Farmers, scientists, and civil society groups have developed and promoted many new frameworks for improving environmental and social outcomes from agriculture. Some of these strategies are associated with grassroots social movements, such as agroecology and the system of rice intensification (SRI), while others, like Climate-Smart Agriculture and conservation agriculture, are more associated with agribusiness and existing government institutions. Despite their differences, many of these strategies are conceived of as decision-making or design frameworks that can be adapted to a wide range of ecological and social contexts.

Defining these strategies as frameworks or sets of principles, rather than technological packages, presents difficulties for “Boolean” (True or False) classification of farms relative to a strategy. Organizations promoting such strategies face difficulty tracking their adoption and may counter-productively simplify a strategy into the presence or absence of a few well-defined techniques (Giller et al., 2009). Scientific inquiry can become divided between researchers who study a strategy as a “recipe” through controlled trials and those view it as a flexible set of principles to be examined through case studies of implementation on real farms. These divides are particularly large regarding Holistic Management Planned Grazing (Briske et al., 2008; Gosnell et al., 2020) and the System of Rice Intensification (Glover, 2011; Sheehy et al., 2005).

Ecological certification of farming systems, which requires Boolean classification, has become increasingly important to food systems governance.

Integrated Pest Management (IPM) is one of the most prominent frameworks for increasing eco-efficiency in agricultural systems. First formulated in \_\_\_\_, IPM is now promoted by a wide array of organizations throughout the world as a means of increasing yields while reducing harms from agrochemical use and ensuring the sustainability of food supplies. Like other strategies, IPM is notoriously difficult to define (Bajwa & Kogan, 1996), alternately referred to as a “philosophy” (Sappington, 2014), “a way of thinking” (Maupin & Norton, 2010) or a ”decision-support system” (Kogan, 1998). Difficulties in Boolean classification of IPM make it harder to measure its adoption and impact (Castle & Naranjo, 2009; Ehler, 2006; Maupin & Norton, 2010; Sappington, 2014; Zalucki et al., 2009).

As a contested concept that nonetheless enjoys near-consensus support There is a wide range of diversity of programs- certifications differ in their geographic scope, from small regions to international, and in their crop scope; from single commodity to any food commodity. Likewise, these programs differ in their origin and intentions, they may come from environmental or development NGOs, university extension services or some combination of the 3. Examining this set of certifications can give insight into the universe of possibilities for certifying and delineating alternative agriculture systems.

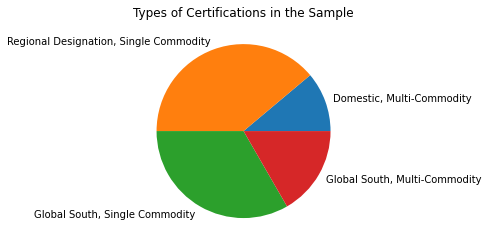
**Methods:**

A set of eco-labels for foods sold in the United States were assembled from the ecolabel index (cite). Inclusion criteria were: labels must be used (directly or indirectly) in the United States, and that the certification protocol must reference the framework of “Integrated Pest Management” in all, 20 certification programs were identified (Table 1). The certification protocols for these programs were inspected line by line and the criteria related to IPM were coded and categorized. Because some certifications included requirements relating to worker safety in handling pesticides under the rubric of IPM, these types of requirements were included for all certifications.

Criteria were classified as “Requirements”: the applicant fails certification if the criterion is not met, “Improvement”: the applicant does not have to initially meet the criterion to pass, but after several years in the program, it becomes a requirement, and “Scorecard”: The criterion is assigned a certain number of points, and the applicant must achieve a certain number of points in total to pass.

**Results:**

**Sample Description:**

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The scope of certifications are categorized across two dimensions, geographic and commodity group. Geographically, certifications were either for all areas within the United States, domestic but confined to a particular region, or focused on producers in the global south. In commodity scope, certifications were either for a single commodity/commodity group or for a wide range of commodities. Of the six possible combinations, only 4 were represented, there were no regionally specific multi-commodity standards and no domestic nationally applicable standards for a single commodity group.

**Results:**

**Certification Structure:**

The criteria used within certifications were coded as being ‘affirmative requirements’, which farms must meet all of to pass, “scorecard criteria” where farms must earn a certain number of points to pass, and ‘improvement criteria’ which are scorecards where the farm’s performance must increase over time. 6 standards were classified as “primarily scorecard” with relation to IPM, 5 were classified as solely requirement-based, and 8 were “mixed” between requirements and scorecards and/or improvement.

**Differences Between Certification Clusters:**

**Performance Standards:**

Three certifications (Healthy Grown, Lodi Rules and Protected Harvest Citrus) utilized a toxicity-units model as a pass-fail criterion. These models are of the form:

For each pesticide p applied. Where TU is total toxicity units, is the toxicity score of pesticide p and is the mass of that pesticide applied. For each certification, a total TU cap is set, and farms must stay at or below that cap.

**Discussion:**

Single-region single-commodity certifications stand out as different from other groupings. They include the most criteria overall, more monitoring criteria, including action thresholds, more likely to promote MOA rotation, and included more criteria relating to biosecurity and sanitation. Further, these were the only certifications which specified the use of models for predicting pest pressure. These differences likely reflect two factors. First, standards for a specific crop in a specific agroecological zone can be more exhaustive and specific. Several of the standards in this group contained monitoring and/or threshold standards or suggestions for multiple different insects and diseases. Comprehensive description of monitoring and threshold techniques for “any pest, any crop, anywhere” is obviously not possible within a single guidance document.

Additionally, these differences in standards reflect the collective-action and public-goods aspects of IPM. In contrast to many other environmental problems in agriculture, chemical resistance in pests and the import of exotic pests and diseases are public goods problems that are spatially bounded and primarily impact the farmers themselves. The same applies to natural enemies, to a lesser extent. These issues closely resemble the types of problems successfully dealt with by informal “commons-type’ governance structures (Ostrom et al., 1999); individual efforts in these areas can have high positive externalities within the community of crop-producers, creating the potential for free-rider problems. As such certification provides the opportunity not just for farmers to differentiate their products to consumers, but to coerce each other to undertake pro-social actions. Resolving such collective-action problems has long been acknowledged as a key challenge and opportunity in IPM promotion (Bottrell & Schoenly, 2018; Parsa et al., 2014).

Certifications focused-on low-income countries were different in two respects. First, the number of banned and restricted pesticides tends to be much greater. This likely reflects the fact that many of the banned pesticides are not allowed for use on crops in some countries but not others. More interestingly, these standards place much more emphasis on worker safety and hazardous materials handling. This not only reflects the different missions of some of the certifications, which often foreground social concerns, but also the role that these certifications play in substituting for and supplementing legal standards in these areas.

One-commodity regional domestic certifications generally included some worker protections. Most of these commodities commonly utilize migrant agricultural labor. Wisconsin Healthy-Grown Potatoes is the only one of these certifications not including any worker protection criteria; migrant farmworkers do not commonly work in this crop-sector.