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When the apple falls close to the tree: Local food systems and the preservation of diversity

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Abstract

Agricultural industrialization, Green Revolution technologies, environmental change and civil conflicts have all been cited as contributing to the erosion of crop biodiversity. An additional factor is change in the characteristics of markets, including distance to market. Proponents of sustainable agriculture claim that one benefit of local food systems is the preservation of crop biodiversity. This paper explores that claim, examining Ohio orchardists' understanding and valuation of apple varieties and relating these to the preservation of biodiversity. Growers provided lists of apple varieties and then performed pilesorts on them. Analysis using multidimensional scaling reveals the underlying dimensions growers use to distinguish those cultivars. Salient characteristics are taste, use and market focus. Demands of the conventional commercial market with regards to transportation, appearance and storage exclude the old varieties. On the other hand, there is a strong congruence between sales in local markets and production of old varieties. Local markets, such as roadside stands and 'pick-your-own' operations, play an important role in the preservation of heirloom varieties of apples.

Key words: local food systems, crop biodiversity, apple varieties, sustainable food systems, heirloom varieties, niche markets

Introduction

Crop biodiversity is 'the biodiversity that people made'[1]. It is the result of millennia of selection for favorable traits, such as larger fruits, stronger stalks, earlier ripening and frost resistance. The result has been the creation of tremendous intra-species diversity of crops: thousands of cultivars of staple crops such as potatoes in the Andes, rice in South-East Asia, wheat in the Near East and maize in Mesoamerica, as well as countless varieties of fruits and vegetables.

The trend of expanding crop biodiversity is now being reversed. The shift in agricultural production and distribution systems towards greater commercialization, increased technological inputs and globalization has been accompanied by the rapid loss of crop biodiversity. The magnitude of the loss is substantial. In Indonesia, thousands of rice varieties disappeared in just a few years when the planting of local varieties was banned[2]. In China, the 10,000 varieties of wheat that were grown in 1949 were reduced by 90% by the 1970s[3]. This story is repeated with other major crops as well as fruit and vegetables. A study undertaken by the Rural Advancement Foundation International (RAFI) compared lists of varieties compiled by the USDA in 1903 (based on varieties being sold at that time by commercial seed houses) with varieties currently held in the US National Seed Storage Laboratory. Table 1 shows the extent of the loss for five vegetables, ranging from 81% to 95%; these numbers are typical of fruits and vegetables, for which the estimated loss of varieties during the 20th century was 80–90%[4].

In the face of rapid erosion of crop diversity, substantial effort has been given to the *ex situ* preservation of genetic material. Today, thousands of varieties of crops are maintained in storage banks throughout the world[5]. While preserving this genetic material is vital, its isolation from the functioning ecosystems in which it adapts and evolves is none the less problematic[6,7]. In addition, *ex situ* storage does not address the preservation of farmers' knowledge of landraces (crop varieties improved by farmers' selection rather than modern breeding techniques)[8,9].

In parallel to efforts surrounding *ex situ* preservation, attention has been given to understanding the range of on-site crop diversity, particularly among traditional

Table 1. Loss of varieties and distance traveled to market, for selected vegetables.

Item	Loss of varieties since the end of 19th century[30]	Distance to market (miles)[25]
Carrots	95%	1838
Onions	94%	1759
Peppers	93%	1589
Tomatoes	90%	1569
Cabbage	81%	719

agriculturalists. The ecological benefits of maintaining such diversity are clear, yet our understanding of why farmers continue to use genetically diverse crops lags[10]. This is especially true in developed locales, where it is virtually assumed that the commercialization and industrialization of agriculture has resulted in monocrops.

The main cause of genetic erosion is presumed by many authors to be the widespread adoption of modern crop varieties in areas previously dominated by traditional varieties of the same crops[11–14]. Often—but not always[10,15]—modern varieties replace the array of traditional varieties, leading to the domination of crops by one or a few varieties[16]. While the newer (Green Revolution) varieties may be higher yielding, they also require higher inputs of fertilizers, irrigation water and pest controls.

Other explanations for why this loss has occurred (and continues to occur) have been offered. Among the factors cited are:

- Environmental changes, which may include precipitation shifts, depletion of soils, or changes in pest and disease threats. As a result of such changes, traditional crop varieties may no longer be adapted to growing conditions. This happened with rice in Senegal and Gambia, where several decades of below-normal precipitation led to the displacement of traditional varieties by improved ones that matured rapidly[3].
- Civil conflicts can have substantial impacts on crop arrays. Seed stores may be looted and seed networks disrupted[17]. Such conflict can also destroy harvests and create hunger. In response, farm families may be forced to eat seed stock, setting the stage for shifts in varieties.
- Changing labor markets can lead to decreased numbers of growers as farming people became full-time wage laborers. When this happens, the risk of loss of agricultural knowledge increases, including the loss of important skills such as seed-saving[18].

As a consequence of these processes, once-diverse crops are now dominated by one or a few varieties. As Durning[19] describes it 'crop fields, orchards, animal farms, tree plantations, pastures, fish runs—all have been turned into genetically-uniform super producers'. In the wake of the southern corn blight in 1970, US researchers established that 60–70% of the total bean acreage was planted with two to three varieties, 72% of the potato acreage contained four varieties, and 53% of the cotton land contained only three cotton varieties[20]. These monocrops are vulnerable to a variety of threats, including disease, pest infestations and unfavorable climatic events[6,18].

Yet another factor that can impact crop biodiversity is development of, and access to, markets. For example, in Andean farming systems, families plant diverse native potato varieties in scattered agricultural fields, both for different culinary purposes and as part of their response to risk[21,22]. However, this native diversity is not represented in the market system[23] and, indeed, the erosion of genetic diversity seems to be most severe where market involvement is greatest. Changing characteristics of the market system can also affect the preservation of crop biodiversity. One such characteristic is the distance food travels to market. As the geographic scale of our food system has increased, different characteristics of foods have become more significant. This factor will be the focus of the present paper.

Geographic Scale of the Food System

We begin by considering the geographic scale of our food system. The figure commonly cited is that the average morsel of food travels 1300 miles from the time it leaves the field (or pasture) and arrives on the table[24]. Recent work at the Leopold Center in Iowa generally confirms this figure as a reasonable average across many produce items (Table 1). Researchers calculated the distance traveled by a variety of produce items in the conventional distribution system—that is, items produced somewhere in the continental United States and then shipped to Iowa for consumption, and found an average distance traveled of 1494 miles[25].

In contrast to the conventional food system that operates on national and transnational scales, a movement towards the re-localization of food systems has gained prominence[26]. Wendell Berry[27] described such a system as: 'an economy in which local consumers buy as much of their food as possible from local producers and in which local producers produce as much as they can for the local market'.

A number of sustainable food system advocates have made the link between the distance food travels, on the one hand, and the loss of crop biodiversity, on the other. Norberg-Hodge[28], for instance, makes the argument that the process of globalizing our food supply has led to the disappearance of countless crop varieties: 'In the process [of globalization] ... Diversified food production for local communities is replaced by export monoculture for profit. Thousands of local plant varieties disappear'.

Others suggest explicitly that a benefit of local food systems is the preservation of crop biodiversity. Halweil[29], for example, states that 'Farmers producing for the local market tend to increase the diversity of their plantings'.

This is central to our examination. Our aim is to explore the claim that, in the face of rapid genetic erosion of crops, the re-localization of food systems helps maintain crop biodiversity. Key to this argument is the premise that when food crops do not have to travel far to reach their markets, farmers are free to select varieties for qualities other than their ability to withstand the increased handling and packaging, long-distance shipping, and prolonged shelf-life demanded by the distances traveled in the conventional food system. We will explore this issue in the context of apple diversity.

RAFI researchers documented a tremendous historical diversity of apples but an enormous loss as well. Between 1804 and 1904, 7098 varieties of apples were in use in the US. Of these, 6121 (86.2%) have been lost[30].

Against this backdrop, our goal is to answer this question: Do local food systems help preserve crop biodiversity, and if so, how? Our approach is to understand the characteristics by which growers distinguish and value different varieties. Growers, after all, are the ones making choices about whether or not varieties will be maintained[14,31].

Methods

To begin to answer our question, we worked with ten apple growers in Central Ohio who grew, on average, 25 different varieties of apples. As a first step, the growers were asked to name both current and old varieties of apples grown in the area. Respondents named 100 varieties as 'current' varieties and 64 as 'old' varieties. Apples named on the 'current' list are many that would be familiar to most US-based consumers, and include varieties such as Fuji, Golden Delicious and Gala. Named 'old varieties' include Cox's Orange Pippin, Rome Beauty and Winesap, all of which originated prior to 1850.

Table 2 lists the 33 varieties (both 'current' and 'old'), which were most frequently mentioned, their dates of origin or introduction, and the code used to identify each in subsequent figures. Included are those 'current' varieties mentioned three or more times, and 'old' varieties mentioned as least twice. We used these—the most frequently named varieties—for additional data collection.

We wrote the names of these varieties on index cards, one name per card. Each grower was visited and during the visit asked to sort the cards into separate piles, however many they deemed appropriate, based on similar characteristics. When done, they were asked to explain what characteristic described each pile. After this, the process was repeated with a second set of cards, instructing the grower to base the second sort on some different characteristic than the first time. This data collection method, called pilesorting, is a way to elicit information from respondents about their judgments of similarities and differences among a set of items[32]. The information collected in these pilesorts was then used in a multidimensional scaling analysis.

Table 2. Apple varieties used in pilesorts, code (used in Figs 1–3) and date of origin for each variety.

Variety name	Code	Date
Adam's Pearmain	n/a	1826
Braeburn	BURN	1952
Cortland	CORT	1915
Cox's Orange Pippin	OPIP	1830
Empire	EMP	1966
Fuji	FUJI	1962
Gala	GALA	1965
Golden Delicious	GDEL	1900
Granny Smith	SMTH	1868
Grimes Golden	GGLD	1804
Honey Crisp	HCSP	1991
Idared	IDA	1942
Keepsake	n/a	1979
Jonafree	JFRE	1979
Jonagold	JGLD	1968
Jonathan	JTHN	1826
Law Rome	LROM	1980
McIntosh	MC	1870
Melrose	MLRO	1944
Mollie's Delicious	MDEL	1966
Mutsu	MUTS	1948
Newton Pippin	NPIP	~1700
Northern Spy	NSPY	1800
Pink Lady	PLDY	1979
Red Delicious	RDEL	1870s
Rome Beauty	RBTY	1848
Russet	RUSS	1600s
Stayman Winesap	SWNS	1866
Wealthy	WLTH	1860
Winesap	WNSP	1817
Winter Banana	WBAN	1876
Wolf River	WRIV	1875
York Imperial	YIMP	1830

Findings: Multidimensional Scaling Analysis

Multidimensional scaling is a way to graphically represent the respondents' collective understanding of the similarities and differences among the sorted items. Based on a multidimensional spatial representation of the items, clusters of items regarded as similar can be identified, and the underlying criteria by which respondents distinguish items can be inferred[33]. In the present case we used the information we collected during the pilesorts for this analysis, relying on the computer program ANTHROPAC 4.0[34] to perform the actual calculations, which are based on estimates of Euclidean distances.

The lists of items contained in the piles created by each respondent were entered into ANTHROPAC. The program constructs a similarity matrix of inter-respondent correlation for each item sorted. This matrix is used to create a visual plot of the spatial relationships between items, where distance is a measure of similarity. Items that appear to be clustered together are those that, in the aggregate, were seen to be similar by respondents. The challenge for the analyst is to understand the underlying characteristics that create the similarities and differences reflected in the visual representation. These characteristics create the N-dimensions of the graph. For example, if respondents were sorting breeds of dogs, characteristics that could make up these dimensions might be size and demeanor. These trends would emerge in the way the breeds are located on the plot in relation to each other. Breeds of similar size would be positioned in close proximity along the axis defined as size. Those with similar demeanor would be located close to each other along the axis defined as demeanor. Inferring what characteristic corresponds to each axis (or 'dimension') is the task of the analyst[35].

Although we collected 20 pilesorts in all, 13 were entered into multidimensional scaling for analysis. The sorts that were eliminated were done so because the characteristics used in the sort were very idiosyncratic (such as number of trees the orchardist had in each variety). Two apple varieties were also eliminated from the final analysis. Adam's Pearmain and Keepsake were eliminated because they were put in the respondents' 'unknown' pile a majority of the time. Thus, the final analysis was based on 13 sorts and 31 varieties.

When the analysis was run in two dimensions, an unacceptably high stress level of 0.17 resulted. Assessing 'stress' in multidimensional scaling analysis provides a measure of fit. A high stress level means that the representation of the data may be very poor or highly distorted[33,35]. In order to reduce the stress level, and increase the accuracy of the representation, the same data were run using three dimensions. This resulted in an acceptable stress level of 0.118. Thus the results from the three-dimensional analysis are used as the basis for the analysis.

Experts in their Fields: Growers' Understanding of Apple Varieties

The three dimensions we identified are termed 'taste', 'use' and 'market'. The last is most significant in understanding the role of local markets in the preservation of biodiversity. Because of the difficulty of representing three dimensions on the two-dimensional space of a flat piece of paper, the plots of these spatial relations are presented two at a time. Figure 1 will be used to discuss the dimension of 'taste', Figure 2 'use', and Figure 3 will be used to discuss 'markets'. Table 2 gives the codes used to plot apple varieties in these figures.

First dimension: taste

Qualities of taste runs on a continuum of Dimension 1, in Figure 1 plotted along the *x*-axis. At the left side of the plot are those varieties with desirable taste qualities, which are

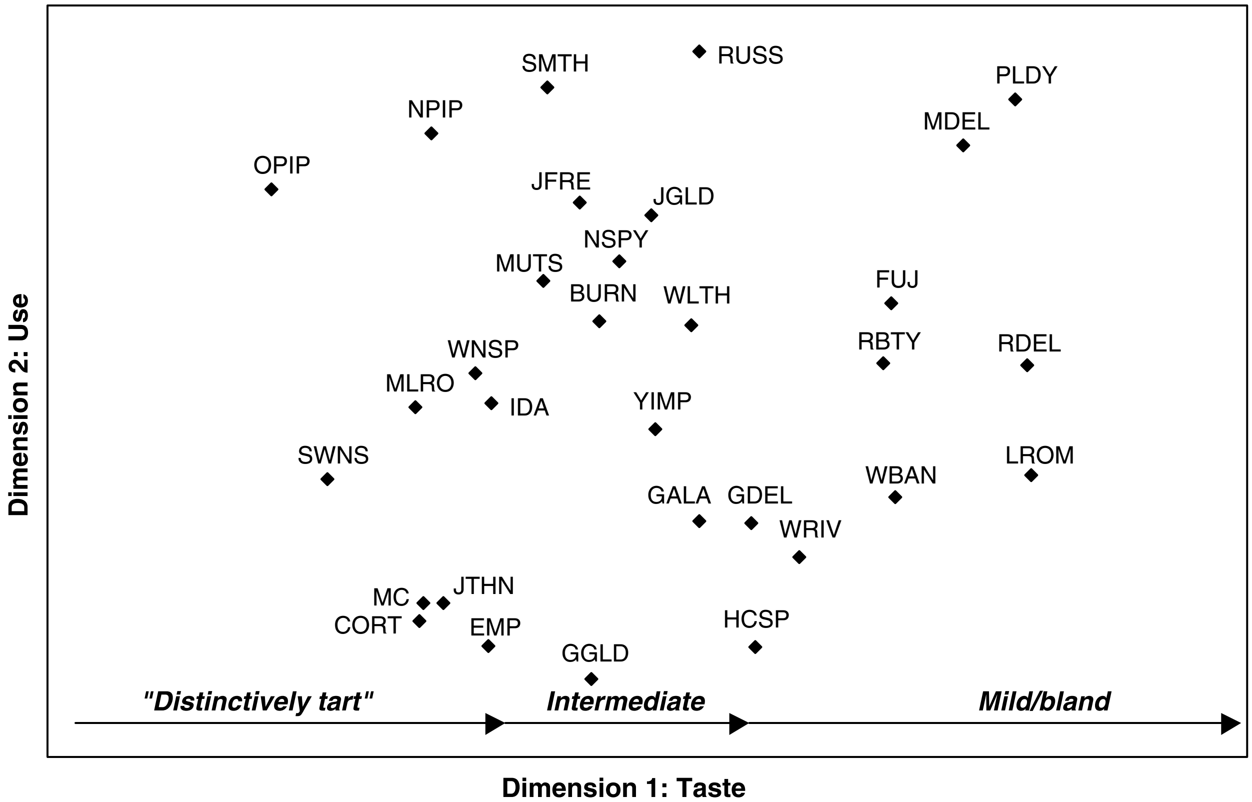

Figure 1. Results of the multidimensional scaling analysis: taste. The first dimension, taste, runs on a continuum from apples perceived by growers as distinctively tart to those regarded as bland.

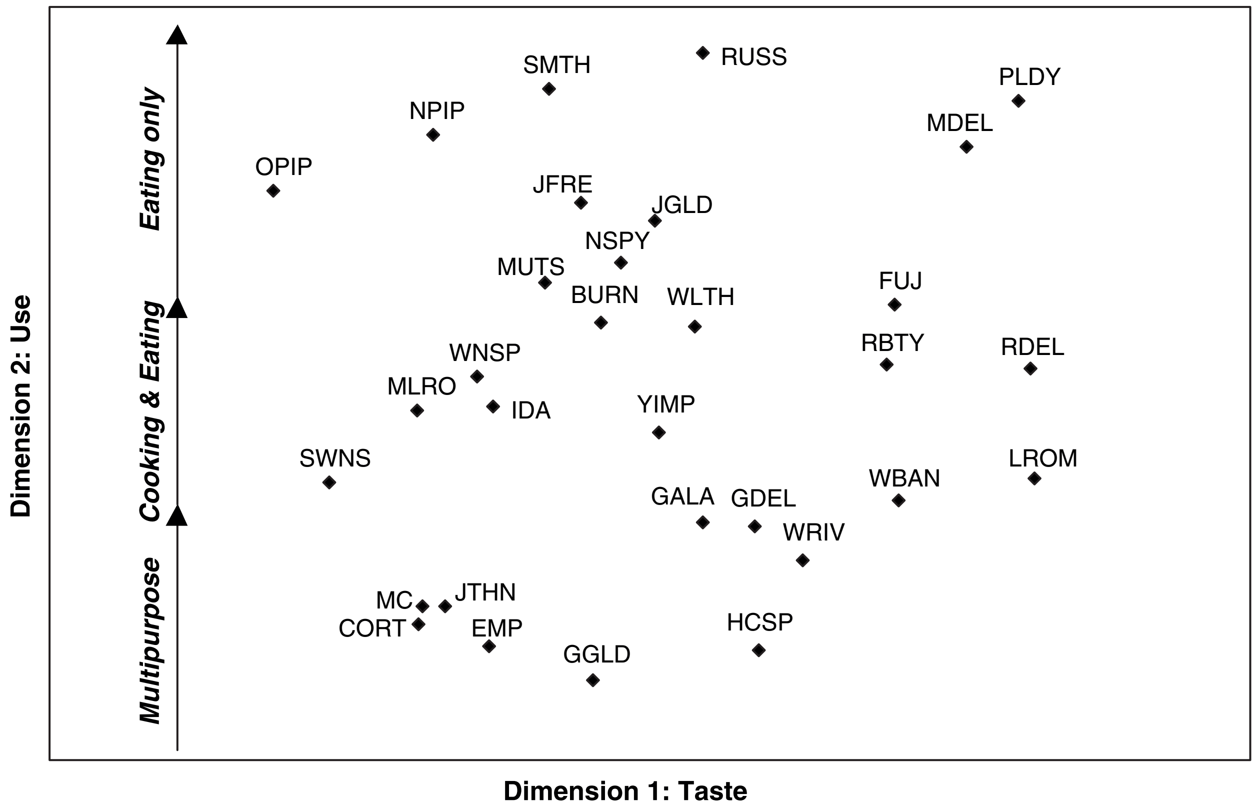

Figure 2. Results of the multidimensional scaling analysis: use. The second dimension, use, runs on a continuum from highly valued multipurpose varieties to those that can be used for eating only.

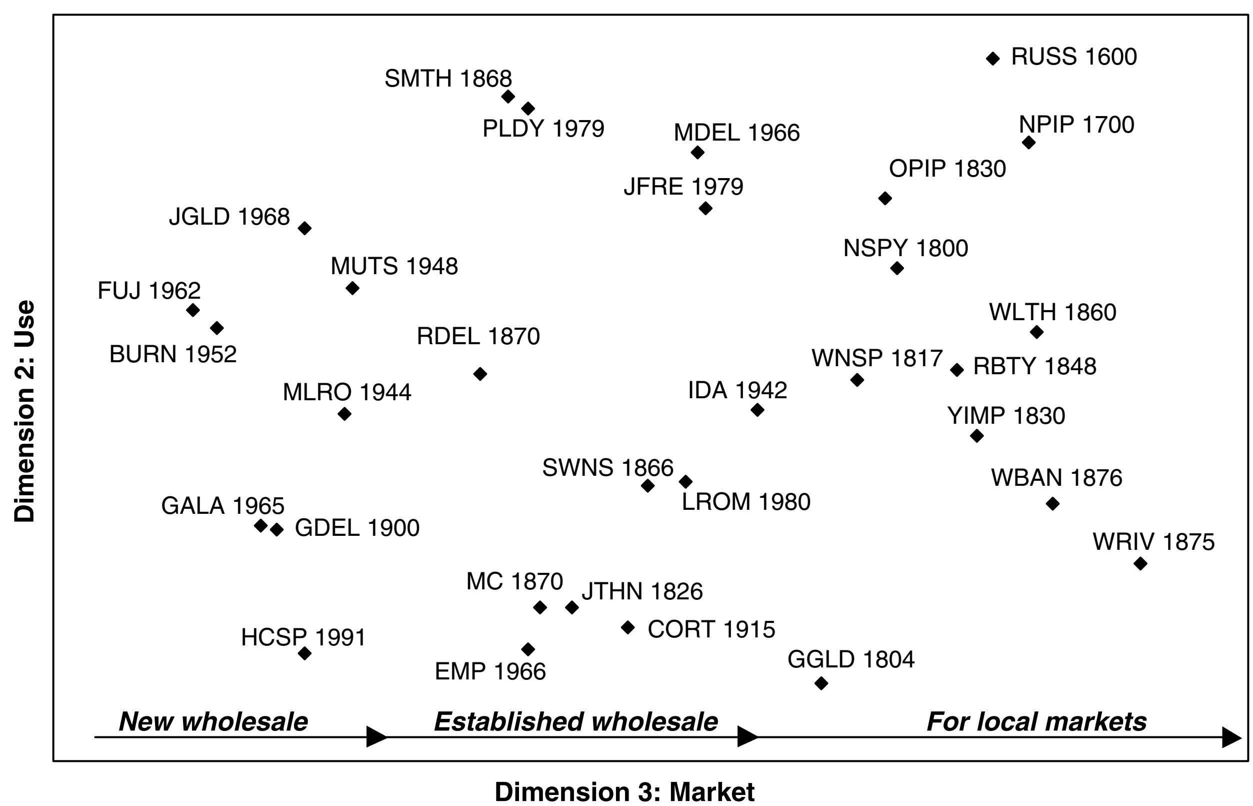

Figure 3. Results of the multidimensional scaling analysis: market. The third dimension, market, runs on a continuum from varieties emerging on the large-scale commercial market to those that are suitable for sale only in local markets. In addition to variety name, year of introduction is also plotted, illustrating that local markets provide the retail outlet for old varieties.

described by growers as a 'distinctive' flavor; varieties at the opposite (right) end of the scale are those considered to have an undesirable taste—described as mild or bland. In the intermediate range are tart-tasting apples, varieties described as a combination of tart and sweet, and sweet. In open-ended discussions, respondents emphasized tart as a more desirable taste than sweet.

Starting on the left, varieties such as Cox's Orange Pippin, Grimes Golden, Stayman Winesap, Cortland, McIntosh, Newton Pippin, and Winesap are described by growers as possessing distinct, flavorful taste. Stayman Winesap and Winesap are known for their tart, rich, wine-like flavor. McIntosh and Cortland both have similar tart, tangy, spicy tastes. Newton Pippin is characterized as having a taste that is rich with a piney tartness. Continuing, the varieties retain the tart quality, but are not described as being distinct. Granny Smith and Northern Spy are both extremely tart apples, but according to growers they lack the richness or distinctiveness of the varieties mentioned earlier; as such, their taste is not considered outstanding.

Moving on, tartness is replaced by sweetness with varieties such as Golden Delicious and Honey Crisp. Finally, at the end of the continuum are varieties that growers described as bland, including Rome Beauty, Red Delicious and Law Rome. One respondent described Rome Beauty and Law Rome as 'bad apples', and added that he didn't know why people even grow them.

Thus, Dimension 1 represents growers' values of taste among varieties, running on a continuum from those with distinctive tart tastes to those that are sweet or bland. Moving from distinct to bland, tartness levels decrease, reflecting most growers' preference for tart apples. The neat organization of varieties along this continuum demonstrates that the quality of taste is highly salient among growers.

Second dimension: use

The second dimension is the different uses for which varieties may be grown (plotted along the *y*-axis in Fig. 2). Respondents grow apples for eating raw, for cooking and for making cider. Varieties that can be used for all three are considered to be 'all-purpose' and are highly valued by the growers for their versatility and marketability. This includes varieties such as Grimes Golden, Honey Crisp, Cortland, McIntosh, Jonathan, Gala and Golden Delicious. These all-purpose apples are described by growers as having a 'dessert like' quality, making for good eating, but also retaining this quality when used for cooking. Cider processors also value these varieties, as they are used to produce quality cider. Jonathan and Golden Delicious are two of the cultivars most commonly used in Ohio apple cider blends, explaining, perhaps, why these are the among the varieties most commonly found growing in Ohio's apple orchards (they are grown in 94% and 81% of orchards, respectively)[36].

Continuing along the *y*-axis, there are varieties that are well-suited for cooking and eating, but not for processing. Winter Banana, Stayman Winesap, Winesap, Rome Beauty, York Imperial and Wealthy are all valued for their outstanding cooking characteristics, and are also quality eating apples. The ability to keep its shape when cooked is an important factor in a cooking apple; not being too sweet is also important. Having a slightly tart flavor allows the cook to add sugar to the desired sweetness; apples that are already sweet cannot be made less sweet. Thus their cooking and eating appeal makes them valuable to the grower for he or she can market them to those who want both an eating and cooking apple.

As their value as cooking apples decreases, what remains are those varieties appreciated only for their eating qualities. These varieties are less profitable for the grower because they have more limited marketing appeal. Varieties such as Red Delicious, Fuji, Mutsu, Mollie's Delicious and Granny Smith fit this category. Even though they can be, and sometimes are, used in other capacities, they are categorized as mainly eating apples. Thus, to the grower they are less valuable in terms of the range of purposes for which he or she can sell them.

Thus, this dimension reflects how growers value apples based on their uses: varieties that are suitable for multiple purposes (eating, cooking and cider processing) are most valued. Those that are suited only for eating are less valued because of the way their limited use restricts market possibilities.

Third dimension: market

Our interpretation of Dimension 3 centers on the market in which each variety is sold. Throughout interviews, the issue of markets and how they affect the types of varieties that a grower produces was a recurring theme. This, we believe, is key in understanding how apple varieties may be preserved. Growers distinguish between the varieties grown for the wholesale or 'commercial' market and those grown for the local (or 'niche') market. The latter includes 'pick-your-own' (u-pick) sales, farm markets and roadside stands; this distinction is echoed by other studies[37,38]. Growers' comments indicate that specific qualities make a given apple variety more suited for one market outlet or the other.

Appearance. Appearance is one such characteristic. On the wholesale market, apples have to look good, especially the color and texture of the skin. Color, for instance, should be even and vivid. As early as 1933, researchers at the Ohio Agriculture Experimental Station observed that the demands of the market had shifted the value of some varieties, citing Grimes Golden as an example. This apple, they claimed, 'has within the last 2 or 3 years met serious sales resistance because of its color'[39]. Likewise, apples with easily bruised skins or skin that has a speckled, or russeted, appearance can't be sold to this outlet. On the other hand, in the local markets growers are able to sell apple varieties that are not as 'perfect' in appearance. One grower proclaimed that 'we ship beautiful mediocrity' to note his judgment that the apples sold wholesale were pretty to look at, but inferior in other qualities.

Resistance to bruising. This is a second important characteristic of apples sold commercially, as they will need to be shipped, sometimes long distances. Because they will be handled heavily in the process of packaging, transporting and displaying, only varieties resistant to bruising can be marketed this way. Apples that are sold on-site are not exposed to these conditions. They are simply picked and stored locally until they go into the hands of the customer—or in the case of u-pick, it is those same customer hands that do the picking. The minimal amount of handling means that varieties sold in this way can be more susceptible to bruising without adverse effect.

Keeping quality. The ability to store well is also a factor. Varieties sold wholesale are generally neither stored nor displayed in highly refrigerated areas, so must be able to keep reasonably well without constant refrigeration. The waxy coating characteristically found on wholesale apples is applied in order to hold in both temperature and moisture, but even with this measure some varieties cannot be kept under non-refrigerated conditions for extended periods of time. Many locally sold varieties, on the other hand, are generally offered on a production basis: they are sold soon after being picked and therefore are not subject to the same storage requirements.

These differences can be used to interpret the organization of varieties along Dimension 3 (the *x*-axis in Fig. 3). This dimension is organized along a continuum from varieties that have strong wholesale market potential—because they possess these qualities—to those that only have a viable place in local marketing schemes.

Varieties such as Fuji, Gala and Braeburn are considered to be new varieties by growers, and are described in forecasts as the 'key ''new'' cultivars'[40]; they are up-and-coming in the wholesale market, meeting its demands for appearance, hardiness and keeping. Another such apple, Melrose, recently became the official apple of Ohio. This title has brought increased name recognition for the variety and thus more large-scale market appeal.

Further along Dimension 3 are varieties that are already well established in the wholesale market. Red Delicious, Granny Smith, Empire, McIntosh, Jonathan and Cortland are among the most popular and well-known commercial varieties; and these varieties conform to the characteristics required by the wholesale market.

Varieties such as Grimes Golden, Cox's Orange Pippin, Northern Spy, York Imperial, Russet, Newton Pippin, Wealthy and Winter Banana are located at the end of this continuum. Many of these old varieties are not attractive enough to be viable in the wholesale market. Russet, for example, is named because of the appearance of russet spots on its skin. Cox's Orange Pippin has a dull finish and thin skin, which is not suited for rough handling. Northern Spy, York Imperial and Newton Pippin are all flat or squat in shape and have uneven greenish-yellow areas. These were once important varieties in orchards, but they have lost their place as the value of appearance and hardiness in transport increased with larger, and more distant, markets. However, these last varieties still have an established place in local markets.

Importantly, Figure 3 also shows the year of introduction of each of the varieties. In general, there is a gradient from relatively recent introductions to old varieties, those that originated during the 18th and 19th centuries. Of greatest importance are those on the right-hand portion of the graph, where these old varieties are clustered, corresponding to the use of local markets. This pattern underscores the point, voiced both by growers and sustainable food system advocates, that local markets preserve crop biodiversity.

Conclusion

> The reduction in the number of apple varieties grown and the pursuit of the ideal 'commercial' apple has slowly and insidiously changed our perception of the fruit itself[41].

For Ohio apple growers, qualities of taste, use and market destination are key in their understanding of, and decision-making about, apple varieties. Varieties that are regarded highly for their taste qualities or versatility of use are not necessarily those regarded for commercial market potential. This reflects the demands placed on apples in the commercial market (for appearance, for durability, etc.), which contrasts with the way(s) in which growers value the apple varieties. When marketing on the local level, the main criteria that growers apply in choosing varieties are taste and use. Of the growers who sell on the commercial and local level, most of them expressed a preference for the local markets because they can apply their own values in deciding which varieties to grow.

Our conclusion is that local food systems do help preserve apple biodiversity. Many of the old apple varieties cannot participate in the conventional market system because they do not meet its standards of appearance, they bruise too easily and they are unable to withstand the transport and storage demands. Local markets thus give growers the freedom to select the varieties they produce, based on their own valuation of these varieties, rather than those dictated by the commercial market. In essence, we can look at local markets as refuges for the old varieties; in the absence of local markets, many of the older varieties would no longer be grown.

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