Page 256 to 261

Volume 1 • Issue 6 • 2017

Research Article

Innovative Techniques in Agriculture

ISSN: 2575-5196

Quantitation of Fence Technology Through Analysis of US Patents

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Received: March 22, 2017; **Published:** October 10, 2017

Abstract

For centuries, fences have been a useful strategy for wildlife and domestic animal management and for avoiding human wildlife conflict. A quantitative understanding of their development can help reveal patterns about where fence technology is headed and has it been in line with the patterns in human wildlife conflict. The number of patents in the field is a fine quantitative indicator of development but there is no single document evaluating the growth of patents related to fence-technology. Hence this study systematically evaluates the evolution of fence technology, as evinced by the growth in USA patents on fences. Our analysis shows a continuous growth in fence technology, which one might think of as a simple established tool with no scope of further development. Fence technology has intensively developed in the area of electric fencing where most patents have been filed on fence design and insulators. Apart from this, technologies have also been developed that restrict wildlife to an area with tracking and vibration sensors. This is the first work on quantitation of development in fence technology and we hope that it propels further developments in the field.

Keywords: *Fence; Electric fence; Human-animal conflict; Sustainable development; Data driven policy*

Volume 1 Issue 6 October 2017

Introduction

Fences have been in use for controlling animal movement much before modern science [1,2]. Continuous developments in fence design and improvements in fence technology, including their electrification have contributed a lot to the ecology and the economy of the fenced regions [3–13]. Fence designs and technologies have evolved towards increasing difficulties in crossing the fence. While studies on the effectiveness and the cost of fence technology have found electric fences to be the most cost effective in keeping wildlife off the crops [3–5], not many studied have looked at the development in fence technology over time through patents. We posit that such an analysis can provide useful information for a good understanding for smart data driven policy-making, as information on the trends of development has benefited several other related fields like animal movement and human animal interface by allowing for the development of better models to understand these systems [14,15]. With this goal in mind, we have evaluated all US patents from 1976 (beginning of complete online available patent dataset) to 2016 May. A large fraction of the patents in any field wrongly contain some keywords, largely because of the patentee's intention of covering as wide of an intellectual property as possible, hence a simple automated analysis is not suitable [16]. Thus we evaluated all the patents manually in this study.

Methods

US patents were searched at http://patft.uspto.gov with the queries: 1. “animals” and “fence” and 2. “animals” and “electric fence”. The search term “animals” and “fence” indeed covered all fence technology relevant to animal management because it is highly unlikely that a patent related to fence technology for animal management misses out these two words. Moreover, entries that were not relevant were manually marked as irrelevant. We excluded from this all the electric fence related technology because we wanted to quantitate the development in electric fence related technology separately. All resulting patents were read by researchers independently and classified in the appropriate categories. The patents were covered from 1976 to May 2016.

Results

After obtaining each patent, we read them fully. Mis-categorized patents, which had nothing to do with fence technology, were classified as irrelevant. For both non-electric and electric fences, we chose the other categories based on the main feature developed in the patents, say animal dislodging or insulator. We have parsed our results finely but a reader who might be interested in a broader categorization, can easily get the numbers from the two tables (Table 1 and Table 2) that we present in the paper. Table 1 covers technologies that are common to both non-electric and electric fences, while table 2 specifically looks at electric fence related technology. Figure 1 plots data presented in the two tables. We have left out irrelevant entries from the figure. All the patents that have been presented in the tables and the figure are catalogued by patent number in supplementary material 1.

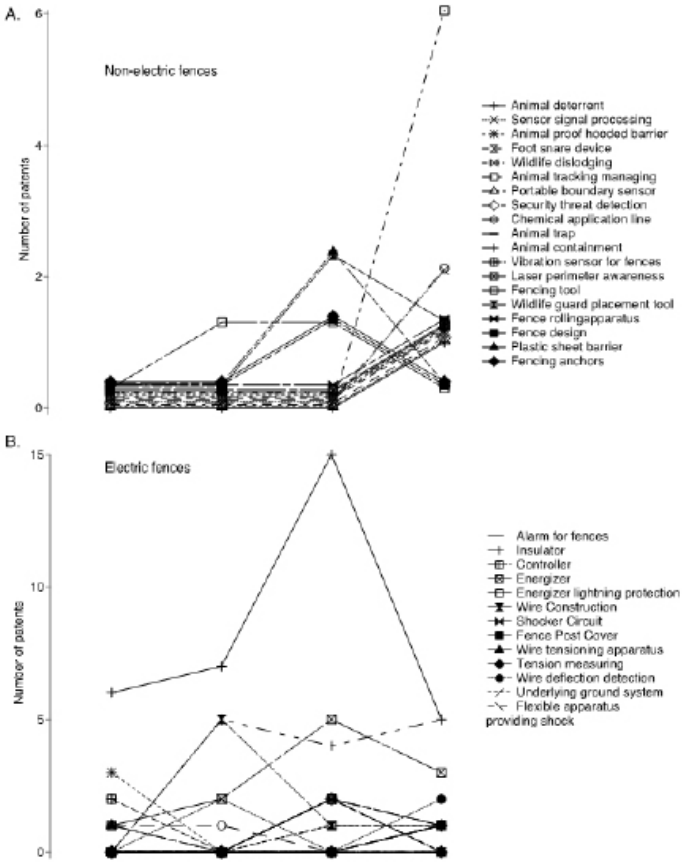

Figure 1: *Growth of patents in fence technology over the years.*
A. Non-electric fences (some data points are offsetted by 0.025 to 0.4 values to show overlapping traces) B. Electric fences. Non-electric fence technology can be of use for electric fences too.

For non-electric fences, there have been few new patents [Table 1] suggesting thin development in the technology except in the past decade. Rather than physical fences, the focus in the past decade has been towards developing tools that can restrict wildlife to an area like vibration sensors and animal tracking systems. A good fraction of the development comes in sensor and tracking related technologies where animals are monitored by a sensor installed on their body and an automated alarm is raised if the animal goes out of the restricted area. These technologies add a new layer to wildlife management.

	1976-1985	1986-1995	1996-2005	2006-Now
Animal deterrent	0	0	0	1
Sensor & signal processing	0	0	0	2
Animal proof hooded barrier	0	0	0	1
Foot snare device	0	0	0	1
Wildlife dislodging	0	0	0	1
Animal tracking & managing	0	0	0	6
Portable boundary sensor	0	0	0	1
Security threat detection	0	0	0	1
Chemical application Line	0	0	0	2
Animal Trap	0	0	0	1
Animal containment	0	0	0	1
Vibration sensor for fences	0	0	0	1
Laser perimeter awareness	0	0	0	1
Fencing Tool	0	1	1	0
Wildlife guard placement tool	0	0	2	1
Fence rolling apparatus	0	0	0	1
Fence design	0	0	1	0
Plastic sheet barrier	0	0	2	0
Fencing anchors	0	0	1	0
Irrelevant (not related to fences)	4	14	36	102

Table 1: *Growth of patents for non-electric fences.*

In electric fences, there have been consistent improvements since 1976 that have resulted in interesting developments [Table 2]. Specifically in the last decade, the focus in electric fences has been towards improving the fence design and the underlying electronics such that the fences become easier to install, more difficult to cross, use lesser energy, and utilize other sources of energy like solar power. Insulators have been a major area of improvement. As electric fences are bound for support to trees and other posts, improvements in insulator design have allowed for better designs that can handle load more efficiently and elastic cables that do not get damage if the tree grows in size. Electric fence designs have also improved such that the fences have become adjustable and portable. Also, depending on the area to fence, energizers and electric circuits have also been improved. For instance, developments in energizers have led to randomized firing of electric pulses in electric fences making it an energy efficient solution.

	1976-1985	1986-1995	1996-2005	2006-May 2016
Electric Fence design	6	7	15	5
Fence identification device	0	2	0	0
Fence gate	3	0	0	0
Fence rail holder	0	0	2	0
Portable electric fence	0	0	1	1
Solar panel along with fences	0	0	0	1
Communication in wiring system	0	0	2	0
Stringing and retrieving fencing	0	0	2	0
Fence voltage indicator	1	1	0	0
Alarm for fences	1	0	0	0
Insulator	0	5	4	5
Controller	2	0	2	1
Energizer	1	2	5	3
Energizer lightning protection	0	0	0	1
Wire Construction	0	5	1	1
Shocker Circuit	0	0	2	1
Fence Post Cover	0	0	0	1
Wire tensioning apparatus	1	0	0	0
Tension measuring	0	0	0	1
Wire deflection detection	0	0	0	2
Underlying ground system	0	0	1	1
Flexible apparatus providing shock	0	0	2	0
Irrelevant (not related to fences)	9	13	19	24

Table 2: *Growth of patents on electrical fences.*

Discussion

Our study is the first to present an evaluation of trends in patents of fence technology. It is limited in its scope because of not being able to compare these technologies or the commercial success of these technologies. This is because of incomplete data sets. We also have not delved into non-US patents. It is possible that some other country patents have important technologies that have not been filed for US patent. Our choice of selecting US patent was based on the fact that technologically US is more advanced and has a major contribution in technological development in most fields but we hope that the follow up studies expand on the scope of our work. There is hardly any data on the use of fences in several developing countries, such as India, Indonesia, Brazil and China. We hope that fence technology is used wisely for sustainable development and further data analysis on the use of fences enable better data driven policy making.

In the two tables and figure, we focus on quantitating the development of technology but stay away from evaluation of the technology. Evaluation of the overall technology depends not just on the strength of the patent but also on its commercialization. It also depends on the field studies, revealing the pros and cons of a technology that might not be revealed by lab tests or tests in limited field conditions only. Unexpected responses of herbivores and changes in their migration have come to fore from large scale field trials only [17,18], which would not have been obvious from the patents at all. It is clear that the field is moving towards animal tracking, drones, and virtual fences as more advanced and technological tools are being used [19-23]. A similar result can be observed in this study as more patents are being filed in the sensors and animal tracking systems in the recent years [Table 2]. Soon the current approaches to

fence technology would undergo a major overhaul. There are a few good evaluation studies on the development of fence technologies [24-28] but given that the impact of technology is different on different animal species and depends on geographical location, duration of fencing (as animals learn a way to overcome barriers) and other parameters, we avoid a systematic discussion of those issues here. With a data science approach, this study highlights the trends in the development of fence technology to encourage data driven policy making and also encourage more such studies in related fields. We hope our quantitation of patents enables better such evaluation by researchers involved in systematic appraisal of fences.

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