the time someone becomes ill and consults a physician, and health authorities identify the contaminated product and the place and date of purchase (or consumption in the case of food service institutions), the perishable produce is usually long gone. Even when the produce comes in consumer-ready packages, such as a bag of apples marked with the shipper's name, the packaging is also usually discarded. For a branded processed product, consumers may know that they always buy a particular brand, but for a fresh product, most people have no idea who provided it. In cases where the box or other container is no longer available, traceback relies on good recordkeeping by all the firms in the marketing chain.

If the Centers for Disease Control and Prevention or State/local health departments can identify the contaminated product and the place and date of purchase, commercial buyers can usually identify the shipper. In the best case scenario, where a firm was using only one supplier of the problem product on that date, the retailer or food service firm could call up the shipper, who would have all the information about the product. But in practice there can be a lot of uncertainty about whose product was sold.

One potential solution to this problem of tracing from the retailer to the consumer and back is the RSS sticker with barcode identifying the shipper as well as the PLU code. If a retailer knew only the day the problem produce item was sold, the firm could look at all the product sold that day and perhaps reduce the number of shippers that could potentially be involved. If a consumer used a consumer purchase card, a retailer might be able to look up just what the sick consumer bought and know the shipper to contact. In the case of club stores, where only members can make purchases, traceability is more complete.

Conclusions

Traceability has been a critical component of the produce industry for many years. Historically, the perishability of produce and the potential for deterioration during cross-country shipment demanded better recordkeeping to ensure correct payment to growers. Because produce must be packed in relatively small boxes to minimize damage, implementation of traceability has also been relatively low cost. The industry is in a much better position to adapt to new concerns than industries where bulk sales have been the norm and segregation and traceability would involve new costs.

Currently, there are two systems of information involved in produce. First, there are physical labels on boxes and sometimes on pallets. For general business purposes, it is important to be able to identify the product in the boxes. There are various State laws requiring box information, and marketing orders also often require additional box information. Pallet tags are completely voluntary. Second, a paper or electronic trail allows traceback between different links in the marketing chain, though each link may use a different traceability system. U.S. and Canadian produce organizations are looking at ways to promote a universal traceability system between links in the chain. They recommend that shipper name, pallet tag number (if available), and lot number be part of the paperwork at each link. This would effectively combine information on boxes and the paper or electronic trail. Such a system would require developing a standardized system of barcodes or other machine-readable information, as well as shipper and buyer investment in machines to apply and read codes. One of the challenges to developing a compelling technical solution that all market participants would use voluntarily is to ensure that all segments of the industry can afford the costs of a new system.

Grain and Oilseeds

Virtually all grains and oilseeds produced in the United States are traceable from production to consumption. For the most part, however, quality and safety variation in grain and oilseeds has not warranted the cost of precise traceability systems. Systems to track product to elevators, the point at which quality and safety are monitored, have been largely sufficient for the efficient operation of grain and oilseed markets. Growing demand for specialty crops, including products not genetically engineered, has spurred the development of more precise traceability systems, although the elevator still operates as an important quality-control point.

The history of the grain supply chain in the United States chronicles the growth of an infrastructure built to manage large flows of product differentiated on a limited number of variety or class attributes and then blended or processed to meet quality and safety standards. In most cases, the blending and homogenization of product begins as soon as farmers deliver their crop to the local elevator and continues until the crop is transformed into animal feed or into the loaf of bread, cereal, or other grain product on grocery-store shelves. In most cases, grain and oilseeds are mixed and transformed all along the chain, so that safety and quality characteristics are redefined at each step. As a result, processors need information on the characteristics of the product as delivered only from the last stage of processing. The high level of processing necessary to produce consumer-ready grain products eliminates most safety and quality problems stemming from mishandling or contamination early in the supply chain and often eliminates the need to establish traceback to the farm for safety or quality reasons.

More recently, consumer and processor demand for specialty grains, including products not genetically engineered, has introduced the need to differentiate product over a new set of quality characteristics. In a few cases, these new quality demands are accompanied by demands for traceability systems to track product back to the farm. For the most part, just as it has many times before, the grain and oilseed infrastructure is adjusting to accommodate new quality variations and ensure the delivery of homogeneous product meeting new quality and safety standards.

From the Farm to the Elevator

With the exception of a small amount of on-farm feed use (mainly corn), most grains and oilseeds are marketed through a supply chain that includes country elevators, sub-terminal elevators, processors, river elevators, export port elevators, and retailers (fig. 6). This supply chain handles a wide range of bulk commodities distinguished by variety or class, such as No. 2 yellow dent corn and hard red winter, hard red spring, soft red winter, white, and durum wheat. Large-scale marketing affords efficiencies in terms of lower per-unit handling costs.

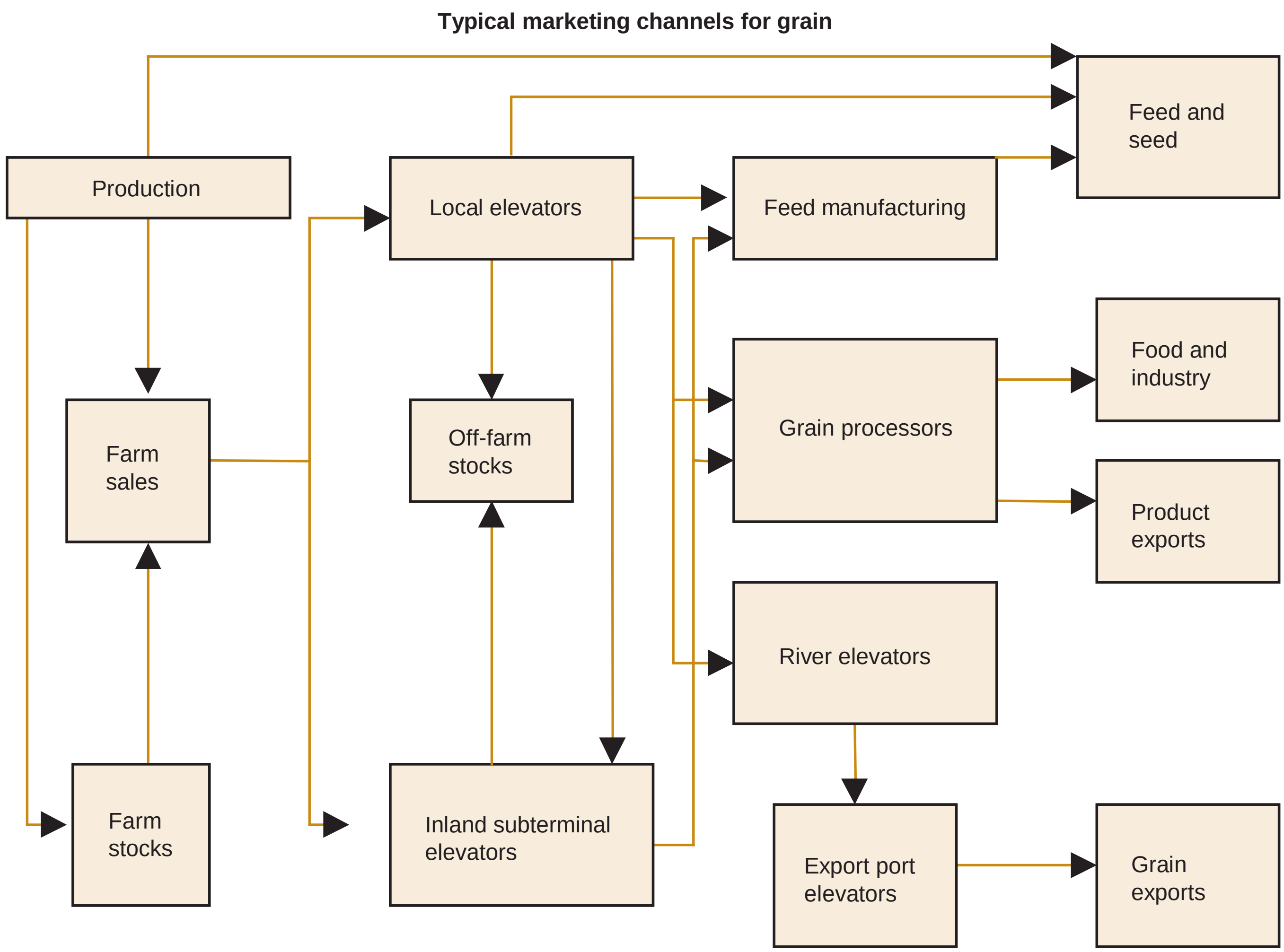
Conventional Crops

When farmers harvest standardized crops, they usually store the grains and oilseeds in large storage units (or bins) on their farms. Crops of a certain type—for example, wheat—are typically commingled, even though producers may have grown several different varieties. These may differ in terms of yield, maturity, resistance to adverse weather conditions (e.g., drought), and other factors, but often do not have quality attributes valued by buyers and are not sold at a premium.

Producers sell their crops to local (country) elevators. In 1997, there were 9,378 wholesale handlers (particularly country and export elevators) of grains and oilseeds operating in the United States (U.S. Dept. Commerce, Bureau of the Census, 2000). When farmers deliver their crops to local elevators, they are given receipts that indicate the commodity sold, its weight, price received, time of purchase, and any premiums or discounts for quality factors such as extra moisture, damage, pests, or dockage (easily removable foreign material). Country elevators keep this information, thus establishing a recordkeeping link from the product in an elevator at a point in time to the farmers who supplied the product. An elevator operator knows the farmers who delivered grain and oilseeds at that location and the geographic area from which they came.

This rather imprecise system of traceability from the elevator to the farm is sufficient because quality variations that may exist at the farm level are mostly eliminated at the elevator level. The elevator serves as a key quality control point for the grain supply chain. Elevators clean each shipment to remove the foreign material and lower quality kernels or beans. If the moisture level is too high, the shipment may be dried before being placed in the silo. Elevators also sort deliveries by variety and quality, such as protein level. Different quality, variety, or classes of crop are either segregated at the silo or bin level

Figure 6
The grain marketing system



Source: Adapted from *The Organization and Performance of the U.S. Food System* by Bruce W. Marion, 1986

depending on the size of the elevator and anticipated volumes of production. Elevators then blend shipments to achieve a homogeneous quality. Once blended, only the new grading information is relevant—there is no need to track back to the farm to control for quality problems. Strict segregation by farm would thwart the ability of elevators to mix shipments for homogeneous product and would not be necessary for safety or quality assurance.

Country elevators strive to market crops of homogeneous quality to millers, feed manufacturers, and oilseed crushing facilities. Millers and crushers, in turn, sell processed grains (such as corn grits), flours, and oil to food processors. Crushers also sell soybean meal to feed manufacturers. Country elevators send grain and oilseeds to inland sub-terminal and/or river elevators, which collect crops from different regions. River elevators then ship crops to port elevators that load grain and oilseeds onto vessels for export to foreign countries.

Precision in traceback to the farm declines the further one goes down the production chain. As grain is funneled from a wider geographic area, it is more difficult to pinpoint from where and from whom the commodities came. For example, grain held at port elevators may have originated from a number of country elevators serving a large number of farmers across a wide geographic area. Traceability at the port elevator level typically extends only back to the country or sub-terminal elevator.

Recordkeeping systems for conventional grains and oilseeds can therefore be best characterized as "one step forward, one step backward." That is, handlers know from whom they bought grain and to whom it was sold. This one-step-forward, one-step-backward system means that a given handler is acquainted only with the entities that it deals with directly. Retrieving information from further up or down the marketing chain forces the handler to rely on the recordkeeping ability of others in the chain. For example, if a river elevator needed information on the farmers who produced the soybeans stored in its silo, the river elevator would need to look up in its own files the identity of the local elevators that supplied the soybeans. Each local elevator would have to check its accounting information on which farmers had made deliveries. Thus, traceability to the farm, or handful of farms, in conventional grain marketing is possible only with the collection of records from each handler along the supply chain.

Grain or oilseed handlers that are vertically integrated have access to more information. That is, such firms operate at more than one stage in the grain marketing chain. For example, a large grain company may own local elevators as well as river and export port elevators. The depth of information is greater for vertically integrated firms simply because records from different stages are maintained in-house. Vertically integrated firms can more easily retrieve information from their operating units.

Whether vertically integrated or not, elevators serve an important role as a quality-control point in the grain supply chain and as the linchpin in the traceability system. They monitor and control product quality and safety and keep records on the flow of product from farms to the elevator. Since the bulk system fulfills buyers' demands with cleaning and blending, there is no need for information to be collected throughout the supply chain: information from the next immediate step in the supply chain is sufficient.

Specialty Crops

While most grains and oilseeds in the United States are produced and marketed in bulk, there are growing markets for more specialized commodities. Some examples include high-value crops (e.g., high-oil corn), organic foods, and non-genetically engineered crops (Dimitri and Richman; 2000; Lin, Chambers, and Harwood, 2000). Traceability systems are becoming more extensive in these markets, reflecting customers' demands to verify the presence of the specialty attribute, particularly when it is a credence attribute. These traceability systems document the efforts of each segment in the supply chain to segregate the high-value specialty product from conventional or other specialty products.

Segregation and traceability documentation for specialty attributes may begin as early as the seed. At this point, documentation verifies the existence of specific crop traits and purity levels. In general, seed is tested and lots are tracked using identification numbers. If necessary, specific information about parent genes is obtained from the seed developers.

At the farm level, farmers must segregate crops to ensure that cross-pollination does not result in a crop that does not meet required specifications. For example, producers of non-genetically engineered crops, particularly corn, may be required to keep genetically engineered varieties away from other fields by a minimum distance to prevent cross-pollination. In addition, farmers must either dedicate certain storage, harvesting, and other equipment to each specialty crop or thoroughly clean equipment and storage units between different crop types. Some farmers specialize in particular specialty crops thereby avoiding commingling problems.

To verify that adequate precautions have been taken at the farm level to assure the quality of the specialty grain, farmers may be asked to provide elevators with third-party certification. For example, for organic crops, third-party certifiers accredited by the U.S. Department of Agriculture work with individual farmers to determine the requirements for organic production for each crop and then verify that these requirements have been fulfilled. Farmers provide this certification to buyers.

For some crops, farmers may be asked to submit their shipments for testing. For example, the oil content of corn and the protein level in wheat are routinely tested. Tests may be performed by the elevator or by independent third-party verifiers. Elevators usually keep records of test results, including the identity of the farms that sold the commodities to them. For some specialty crops, buyers may simply require farmers to "certify" that the crops are as specified. This was the case early in the development of differentiated markets for non-genetically engineered crops.

As the repository of documentation certifying attributes or the point of attribute testing, elevators play an important quality-control function in the specialty crop supply chain. In many cases, testing results and certifications are not sent further up the supply chain because elevators essentially certify the quality and homogeneity of their products. As with the conventional supply chain, elevators blend shipments to achieve a homogeneous quality and meet sanitation and quality standards. Once blended, only the new attribute information is relevant;

there is no need to track back to the farm to control for quality problems.

At the elevator level, segregation of specialty crops is achieved with dedicated elevators (those specializing in one type of specialty crop, such as organic, waxy corn, non-genetically engineered crops, and food-grade soybeans), multiple bins, or by thoroughly cleaning bins and equipment after each crop has passed through. If identity preservation is required, shipments may be containerized in order to minimize handling and the number of points at which quality could be compromised.

A key constraint in the ability of the bulk-system infrastructure to supply specialty grains is the ability of elevators to adjust their product flow in response to consumer demand. Large grain companies with a large infrastructure at their disposal, including country and export elevators as well as railcars and barges, may have more flexibility in managing flows and creating segregated systems. Likewise, smaller producers with access to a number of small elevators may be able to efficiently manage specialty flows. However, as the number of specialty attributes grows, investments in elevator infrastructure may be required, raising the costs of segregation.

Segregation and documentation for specialty crops continue from the elevator to the final producer or consumer. Trucks, railcars, and barges must all be thoroughly cleaned between specialty crops or be dedicated to a particular specialty crop, as must sub-terminal, river, and export port elevators. All along the line, either testing or process certification guarantees that quality attributes are maintained. As with conventional crops, such verification is usually of the “one-step-forward, one-step-back” variety. Each player in the specialty chain is usually required to retain information on product identity, volume, lot numbers, test results, and suppliers/customers to ensure quality and allow for traceback if problems arise in the marketing chain. How far back a given elevator can trace a shipment depends on the extent to which the firm is vertically integrated. As with conventional grain production, vertical integration in handling—whereby a firm owns operations in more than one level of the marketing chain (e.g., country and export elevators)—eases traceback, since information can be retrieved from internal suppliers and/or buyers. If elevators are not vertically integrated, they must rely on other handlers to retain much of the information.

A number of third-party certifiers offer services to verify that specialty quality attributes have been adequately safeguarded throughout the supply chain. In the case of organic products, farmers, handlers, processors, and retailers are certified by third-party firms that must be accredited by the U.S. Department of Agriculture. Wholesalers and retailers must prove that the organic product came from certified sources satisfying the organic labeling and handling requirements. As a result, organic products can be traced throughout the supply chain.

Generally, the cost of establishing and verifying supply chains for specialty grains makes them more expensive to produce than conventional grains. As a result, farmers, elevators, and handlers may be reluctant to construct these chains and produce these grains without some guarantee that they will receive adequate compensation. A large segment of the specialty crop market is therefore built on contracts. Contracts not only allow buyers to specify the attributes they desire, they also provide sellers with assurances that their costs will be covered through price premiums or long-term sales. Premiums must cover the additional physical costs associated with segregation and traceability, and also customer service and coordination activities.

Elevators typically contract with producers to grow certain varieties, such as high-oil corn or food-grade soybeans, with the delivery volumes and times being predetermined. The contracts may specify that producers follow certain production and handling practices that are consistent with the traced products. Contracts are also drawn up between the elevator and the buyer. Contracts provide a type of paper trail by which commodities can be traced.

Manufacturers may require information on a host of characteristics, such as color, variety, grind, etc. For example, a cereal manufacturer that uses a specific class and grade of wheat to produce the desired flake curl may require special coding. Larger food processors may also require that suppliers use codes that signify that the ingredients are specifically for the food manufacturer. All these steps are taken to ensure high and consistent quality over time—and to facilitate efficient ingredient management. For efficient output management, firms may also track final products. This information allows companies to understand which products are popular and where they are selling well. This information helps companies produce the right mix of products and the best distribution.

In general, traceability systems for specialty crops are more precise than for conventional ones. The paperwork generated with contracting and the existence of relatively few producers and handlers who deal with specialty crops make it easier to track shipments; a railcar filled with a certain commodity can be traced back to a small set of handlers and producers. However, in most cases, one could not likely associate an individual kernel or bean with a particular producer, since even specialty crops are commingled by elevators. There are a few cases for which one can trace shipments back to individual farmers. For example, food-grade soybeans are containerized on-farm and shipped directly to Japan.

Conclusion

Regardless of whether they involve specialty or conventional grains, vertically integrated firms or independent operators, most traceability systems for grains do not extend back beyond the country elevator. For most manufacturers and consumers, this depth of traceback is sufficient to ensure quality and safety, even for specialty quality attributes. As long as elevators continue to ensure the safety and quality of the shipments they receive from farmers, manufacturers will likely not demand farm-level traceability.

If elevators fail to monitor the safety of the system, manufacturers and consumers may demand better control and maybe even farm-level traceability. The StarLink incident in 2000 highlights the economic consequences of inadequate quality control at the farm and elevator level. StarLink is a genetically engineered corn variety that was approved for animal feed and industrial uses but not for human consumption (Lin, Price, and Allen, 2003). In 2000, a portion of the StarLink crop was commingled with other corn varieties, contaminating millions of bushels stored on farms and in elevators. Moreover, as a precaution, food manufacturers took hundreds of food products off the market along with nearly 100 products served at restaurants. Disruptions occurred in domestic marketing and exports to foreign countries in the initial stage of the incident as commingled corn was rerouted to approved uses and contaminated food was removed from shelves. Had StarLink been properly segregated at the elevator, this incident would probably have been at most a minor issue.

In the wake of the StarLink incident, many consumer groups called for complete traceability for StarLink and other genetically engineered crops. Better quality control at elevators may actually be a more cost-effective means of ensuring the quality of the Nation's grain and oilseed supply. However, with the growth in the variety and type of credence quality characteristics, the ability of elevators to continue to serve as the system's quality-control monitors hinges on advances in testing technologies and improvements in verification services.

Cattle and Beef

The cattle/beef sector has a long history of identifying and tracking animals to establish rights of ownership and to control the spread of animal diseases. Producers in the meat sector have also developed traceability systems to improve product flow and to limit quality and safety failures. Recent developments are motivating firms to bridge animal and meat traceability systems and establish systems for tracking meat from the farm to the retailer. Though technological innovations are helping to reduce the costs of such systems, institutional and philosophical barriers are slowing their adoption.

A number of recent events, including the emergence of bovine spongiform encephalopathy (BSE, commonly known as mad cow disease) and the country-of-origin labeling provisions included in the 2002 U.S. Farm Bill, have focused attention on traceability in the cattle/beef sector. Policymakers, producers, and consumers are reassessing the value of systems to track animals and meat from the farm to the consumer. These events, however, are not the first to motivate livestock owners and meat processors and retailers to establish traceability systems for livestock and meat. Ownership disputes, animal health concerns, and meat foodborne illness outbreaks have all motivated the development of systems to identify the ownership and health status of animals and the safety attributes of meat and meat products.

The result of these historical motivations has been to create two largely distinct sets of traceability systems in the livestock/meat sector: one set for live animals and another for meat. The current challenge for the cattle/beef sector is to link these systems and develop a system for identifying farm-level attributes in finished meat products—in other words, to trace meat back to the farm.

Traceability for Live Animals

Livestock owners have three primary motives for establishing traceability systems for live animals. First and foremost, owners want to protect their property from theft or loss by clearly identifying which animals belong to them. Whenever animals are commingled, as is common in the open ranges of the United States, owners may be motivated to use identifying marks to distinguish their cattle from those belonging to others.

A second primary motive driving livestock owners to establish traceability systems for live animals is to control the spread of animal diseases. Efficient control or eradication of disease depends on the ability of owners to identify and track healthy and unhealthy animals. This information is vital in calculating contagion and in designing effective vaccination, segregation, and indemnity programs.

A third motive for establishing traceability systems for cattle lies in the fact that many valuable animal attributes are not evident to the naked eye—or even to specialized testing equipment. Credence attributes such as up-to-date vaccinations, proper medical care, animal welfare provisions, or feeding regimens may increase the value of an animal. Farmers who can prove, through traceability documentation, that their animals possess such valuable attributes are more likely to be able to negotiate higher prices for their animals.

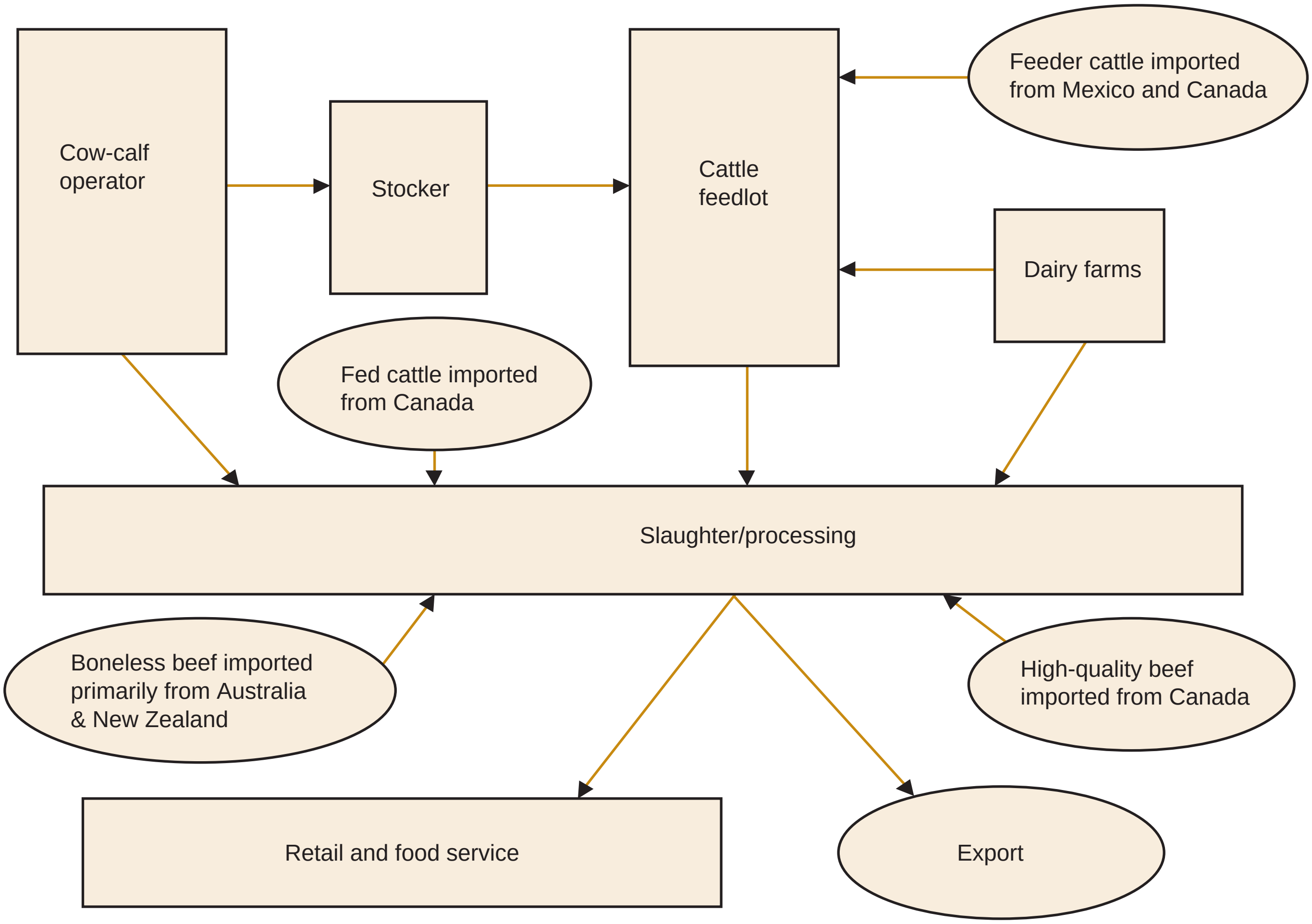
These three motives have influenced the development of traceability systems in the livestock sector in the United States. Livestock owners have established animal traceability systems to meet one or many of these objectives—and have expanded or contracted systems to reflect dynamics in animal management, disease outbreaks, and consumer preferences for credence attributes.

Traceability at the Cow-Calf and Stocker Level

Most of the beef that Americans consume originates from cattle born and raised on one of the country’s 800,000 cow-calf farms (fig. 7), with lesser amounts coming from U.S. dairies (culled dairy cows) and from Mexico and Canada. While the American West is traditionally recognized as “cattle country,” the majority of the beef cattle in this country are in fact raised in the center of the country between the Mississippi River and the 100th meridian. And, contrary to general perceptions, the majority of cows are raised by small and mid-sized operators. In 2002, the 5,390 large cow-calf operations, those with more than 500 head, accounted for only 14 percent of the beef cows in this country. The 630,000 smallest operations, those with fewer than 50 head, accounted for 29 percent of cows. In 2002, the average herd of beef cows in the United States totaled only about 41 animals (USDA/NASS, 2003).

Cow-calf operations require large amounts of pasture and range land to feed the cows and growing calves. The cows and calves may graze on land owned or leased by the cow-calf operator or, for a fee, on Federal lands.

Figure 7
Cattle/meat marketing system



Grazing lands may be adjacent and not separated by fencing, meaning that animals belonging to different people may get mixed. Many farmers find it worthwhile to brand or otherwise identify their cattle to avoid ownership disputes.

The traditional method of identification for cattle is branding, whether hot branding, freeze branding, hide branding, or horn branding. As early as the Roman Empire, competitors employed branding irons to burn their names onto horses used in chariot races (Blancou, 2002). In the 7th century, the Chinese used branding irons to identify horses used by the postal service. Branding is also the traditional method of animal identification used in the United States. Most Western States still have branding laws that require brands to be registered and to be inspected when animals are moved or sold.

Other methods of animal identification include tattooing, retina scanning (Optibranding™), iris imaging, and, currently the most common method, tagging. Tags may have simple printed numbers, imbedded microchips, or machine-readable codes, such as radio frequency identification (RFID). Ear tags cost in the neighborhood of $1 or $2 apiece. RFID technology is more costly, with instruments for reading RFID tags costing several hundred dollars apiece, though prices have been rapidly falling.

Increasingly, tags include more information than just animal ownership. Coded information on tags may provide information on vaccination records, health history, breeding characteristics, and other process attributes. This information is either encoded directly on the tag or kept in separate records that are linked to the animal via codes on the tag. Larger cow-calf operations are much more likely to use individual or group calf identification systems than smaller operations because it is more difficult to remember characteristics of individual cattle when there are many animals. Information on individual animal characteristics is also valuable in cases where calves are sold to other cow-calf operators—a common occurrence as calves are moved to operations with available forage. New owners may demand information on vaccination records and other animal characteristics.

APHIS/USDA estimates that in 1997, 65 percent of calves were individually identified on large cow-calf operations (USDA/APHIS, 2000a,b). Overall estimates suggest that about 49 percent of all cow-calf operators use some form of individual identification with an estimated 52 percent of calves and about 65 percent of beef cows individually identified. More operations use some form of group identification, so that about 74 percent of cows are group identified at the cow-calf level.

Identification systems not only facilitate transactions between sellers and buyers, they also help safeguard the health of the livestock sector as a whole. Animal identification and tracking systems help ensure that unhealthy animals are not allowed to contaminate healthy herds. Nearly all States require a Certificate of Veterinary Inspection (CVI) for livestock entering the State. The CVI for interstate commerce is an official document, issued and signed by a licensed, accredited, and deputized veterinarian. The CVI provides documentation that an animal or a group of animals was apparently healthy and showed no signs of contagious or communicable diseases on the date the inspection took place.

Animal identification is also an important element of Federal programs for animal disease control and eradication. For example the program targeted at eradicating brucellosis, a costly and contagious disease that can affect ruminant animals and also humans (USDA/APHIS, Dec. 2003), hinges on “Market Cattle Identification (MCI).” With MCI, numbered tags called backtags are placed on the shoulders of marketed breeding animals from beef, dairy, and bison herds. MCI, along with testing procedures, provides a means of determining the brucellosis status of animals marketed from a large area and eliminates the need to round up cattle in all herds for routine testing. In the case of test-positive animals, ownership can be more easily identified and herds that may be affected can be efficiently isolated and tested. For cattle and bison in heavily infected areas or replacement animals added to such herds, officials recommend vaccination. At the time of vaccination, a tattoo is applied in the ear; identifying the animal as an “official vaccinate.” The tattoo identifies the year in which vaccination took place.

The brucellosis eradication program has had dramatic results. In 1956, testing identified 124,000 affected herds in the United States. By 1992, this number had dropped to 700 herds, and as of June 30, 2000, there were only 6 known affected herds remaining in the entire United States (USDA/APHIS, Dec. 2003).

The success of the Federal animal-disease eradication programs has not only dramatically reduced the number of diseased livestock but also reduced the motivation for animal identification for these diseases. These programs demonstrate the ability of the industry to establish traceability systems for disease control—and the ability of the industry to jettison such systems when the benefits no longer outweigh the costs.

Traceability at the Feedlot

At 6 to 18 months old and weighing 500 to 900 pounds, calves are moved to a cattle feeding operation. Cattle feeding operations, or feedlots, are enterprises largely unique to the United States and Canada. The extensive production of soymeal and corn in the United States provides an inexpensive source of animal feed and an economic rationale for feedlots. Animals are fed until they reach slaughter weights in the 1,200-1,300 lb. range—for most cattle this corresponds to 90 to 180 days in the feedlot depending on their initial weight.

Feedlots are of two major types: farmer feedlots and commercial feedlots, with the latter gaining greatly in dominance over the last three decades. The approximately 93,000 small farmer feedlots (under 1,000 head capacity) are typically one part of a grain-farm operation and may feed home-raised or purchased calves with home-raised feed. The average small farmer feedlot had an average inventory of only about 25 head in 2002 (USDA, NASS Dec. 2003).

Most commercial feedlots are located in the Western Cornbelt and Plains States of Texas, Kansas, Nebraska, Colorado, and Iowa. Commercial feedlots feed both cattle owned by the feedlot as well as other people’s cattle for a fee (custom feeding). Custom-fed cattle can be owned by a cow-calf producer (called retained ownership) or by outside investors. Because of mixed ownership, identification of cattle on large commercial feedlots is more important than on farmer-owned feedlots, and consequently there is likely to be more branding or ear-tagging on commercial operations. Branding or ear-tagging also helps feedlot operators to more easily sort animals by vaccination records and breeding and other characteristics. Table 3 shows that over 98 percent of cattle on large commercial feedlots (8,000 head of cattle or more) have individual or group identifiers (large commercial lots account for 66 percent of cattle) while almost 80 percent of cattle on small commercial feedlots have such identifiers (USDA, APHIS, 2000).

Table 3—Percent of cattle identified in commercial feedlots, by size of operation[1]

	Small feedlots	Large feedlots
	Percent of cattle	
Tagged with a unique number such that each animal was individually identifiable (excluding tagging of sick animals)	29.6	31.1
Individually identified using a method other than tagging such that each animal was individually identifiable (excluding tagging of sick animals)	1.6	2.1
Identified with a group or owner identifier (pen tag, brand, hot tag, ear notch, etc.)	49.7	80.0
Not identified	21.9	1.6

[1]Small operations 1,000-7,999 head, large operations, 8,000 head or more.
Source: USDA, APHIS, 2000.

Traceability from Feedlot to Slaughter

Cattle ready for slaughter are trucked to slaughter plants. Most fed cattle are sold in direct transactions between the cattle owner (or agent) and the packing company. A typical transaction for cattle sold on a liveweight basis involves the feedlot's placing cattle on a "showlist" and packer-buyers' viewing and placing bids on cattle with a final spot price arrived at by negotiation. Many other cattle are sold on a carcass basis (payment delayed until animal is slaughtered and carcass weighed), increasingly under a contract or agreement specifying the source for a base published price and an agreed-upon schedule or "grid" of premiums and discounts based on actual carcass characteristics. Of course, in these cases, the carcass basis can be determined only after the packer slaughters the animal. The base price and adjustments produce the final "formula" price adjusted for quality.

When valuable animal characteristics are unobservable at the point of sale, traceability records linking a particular animal to records on health and other characteristics help establish the premium grid and facilitate efficient market transactions. At sale from feedlot to slaughter plant—and at every point of sale in the chain—traceability documentation enables producers to sell their cattle at a price that more accurately reflects quality. Traceability documentation is the only way to verify the existence of credence attributes such as animal "playtime" and non-genetically engineered feed.

Though traceability documentation is a valuable tool for farmers who wish to appropriate the benefits of investments in animal health or quality, it may also entail some unwelcome side effects. Traceability documentation may force farmers to "appropriate" the costs of failures in animal health or quality. The possibility that traceability could be used to place liability for unhealthy or low-quality animals on farmers makes many in the livestock sector uncomfortable. Many producers adhere to an ethic that a seller should not knowingly sell diseased or defective feeder or breeder livestock without disclosing such to the buyer, but that after an honest sale, if any problems arise with the animals' health or fitness, including death, the seller is not liable. The buyer assumes all risks associated with long-term animal health.

Livestock producers have accordingly long enjoyed some legal protection from liability for factors over which they have little or no control after the sale. Livestock has traditionally been exempt from commercial implied-warranty laws partly because farmers were considered not to be "merchants." As farms became more commercialized, and buyers more litigious, this protection has become less secure; in response many States passed specific exemptions for livestock. Some version of the statutory exclusion of implied warranties has now been adopted in almost half of the States, in particular those States where the livestock industry is of major economic importance. The Kansas statute is typical of the modification (McEowen, 1996, p. 7):

> Kan. Stat. Ann. § 84-2-316(3)(d):
>
> *[W]ith respect to the sale of livestock, other than the sale of livestock for immediate slaughter, there shall be no implied warranties, except that the provisions of this paragraph shall not apply in any case where the seller knowingly sells livestock which is diseased.*

Traceability at Slaughter

There are over 3,000 small and large firms slaughtering cattle in the United States. Most cattle slaughtered are fed steers and heifers, typically slaughtered by one of the four large major packers located in the feeding States that dominate the industry and account for about 82 percent of steer and heifer slaughter and 69 percent of all cattle. Culled cow and bull slaughter tends to occur in smaller firms, less concentrated geographically and less likely to be vertically integrated (USDA/GIPSA, 2001). In addition to domestic cattle, U.S. plants slaughter imported cattle, mainly from Canada,[2] although calves are also imported from Mexico and fed on pasture and in feedlots to slaughter weights.

FSIS (Food Safety and Inspection Service) regulations require that slaughter plants keep the head and certain organs of slaughtered animals, plus all identifying tags, until all parts of the animal pass inspection. Slaughter plants must be able to identify which head and organs belong with which carcass. In most plants this is done by keeping them physically synchronized on separate chain and conveyors. The identity of individual animals is frequently lost once inspection takes place. At this point, the health and safety of the animal has been "verified" and the focus shifts to the safety of the meat.

Traceability for Meat

Two primary motives have driven the development of traceability systems for meat and meat products: supply management and safety and quality control. Traceability systems enable slaughter plants and processors to more efficiently track the flow of product and coordinate production. Traceability systems also help plants minimize the extent of safety or quality failures, thereby minimizing damages.

A number of large foodborne illness outbreaks and heightened awareness of food safety issues have led many producers to adopt increasingly precise traceability systems. These systems reflect not just the fact that the benefits of traceability are rising, but also the fact that technological innovations are reducing the costs of traceability. These trends are expected to continue as retailers and importers demand safer food and as the science and technology of pathogen control improves, thereby spurring additional demand for traceability and additional incentives for innovation.

Meat Tracking from Slaughter/Processor to Retailer

Most large firms convert beef carcasses into primal and subprimal cuts or "boxed beef." Ground beef is processed from mixes of boneless beef imported primarily from Australia and New Zealand and trimmings from domestic animals to attain a desired fat content. Boxed beef and ground beef are shipped to retailers, food service firms, and exporters, sometimes through specialty processors, institutional processor/distributors, and meat wholesalers. Increasingly, most large firms also further cut and package "case-ready" retail cuts ready to drop into the display case in the grocery store.

Slaughter plants and processors have developed a number of sophisticated systems for tracking the flow of production and monitoring quality and safety. In accordance with ISO 9000 guidelines, most track inputs by batch or lot and then assign new batch or lot numbers to track product as it is transformed. To control foodborne pathogens such as *E. coli* O157:H7 and *Salmonella*, a number of processors have established very precise sampling, testing, and tracking protocols.

For example, one of the largest independent ground beef producers in the United States begins its traceability documentation with the trimmings entering the plant. Incoming combo bins (2,000 lbs.) of raw material are sampled at least every 100,000 pounds, which for most raw material suppliers is daily. All raw materials are routinely screened for Aerobic Plate Counts (APC), generic coliforms, generic *E. coli*, *Staphylococcus aureus*, *Salmonella*, and *Listeria monocytogenes*. If lots test higher than standards, the supplier is notified immediately and testing is intensified. Samples are next taken at the final grind head, where each batch of 3,000 pounds of ground beef is tested for *E. coli* O157:H7. Finally, samples of the finished product are taken from each process line every 15 minutes. Every hour, composites of the four samples are tested to detect *E. coli* O157:H7. These samples are also combined to make a "half-shift" composite, which is tested for an entire microbial profile. If the half-shift composites show spikes or high counts, more tests are run on the backup samples also collected every 15 minutes (Golan et al., 2004).

As a result of its testing protocol, traceability documentation is extensive for this producer. This documentation enables the producer to monitor the quality and safety of its inputs and to work with suppliers to improve the quality of inputs, or drop suppliers that cannot comply. The producer's documentation also serves to provide buyers with assurances about the quality and safety of the producer's products. As a result, this producer has been able to shift from being a commodity producer selling on a week-to-week basis to being a contract supplier to major hamburger restaurants. This shift has allowed this producer to improve its operational efficiency through better planning for capacity utilization, capital investment, spending plans, and other business activities.

[2] Or they did until the ban on importation of animals from Canada due to the discovery of mad cow disease in a single cow in western Canada, May 2003. The United States and Canada are negotiating to begin bringing cattle under 30 months of age into the United States for immediate slaughter, or to designated feedlots for slaughter at less than 30 months of age (www.usda.gov/news/releases/2003/10/0372.htm).

Though not every processor or slaughter plant maintains records as precise as in the above example, virtually all meat sold in the United States is traceable from retail back to the processor or slaughter plant. Regulations require that USDA inspection numbers for the processing plant remain on the labels of meat as they pass through the distribution systems along with other information, depending on ingredients in the meat product and marketing chain. Other firm and lot number information can be placed on labels to identify a particular processing batch from a package of meat. Most, if not all, voluntary recalls listed on USDA's Food Safety and Inspection Service website, refer consumers to coded information on products' packaging specifying the lot or batch of items included in the recall. Good product tracing systems help minimize the production and distribution of unsafe or poor-quality products, thereby minimizing the potential for bad publicity, liability, and recalls.

Linking Animal and Meat Traceability Systems

Traditionally, once carcasses have passed USDA inspection, slaughter plants have not maintained information on the identity or characteristics of each animal. Until very recently, there have not been market or human-health reasons to do so. Now, however, meat-quality pricing has begun to expand beyond characteristics that can be judged by examining the meat itself. Meat prices have begun to reflect credence attributes related to farm-level, live-animal characteristics, such as animal welfare, type of feed, and use of antibiotics and growth hormones. In addition, diseases such as mad cow have established a link between animal health and human health—and have motivated many consumers, including those represented by foreign governments, to demand traceability back to the farm and animal feeding records (see box, "Animal Identification").

In response to these new motivations, the livestock sector has begun to build traceability systems to bridge animal tracking systems with those for meat tracking. Several systems can and have been incorporated into slaughtering lines to link group or individual animals with their meat products. These include sequence-in-slaughter order, carcass tagging, trolley-tracking, and RFID devices. Some systems are capital intensive and favor larger firms that can capture economies of scale, while others are labor intensive and may actually confer an advantage to smaller operations. For example, carcass tagging may require a human to apply the tag(s) while trolleys can be tracked optically and electronically. Small low-speed operations may have an advantage in maintaining animal identification because they can more likely use physical separation and tagging. Regardless of which technology is cost effective, the success of the system depends on appropriate operating procedures and traceability recordkeeping to keep sequences and identification numbers synchronized.

Animal Identification

A national animal identification plan is being developed through a cooperative effort of USDA, State animal health officials, and livestock industry groups (see: http://www.usaip.info#.). Called the National Identification Development Team, its goal is to develop a national standardized program that can identify all premises and animals that had direct contact with a foreign animal disease within 48 hours of discovery. The plan is aimed at quickly identifying animals exposed to disease and the history of their movements in order to rapidly detect, contain, and eliminate disease threats (Wiemers, 2003). The first phase of the work requires establishing standardized premise identification numbers for all production operations, markets, assembly points, exhibitions and processing plants. The second phase calls for individual identification for cattle in commerce. Other food animal and livestock species in commerce would be required to be identified through individual or group/lot identification.

Scientific advances in animal identification will continue to reduce the cost and increase diffusion of animal-to-meat traceability. A variety of high-tech, rapid animal identification methods such as electronic implants, banding, or tagging have been developed and science is advancing to a point where DNA testing could be used to help identify and trace animal products. Unlike electronic tags and animal "passports," biological signatures would be virtually impossible to falsify and could follow the product after processing.

Though technological barriers to animal-meat traceability are rapidly dissolving, philosophical and in some cases, legal barriers remain or are being erected. As previously mentioned, livestock has traditionally been exempt from commercial implied-warranty laws. Many in the livestock sector worry that traceability systems linking meat to animals will break this tradition and shift at least some of the liability for foodborne illness back to cow-calf operators and feedlots. Some livestock organizations have even publicly called for limits on liability that may arise from animal identification. For example, the Kansas Livestock Association (2003), a nonprofit trade association representing nearly 6,000 livestock producers, has recommended:

WHEREAS, livestock producers and government officials are researching the feasibility of a national individual animal identification program, and

WHEREAS, such a program, on a voluntary or mandatory basis, could provide the livestock industry a tool to quickly trace animal disease sources and enhance a breeder's ability to identify genetics that meet consumer demands, and

WHEREAS, animal trace-back technology can increase the liability exposure for owners of animals whose food and by-products threaten or cause damages to consumers, and

WHEREAS, liability in these circumstances can often be classified as "strict liability," even though an animal owner may not be at fault for such damages.

THEREFORE, BE IT RESOLVED, the Kansas Livestock Association supports state and federal legislation to limit animal owners' liability exposure that may arise under a private or public animal identification program.

In part to overcome some of the gaps in tracing documentation and quality assurance that may arise in the system, a small but growing segment of the cattle/beef industry has entered into alliances, associations, cooperatives, or marketing groups in which groups of cattle raisers, cattle feeders, producers, slaughter plants, and processors share some combination of decisions, responsibilities, information, costs, and returns. In many cases, alliances set quality and/or safety standards and provide systems to verify that quality standards for credence attributes exist. These types of alliances or vertically integrated operations such as those found in the pork (see box, "Traceability in Hogs and Pork") and poultry sectors, use contracts and incentives to link stages of production. Links are created between entities under separate ownership to help coordinate the efforts of those entities. Alliances attempt to create a market identity with a goal of producing a product that consumers desire and for which they are willing to pay a premium and sharing that premium with upstream entities (Florida Cooperative Extension Service, 2002).

Many of the products marketed through alliances entail credence attributes that the alliance certifies to exist. In some cases, alliances or even individual producers choose to use third-party certifiers to help establish credible claims. One such certifier is USDA's Agricultural Marketing Service (AMS). AMS's service is a voluntary fee-based program that certifies claims on items such as breed, feeding practices, or other process claims. The AMS "USDA Process Verified" label provides buyers with assurances that the advertised credence attributes actually exist (USDA, AMS 2004).

Traceability in Hogs and Pork

There are traditionally three basic types of hog enterprises. The first is feeder-pig production in which the farmer specializes in farrowing operations that produce 10- to 40-pound pigs. Feeder pig producers sell or transfer pigs to others for finishing. At farrow-to-finish operations, all phases of slaughter hog production are carried out by the same operation, though not necessarily in the same physical location. Third is feeder-pig finishing, in which feeder pigs are obtained from others and fed to slaughter weights. In the last decade, hog production has become even more specialized with separate nursery and growing phases appearing between farrowing and finishing. Increasingly, hogs are raised on a batch basis—"all in all out" which facilitates cleaning facilities between batches.

In 1950, over 2 million U.S. farmers sold hogs and pigs with average sales of 31 head per farm per year. By 2002, the number of farms had fallen to around 75,000 operations. More than half of these operations had fewer than 100 head, but this small-size group had only 1 percent of the hogs. In contrast, the 2,300 operations with more than 5,000 head accounted for more than half of the hogs in 2002 (USDA, NASS, Dec. 2003). Much larger mega-farms have been evolving into more important players; the 200 or so mega-farms are highly integrated. Some have more than 30,000 sows under tightly contracted or integrated arrangements from breeding to slaughter or even retail. Identification by herd or batch is therefore much higher today than 50 years ago.

Many hog operations, both large and small, not just mega-farms, are integrated by ownership or contractually connected to slaughtering firms. Less than 20 percent of slaughter hogs were sold in the spot market in 2002. Another large group of slaughter hogs are sold on a formula basis, sometimes under a continuing agreement. Hogs produced by or under contract for slaughter firms require no market transaction between the finisher and the slaughtering firm. Thus, the road from hogs to pork is far more integrated than in the cattle/beef sector—as are traceability systems.

Conclusions

The livestock industry has successfully developed and maintained a host of traceability systems: some for live animals and some for meat. Ranchers, cow-calf operators, and feedlot operators have had at least three motives in developing live-animal traceability: to establish ownership; to control animal diseases and quality; and to facilitate quality-based pricing. Livestock owners have established animal traceability systems to meet one or more of these objectives—and have expanded or contracted systems to reflect dynamics in animal management, disease outbreaks, and consumer preferences for credence attributes.

Slaughter plants and processors have had two primary motives for establishing traceability for meat products: to manage their supply chains and assure quality control and food safety. Traceability systems enable slaughter plants and processors to more efficiently track the flow of product and to coordinate production. Traceability systems also help plants minimize the extent of safety or quality failures, thereby minimizing damages. A number of large foodborne illness outbreaks and heightened awareness of food safety issues have led many producers to adopt increasingly precise meat traceability systems—a trend that is expected to continue with ever-increasing demands for food safety.

The challenge facing the industry now is to coordinate and link many disparate animal and meat traceability systems and priorities and develop a standardized system for identifying farm-level, live-animal attributes in finished meat products. Two institutional barriers may hinder these efforts. First, because USDA determines and certifies an animal's health and its suitability for the human food chain, meat processors may not have as much of an incentive to retain information on the origin of each piece of meat as they would if they were solely responsible for ensuring animal health.

Second, livestock has traditionally been exempt from commercial implied-warranty laws and many institutional or legal barriers are being constructed to safeguard this tradition. Limiting the liability of the cow-calf operator or feedlot will dampen incentives to establish traceability from meat to animal. Traceability to the animal supplier is less valuable if the supplier cannot be held legally accountable for diseased animals.

In part to overcome some of the gaps in tracing documentation and quality assurance that may arise in the system because of limits to liability, a small but growing segment of the cattle/beef industry has turned to alliances, associations, cooperatives, or marketing groups to help establish and enforce quality and safety standards and facilitate linking animal-tracking systems and traceability of meat products. The U.S. Animal Identification Plan is another major effort in this direction.