Analysis

Taking the sting out of Little Fire Ant in Hawaii

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ABSTRACT

In the 1990's, Little Fire Ants (LFAs) found its way to the island of Hawaii, most likely traveling with a shipment of potted plants from Florida. These plants were subsequently sold to consumers along the east coast of the Island, along with Little Fire Ant colonies living in the potting medium. LFA is now thriving and continues to spread. Fifteen years after the initial detection in 1999, LFA has spread to over 4000 locations on the island of Hawaii and has been found in isolated locations on Kauai, Maui, and Oahu Islands. Current efforts are expected to contain the infestations on the other islands but significant additional investment is needed to halt the rapid spread of LFA on the island of Hawaii.
Increased management expenditures can suppress infestations; reduce spread between sectors; and decrease long-term management costs, damages, and stings.

• An immediate expenditure of $8 million in the next 2–3 years plus follow-up prevention, monitoring, and mitigation treatments will yield $1.210 billion in reduced control costs, $129 million in lowered economic damages, 315 million fewer human sting incidents, and 102 million less pet sting incidents over 10 years.
• Over 35 years, the benefits include $5.496 billion in reduced control costs, $538 million less economic damages, 2.161 billion fewer human sting incidents, and 762 million fewer pet sting incidents.

1. Introduction

1.1. Problem Statement

Wasmannia auropunctata (roger), known as the Little Fire Ant (LFA), threatens native biodiversity, alters tropical ecosystems, impairs human health, impedes tourism, diminishes agricultural productivity, mars horticulture sales, and accordingly ranks among the world's worst invasive species (Lowe et al., 2000). Little Fire Ant will sting endangered reptiles and birds, interfering with reproduction, nesting, and survival of young. They also sting cats, dogs and other domestic animals in the eyes, blinding them over time (Theron, 2005). Humans are also stung by this species, both indoors and outdoors. The sting typically causes an intense burning sensation and painful itchy welts. Human habitats provide ideal niches for Little Fire Ant growth and survival (Krushelnycky et al., 2005). Human activities disperse Little Fire Ant quickly and widely.

1.2. Research Statement[1]

The purpose of this research is to assess the long term impacts of Little Fire Ant in Hawaii and to ascertain the economic and social benefit from greater public investment in prevention and control.

We developed a multi-sector, dynamic, stochastic, bioeconomic model to simulate LFA spread, human response, economic damages,

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[1] Abbreviations used in this article: LFA, HDOA.

and social impacts. We parameterized the model with government data, primary survey data, and information from experts and practitioners. We specified several levels of management and simulated outcomes with Microsoft Excel using Frontline Risk Solver Platform©.

1.3. Background

Ants were first introduced when the Europeans settled the islands, in the 18th century. Hawaii is now home to 47 introduced ant species (Krushelnycky et al, 2005); with the recent introduction Little Fire Ant *W. auropunctata* regarded as potentially the most destructive. USDA-ARS (2010) estimate that total damages, losses and control costs attributed to invasive fire ants in the United States is $5.6 billion per year.

Little Fire Ant arrived on the island of Hawaii most probably in the 1990's and by the time the infestation was detected in 1999 (Conant and Hirayama, 2000), Little Fire Ant had spread to 13 separate locations. Aggressive control actions were undertaken immediately, however Little Fire Ant continued to spread (Conant, 2002) and by 2004, infested 31 locations (Fig. 1). In the years following its initial detection, Little Fire Ants have spread to three other islands in the Hawaii archipelago: Maui, Kauai (Vanderwoude et al., 2010) and Oahu in late 2013.

The source of Little Fire Ants found in Hawaii is most likely Florida USA. Little Fire Ants have an unusual form of reproduction. In introduced populations, almost all female reproductive offspring are genetically identical to the parent female and males are genetically identical to the male parent. This clonal form of reproduction allows the source of new invasive populations to be traced to the source population with a high degree of certainty. Foucaud et al. (2010) determined that the clonal lines of Little Fire Ants in Hawaii are identical to those of introduced populations in Florida USA.

Due to the severity and extent of impacts, LFA is considered among the world's worst invasive species (Lowe et al., 2000). In homes, schools, lodging, and parks, Little Fire Ant will sting adults, infants, children and pets. The reaction to stings varies from person to person. Some people experience a severe reaction with a great deal of pain and large raised welts that itch for a week or more. Babies can receive numerous stings within a few minutes of exposure. Pets are stung in the eyes and over

several years lose their sight (Theron, 2005). Little Fire Ant infestations put agriculture crops and workers at risk (Fabres and Brown, 1978). When Little Fire Ant is present, aphid populations explode due to mutualism (Fasi et al., 2013) and farm workers are stung repeatedly. Plant nurseries can and have gone out of business due to lost productivity, high treatments costs, and a reluctance by consumers to buy infested stock. Wild honeybee hives in Hawaii have been swarmed and destroyed by LFA.

Once established, Little Fire Ant can occupy their habitat at an extraordinarily high density. Souza et al. (2008) estimate that total population size can exceed 200 million ants per hectare with worker:queen ratios of approximately 400 (Ulloa-Chacon and Cherix, 1990). This equates to a density of 20,000 ants per square meter, of which 40 will be queens.

Best-practice mitigation activities for affected residents and businesses comprise a regular (six weekly) application of granular baits to exterior areas combined with the use of residual pesticides both inside and on the exterior of structures. The Hawaii Ant Lab (University of Hawaii), with a staff of five people, provides research, outreach, education, training, advice and limited mitigation activities for all invasive ant issues in the state of Hawaii including maintaining a website[2] with information on impacts and remedies. The Big Island Invasive Species Committee provides education and outreach on Little Fire Ant and other invasive species on the island of Hawaii.

In modeling invasive species management, Mumford and Norton (1984) applied Bayesian decision theory to determine the timing and level of management as a function of the invasive species population density. Eiswerth and Johnson (2002) and Eiswerth and van Kooten (2002) incorporated dynamics to model population growth and uncertainty to allow for weather variability. To obtain closed-form solutions to the optimal invasive species management problem, Burnett et al. (2007), Carrasco et al. (2010), Mehta et al. (2007), Taylor and Hastings (2004), and Olson and Roy (2003) assumed a continuous rate of spread and employed optimal control modeling. Leung et al. (2002) modeled discrete invasive species spread employing stochastic dynamic programming.

Prevention management including monitoring invasion pathways associated with trade, transport and travel and inspecting potential vectors was modeled by Perrings (2005). Olson (2006) modeled invasive species introduction as a random variable and included prevention as a means to reduce the probability of introduction. Leung et al. (2002) specified prevention success as exponentially distributed and diminishing with effort. Mehta et al. (2007) indicated that prevention may do little to stop spread when the probability of introduction is small or when the number of invasion pathways is large, and modeled detection as a means of locating new introductions before they have had a chance to spread, where the probability of detection increases with the level of effort.

New introductions and established infestations require mitigation treatment in the form of chemical, mechanical, and manual means to reduce or eliminate the infestation. Treatment effectiveness as a stochastic process that decreases with effort was modeled by Feder (1979). The effectiveness of successive treatments was modeled with a cumulative probability distribution by Lichtenberg and Zilberman (1986). Olson and Roy (2003) used dynamic programming to determine the conditions under which eradication, mitigation, and no mitigation are optimal.

The marginal cost of invasive species management was modeled as a linear function that increased with the size of the infestation by Hastings et al. (2006) and Burnett et al. (2007); as a convex function by Olson (2006); and as a budget constrained function by Taylor and Hastings (2004), and Hastings et al. (2006). The marginal economic damage caused by the infestation was modeled as a linear function that
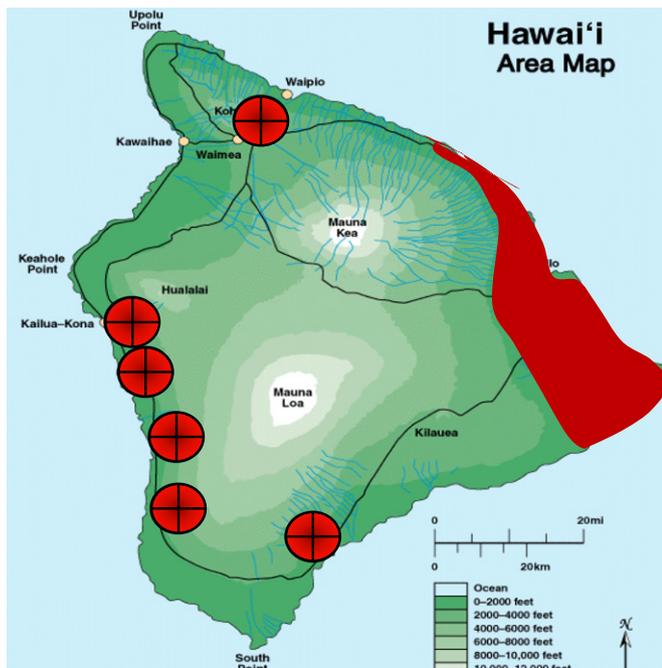

Fig. 1. Regions on Hawaii Island with one or more infested locations (red).

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[2] www.littlefireants.com.