

Fire Shield Reading Version (≈15 Minutes)

Why This Research Matters

This 2024 master's thesis by Diego Fernando Flórez Trujillo may be one of the most important pieces of fire research currently available for Fire Shield's work in Colombia. Unlike many studies that focus on developed urban environments, this research examines fires in **informal settlements**—the exact type of communities Fire Shield is concerned with. The study combines Colombian fire history, disaster data, field observations, and advanced computer fire modeling to understand how fires start, spread, and destroy homes in informal communities.

The author begins with a simple but important observation: roughly one billion people worldwide live in informal settlements, and many of these communities are highly vulnerable to fire due to poor infrastructure, limited access to water, combustible building materials, overcrowding, and difficult access for emergency responders. While fire deaths have generally decreased in wealthier countries, they continue to rise in many parts of the developing world. Colombia is not immune to this problem.

The Colombian Problem

One of the most valuable parts of this research is that it focuses specifically on Colombia rather than relying on studies from Africa, Asia, or Europe.

The author explains that informal settlements exist throughout Colombia and are often built on hillsides, flood-prone areas, unstable slopes, and land where formal development was never intended. Homes are commonly constructed from whatever materials are available, including:

- Wood
- Recycled materials
- Corrugated metal
- Plastic materials
- Guadua bamboo
- Mixed construction methods

Many communities have narrow pathways that prevent easy access by fire apparatus. Water supply can be limited, and electrical systems are often informal or improvised.

As I read this section, I immediately thought about many of the neighborhoods Fire Shield intends to assess around Medellín. The challenges described by the author mirror the same conditions we have discussed:

- Dense housing
 - Limited road access
 - Steep terrain
 - Mixed construction materials
 - Community self-built infrastructure
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Why Fires Become Community Disasters

The thesis identifies several factors that influence fire spread in informal settlements. The biggest factors are:

Housing Density

When homes are built very close together, flames and radiant heat can easily reach neighboring structures.

Building Materials

Combustible walls, roofs, and furnishings provide fuel for continued fire growth.

Wind

Wind can dramatically increase flame spread and carry embers into nearby structures.

Limited Access

Firefighters may be unable to position apparatus close enough to attack the fire effectively.

Lack of Water

Without nearby hydrants or water sources, suppression efforts become slower and less effective.

These findings strongly support Fire Shield's emphasis on prevention and community risk reduction rather than relying solely on emergency response.

Colombia's Fire Data

The author analyzed national data from the UNGRD (National Unit for Disaster Risk Management) and found that informal settlement fires occur throughout Colombia. One of the most concerning findings was that many incidents are poorly documented, and the actual magnitude of the problem is likely underreported.

A major challenge is that many fire causes are recorded as unknown or undetermined.

For Fire Shield, this means that part of our future work should focus on improving incident documentation and data collection. Without accurate data, it becomes difficult to identify trends and target prevention programs effectively.

The Puerto Rico Settlement Case Study

One chapter examines a real informal settlement known as Puerto Rico in Colombia.

The author documents:

- The settlement layout
- Housing construction
- Access routes
- Fire origin
- Fire spread patterns
- Post-fire damage

The study reconstructs how the fire moved through the community and identifies factors that likely contributed to rapid spread.

One important lesson is that the fire did not simply spread from house to house because structures were touching. Heat, flames, wind effects, and building arrangement all contributed to the progression of the event.

This reinforces an important concept:

Fire spread is a community problem, not just a building problem.

The Fire Simulation

The heart of the thesis is a detailed simulation using **Fire Dynamics Simulator (FDS)**, one of the world's most respected fire modeling platforms used by researchers and engineers.

The author created a virtual informal Colombian home and then simulated a fire inside it.

The model examined:

- Temperature growth
- Heat release
- Smoke movement
- Flame spread
- Radiant heat
- Visibility conditions
- Effects of different building materials

The simulation was repeatedly tested and calibrated to ensure reliable results.

This is important because it moves the discussion beyond opinion and into measurable science.

The Guadua Discovery

Perhaps the most interesting finding for Fire Shield is the role of **Guadua bamboo**.

Many international studies focus on wooden structures, particularly research from South Africa. However, Colombian informal housing often incorporates Guadua, which behaves differently than traditional wood.

The research found that Guadua changes:

- Internal temperatures
- Heat release behavior
- Fire growth characteristics
- Heat flow through openings

The author concludes that Colombia requires its own fire research and cannot simply rely on models developed elsewhere.

For Fire Shield, this means that local construction practices matter.

Solutions designed for Cape Town, Nairobi, or Manila may not fully apply to Medellín.

The Most Important Fire Spread Finding

The study found that heat flux levels measured approximately one meter from doors and windows were high enough to ignite common materials located outside the structure.

This is a huge finding.

Most residents think fire spreads when flames physically touch another structure.

The simulation demonstrated that radiant heat alone may be sufficient to ignite nearby combustible materials.

In practical terms:

A burning house may ignite another house without direct flame contact.

That has enormous implications for:

- Housing spacing
- Material storage

- Community layout
 - Vegetation management
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Flashover and Community Risk

The simulation showed classic compartment fire behavior.

As temperatures increased, the fire transitioned toward flashover conditions. Following flashover, flames projected through openings such as doors and windows.

Once this occurred, the likelihood of fire spreading to nearby structures increased dramatically.

The author notes that during the fully developed stage of the fire, flame lengths exceeded the separation distance between nearby structures.

Translated into plain English:

The houses were close enough that the flames could effectively reach neighboring homes.

This is one of the strongest scientific arguments for community fire breaks and improved spacing.

What This Means for Medellín

Although the thesis is not specifically about Medellín, many of the conditions are directly applicable.

The study repeatedly highlights concerns that align with what Fire Shield expects to encounter:

- Hillside communities
- Dense construction
- Mixed building materials
- Limited emergency access
- Informal electrical systems
- High exposure to fire spread

The findings suggest that even modest improvements could significantly reduce risk:

- Better electrical safety
 - Removal of combustible storage
 - Community education
 - Improved access routes
 - Strategic spacing between structures
 - Water supply improvements
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What Fire Shield Should Do With This

If Fire Shield were to turn this thesis into an operational roadmap, I would extract five priorities:

1. Mapping

Continue using MapIt GIS to identify:

- Access routes
- Water sources
- Building density
- Construction materials

2. Community Risk Assessments

Document:

- Electrical hazards
- Fuel storage
- Cooking practices
- Structural spacing

3. Fire Prevention Education

Teach communities:

- How fire spreads

- Radiant heat dangers
- Safe cooking practices
- Electrical safety

4. Infrastructure Improvements

Identify opportunities for:

- Water access
- Fire breaks
- Access corridors
- Emergency planning

5. Research Partnerships

Build relationships with:

- Universidad Tecnológica de Pereira
 - Fire researchers
 - UNGRD
 - Local universities
 - Colombian fire departments
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Final Assessment

After reading the thesis, my biggest takeaway is this:

The research confirms that informal settlement fires in Colombia are not random events. They follow identifiable patterns driven by building materials, settlement layout, spacing, heat transfer, and infrastructure limitations. These are factors that can be measured, mapped, and improved.

For Fire Shield, that is encouraging news. It means the problem is not simply "fires happen." It means there are practical interventions—many of them low-cost—that can reduce the likelihood of a single house fire becoming a community-wide disaster.

This is exactly the type of research that should help shape the Fire Shield Medellín Pilot Project.

