Big Data in Forestry: Big Problems?

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Abstract

Data and data analytics are essential elements of modern farming. Farmers use historic records plus near-real time inputs to make decisions regarding everything from timing of operations to marketing of their products. The same is not true in forest operations.

Introduction

Technological advances of the last 20-30 years have brought about global-scale changes in how businesses and governmental agencies work, particularly in the use of data as a fundamental means of reaching customers and in deriving operational efficiencies. The term 'big data' has been applied to describe the information technology (IT) used to implement this strategy, a term that includes the infrastructure for data collection, it's movement and storage, and the processing power and analytical techniques to derive useful information from its acquisition. Examples abound of companies implementing large-scale data acquisition and communication technologies, in some cases streamlining their current business models and, in others, developing entirely new ones (Loebbecke and Picot, 2015).

Agriculture has been an enthusiastic adopter of computer and data technology across nearly every aspect of farming. Guidance technology, for example, was found by Castle et al. (2015) to be applied on more than 80 percent of acres farmed in Nebraska, and is viewed as having become a driving force in maximizing profitability and in promoting environmentally sound farming practices (Adrian et al., 2005). Technology in ag production is evolving rapidly with: new planter systems that can compensate for travel speeds in precisely depositing seeds, plus deal with multiple hybrids in a single field; variable rate application becoming standard practice in spray and granular systems; and variable rate irrigation with moisture sensor networks deployed across fields and entire farms (Erickson and Widmar, 2015).

The technology to implement site-specific farming has certainly become common over the last couple of decades, but the knowledge base to effectively use it has matured at a somewhat slower

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rate. There are rich data sources available to farmers to exploit for decision making, but data management and analytical techniques have been slower to arrive. And, when solutions have become available, new issues surrounding farm data and its use have arisen that make farmers somewhat wary about investing in them. Despite the problems, the future of farming is viewed as being data-driven and ‘Smart Farming‘ has become the latest paradigm for increasing farm production without sacrificing environmental stewardship Wolfert et al. (2017).

As a natural resource-based industry, there are some commonalities between farming and forestry that would seem to indicate similar trends toward adoption of technology creating economic benefits, but it cannot be said this is true. Mapping and the use of geographic databases have certainly become standard practice in forest management, but, until recently, there has been little movement toward application of operational technology, except perhaps in trucking. Caterpillar and John Deere have released on-board technology for timber harvesting equipment that holds similar promise as that seen in the early days of precision agriculture. The systems use communication technology to upload information on machine status to remote databases, typically those run by the OEM. Data are made available to the equipment purchaser and are used by the OEM to monitor fault conditions as early indicators of maintenance requirements, or potential design or manufacturing issues. With some additional processing, the data could also be useful to a logging contractor for operational planning and assessment.

This paper will outline some of the issues with operational data that have slowed, or at least dampened the enthusiasm for, implementation of ‘big data’ solutions in forest operations. It will first provide background on how and why data are of such value in farming and then will attempt to draw some conclusions about how technology, and the resulting data streams, might influence operational forestry in the coming years.

Big Data and Precision Agriculture

Farming is an endeavor that has traditionally rewarded experience. Investment costs are high and failure brings disastrous consequences so farmers, for good reason, have tended to stick with tried and true methods to maximize their chance of success. This approach worked well enough, but global pressures to grow more on fewer acres and at lower cost, both in terms of direct inputs and to the surrounding environment, have fostered a shift in thinking toward active management at very high spatial resolution. Farmers today are attempting to optimize results from every acre of land using information particular to that location and based on current site-specific conditions, rather than applying field- or farm-wide solutions.

Under this new paradigm, the farmer seeks to select a suite of ‘treatments’ maximizing growth potential at an acceptable cost, and then to time cultural practices that keep crops growing at a rate as close to their maximum biological potential as possible. All of this control is exerted on every acre cultivated and on a poorly understood system about which the farmer possesses only imperfect knowledge, particularly with respect to future weather or market patterns.

The new farming approach is, at least in engineering terms, optimization of a biological 'system'. But, when so many factors influence the outcome, a farmer faces a bewildering task. They can't even know how close their decisions brought them to a true optimum – this year's results can only be compared to previous years, or perhaps to neighbors' or respected peers'. This need for optimization of a complicated and large-scale system has driven the adoption of data as a basis from which to build a management plan. And, as has been seen over the past 20-30 years, data has become the crucial factor in successful farming. Early on, location technology spurred the development of nutrient and yield mapping in fields and provided the impetus for site-specific, or 'precision', agriculture. This led to development of higher levels of control on application equipment and the ability to more nearly achieve a prescription tailored to a given spot in a field. Most recently, the same ability to tailor other factors to site-specific conditions has been introduced, particularly in planting and irrigation. Data recording technology has been developed at the same time and it is possible now to have a complete as-applied map of nearly all inputs during a growing season. These maps make it possible to evaluate the economic and environmental effectiveness of all input investments, leading to very good forensic analysis of previous decisions, and quantitative evidence for driving management in following years. Newer forms of data collection, particularly aerial platforms outfitted with multi-spectral sensors, are also leading to capabilities for generating insights into crop status at any time during the growing season, enabling informed real-time decision making at very high spatial resolution.

Data in Forest Operations

Forestry and agriculture could be considered variations of the same business, both adding value to a biological product. But they are very different in time scale and in management intensity during growth of the crops. Technology has certainly been adopted in forest land management, especially geographic information systems, but also a variety of mensuration tools for assessing stand growth. On the consumption end technology is used in managing inventory at mills, with automated systems for weighing trucks in and out. Certainly the mills themselves have invested heavily in process control technology, especially sawmills applying x-ray and light scanning systems to optimize every log through their plants. Adoption of technology in logging, especially data analytics for management and optimization of production systems, has been slow and the pace of acceptance does not appear to be accelerating.

The Potential of ‘Big Data’ in Forest Operations

A large-scale adoption of data analytics in the near future by loggers, at least in the Southeast, seems a rather remote possibility. Technology, however, will certainly not remain in its present state and the ‘big data’ landscape could change, the question is how?

Large-scale, continuous collection of operational data from logging machines is becoming nearly as ubiquitous as in agriculture. Large manufacturers of farming equipment have for years equipped their machines with communication technology that automatically tracks and uploads performance information to OEM databases. These data are invaluable to engineers for understanding and correcting design limitations, and also for adding value to customers. By studying how machines are applied, OEMs gain insight into what design changes can be included to enhance productivity or efficiency of farming operations, plus overall reliability and durability of equipment. Although touted by OEMs as overwhelmingly positive, the consequences of such tracking could be viewed as unwarranted and potentially harmful if data were misapplied. Much of the controversy in agriculture has to do with yield data being used, with or without the OEMs’ or farmers’ consent, to inform land valuations.

One could easily envision a similar situation in logging. Operational data will undoubtedly be used by OEMs to improve design, durability, and maintainability of their equipment. It could also be used to add value to a machine purchase through benchmarking, or feedback to operators about operational choices that could enhance productivity. Already these data are being used to spot potential maintenance issues before they become critical and to help speed up repairs in the field, all of which is beneficial to an owner.

Ceding these data to the OEM, on the other hand, might also create negative scenarios. If productivity of a machine can be tracked, for example, risk can be accurately assessed when negotiating for purchase of new equipment. Knowledge of risks would be a very important concern in choosing interest rates for a purchase or for setting the amount of insurance coverage required. Farmers have loudly protested the automatic collection of data from their equipment, but OEMs see great value in the data for their business models and will not budge on its collection. They have, however, put into place privacy standards to protect farmers’ interests. Loggers should also be aware of the advantage created for OEMs with knowledge derived from the data they provide, without compensation, and need to understand the consequences for their individual situations.

Unlike in agriculture, it is harder to make the case for technology being the driving force behind large-scale, system-wide changes in forest operations. Farmers clearly understand the benefit from technology to their bottom line but potential economic gains for loggers are much harder to discern. As currently structured, logging is a service industry with no pricing power and, in an era of quotas, one without a clear benefit from out-hustling the competition. Logging is essentially a delivery service, much like FedEx or UPS, but operating in a consolidation role – dispersed products consolidated at a small number of consumers. Traditional delivery services move dispersed packages to even more dispersed destinations and emphasize timeliness as their principle business model. Companies like FedEx have invested a great deal in developing infrastructure, plus tracking and optimization technology, to make delivery of three million packages a day to locations all over the world a profitable business. The key to profitability for the company is their technological edge that optimizes flow of packages throughout the system, lowering costs and providing reliable, quick delivery for which customers will pay a premium.

Logging is a vastly different enterprise. Timeliness is generally not an issue, nor is quality of service necessarily paramount. The customer, in the timber products world, prefers a uniform flow of low-cost, high-quality raw material into their gates but, unlike in the ag world, does not look to mitigate pricing risks by entering into long-term supply agreements. Nor do they hedge against shocks to the system using a futures trading scheme. Timber is not a global market, it has a shelf life and is relatively expensive to ship, so incentives to buy and sell even regionally are not there – nearly all timber transactions are local. As a consequence, loggers are competing within a relatively small geographic area to supply a limited demand where low cost is their only marketing tool, and someone else is always working closer to the mill than them. Their business model lacks stability and there is no incentive to invest in technology to lower their average costs over a longer period of time, they are typically too busy making ends meet on a weekly basis.

Market structure in timber products is likely to remain in its present state for a long time so adoption of technology by loggers should remain low. It could take only a slight change in markets, however, to reshape the technology landscape. Timber-based products could become more highly specialized, especially if there is a carbon cost associated with more traditional building materials like steel. For wood to become a more ubiquitous structural component, it would have to be manufactured with consistent, stable properties. This could require being more choosy about what goes into it in the first place, meaning a specialized market for superior timber. With differentiation in markets, rather than a wide-open, commodity-based system, at least some loggers could afford to become more specialized and would likely be paid a premium to do so. In that scenario hauling a limited supply of high-value logs from multiple sites could force adoption of scheduling and routing technology. That technological toe hold might bring about wider adoption, but, given the nature of the logging community, it would still be a long shot.

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