Battle of Kapyong

Modeling, Simulation, and Military Gaming

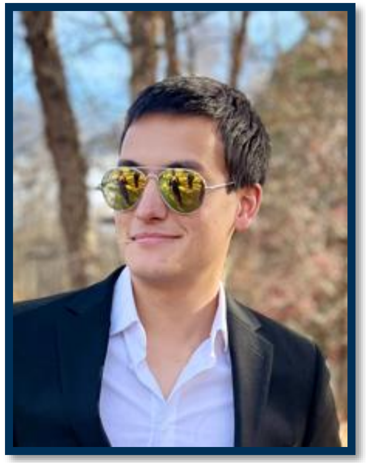
Hot Wash

April 21st, 2025

Georgia Tech

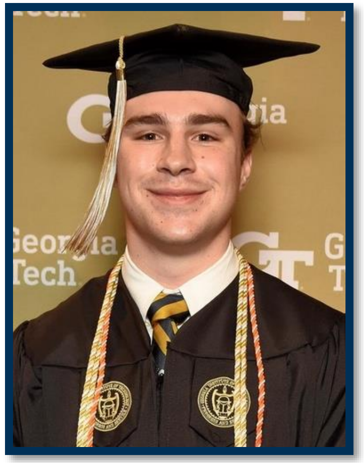
Introductions

Gabriel Rogers
B.S. Mech. Engineering



Donovan Sheppard
B.S. Math

Andrew Solano
B.S. International Affairs



Jack Keller
M.S. Computer Science

Aditya Yadavalli
M.S. Computer Science

Agenda

1. Context & Motivation
2. Research Question
3. Model
4. Analysis
5. Conclusion

Bottom Line Up Front

- Impossible win
- UN Forces abandoned equipment to climb to higher ground
- Steepness is the most important factor for victory

Battle of Kapyong – The Last Stand at Hill 677

Korean War – April 22–25, 1951

Context:

- Last stand against Chinese to prevent fall of Seoul
- UN forces retreated to Hill 677, a strategic high ground

Key Facts:

- 2,000 Chinese troops attacked
- 100 UN defenders - supported by nearby artillery
- An ammo truck had to be abandoned during retreat
- Despite being outnumbered 20:1, the defenders held the hill

Result:

- The UN Successfully defended Hill 677
- UN: 33 casualties
- PVA: ~1,000 casualties

Research Question

Motivation:

- It is difficult and sometimes impossible to carry heavy equipment up steep terrain. When faced with a decision to abandon equipment to gain a steeper position, how critical is it to acquire a steeper position, and how much equipment should be abandoned?

Question:

- How does the steepness of a defensive position and the amount of weaponry affect the attacker's casualty rate in battle, considering soldier fatigue?

Hypothesis:

- In general, steeper defensive positions result in higher attacker casualty rates. However, while additional heavy weapons initially increase casualty rates, their effectiveness diminishes at higher steepness due to soldier fatigue from carrying them.

Independent Variables	Dependent Variables
Hill Steepness	Casualty Rate (troops/hr)
Number of Weapons	Time (hrs)

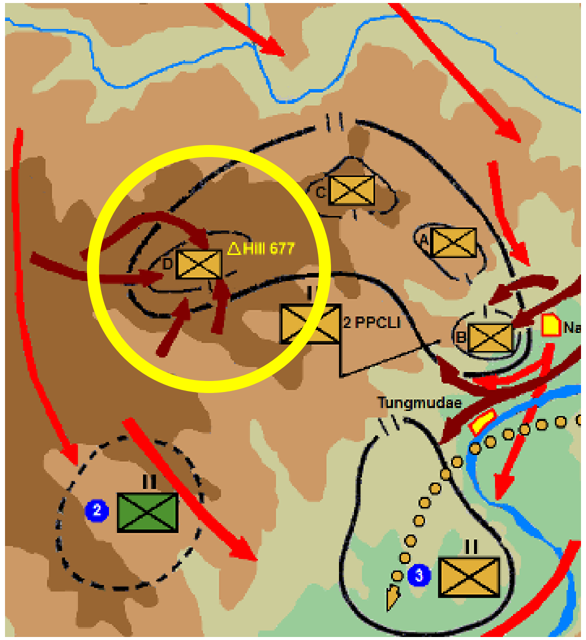
Model

Environment

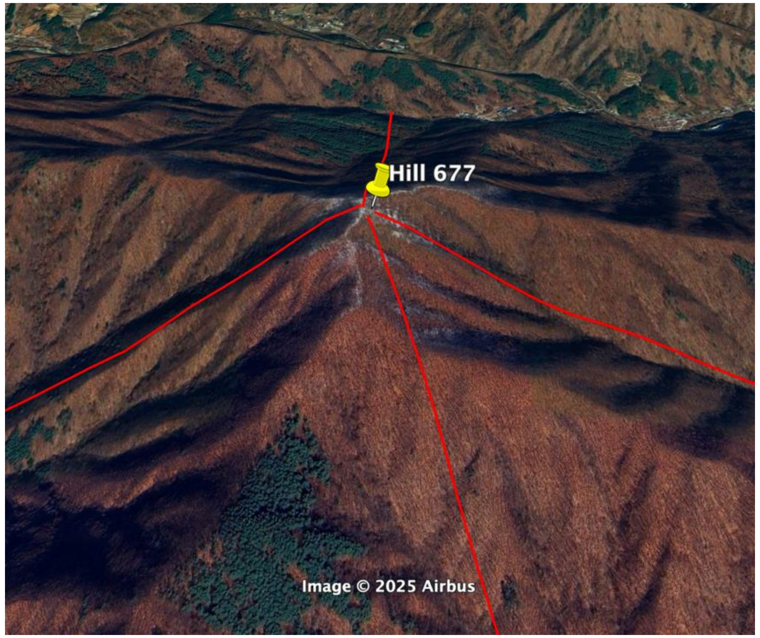
- **Model Dimensions**
  - Netlogo: 201 x 201 pixels
  - Real distance: 2.25 x 2.25 miles

  → *18 x 18 meters per pixel*

- **Pixel Parameters**
  - Elevation (m.)
  - Steepness (°)



Battlefield diagram [12].



Satellite image (Google Earth) [5].

Agents

UN Forces (2 PPCLI D Company & 16 NZFR Artillery)

Type	Count	Varies? (Y/N)
Soldier	100*	N
Artillery	24	N
Mortar	**3**	**Y**
Machine gun	**2**	**Y**

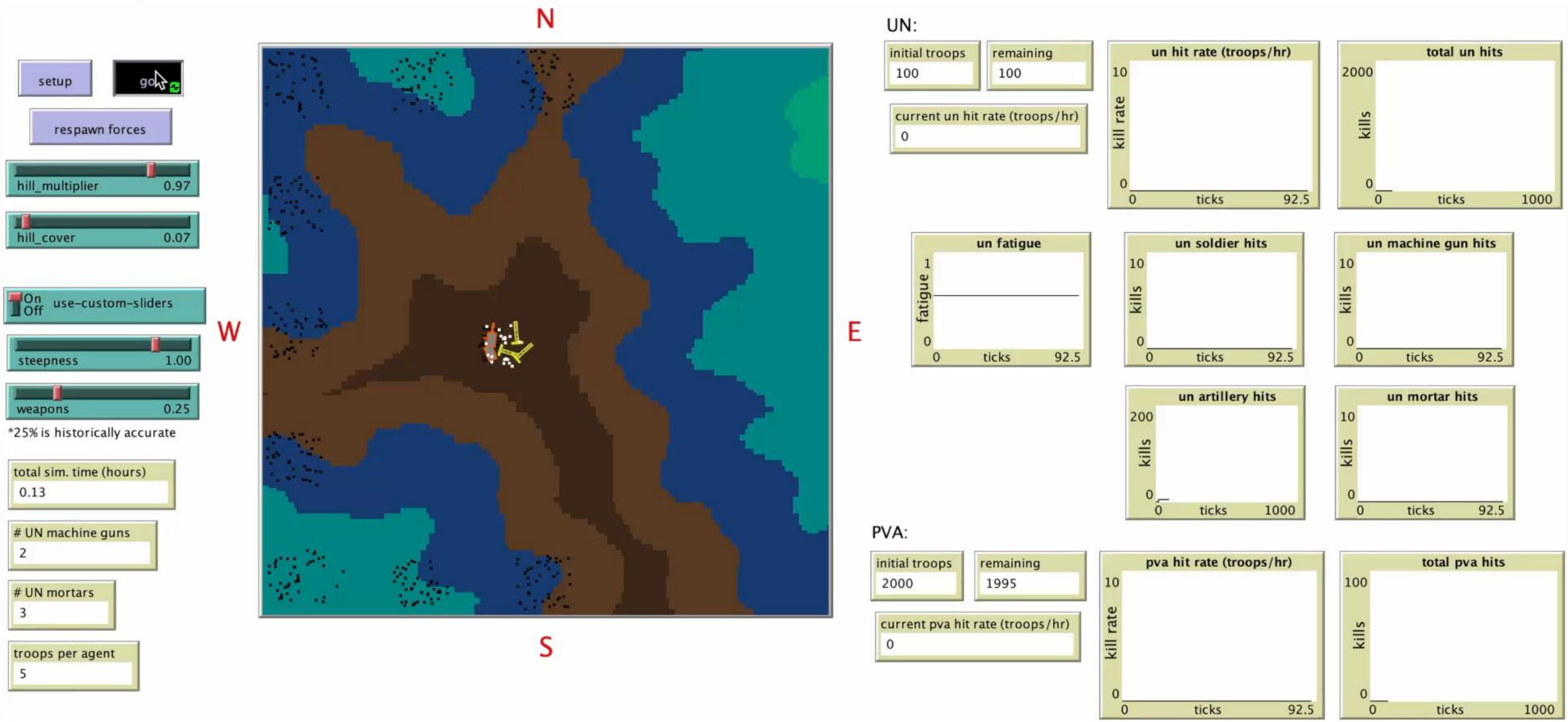
Weaponry
Bolt-action rifle
Bayonet
Grenade

Chinese Forces (PVA 118th Division)

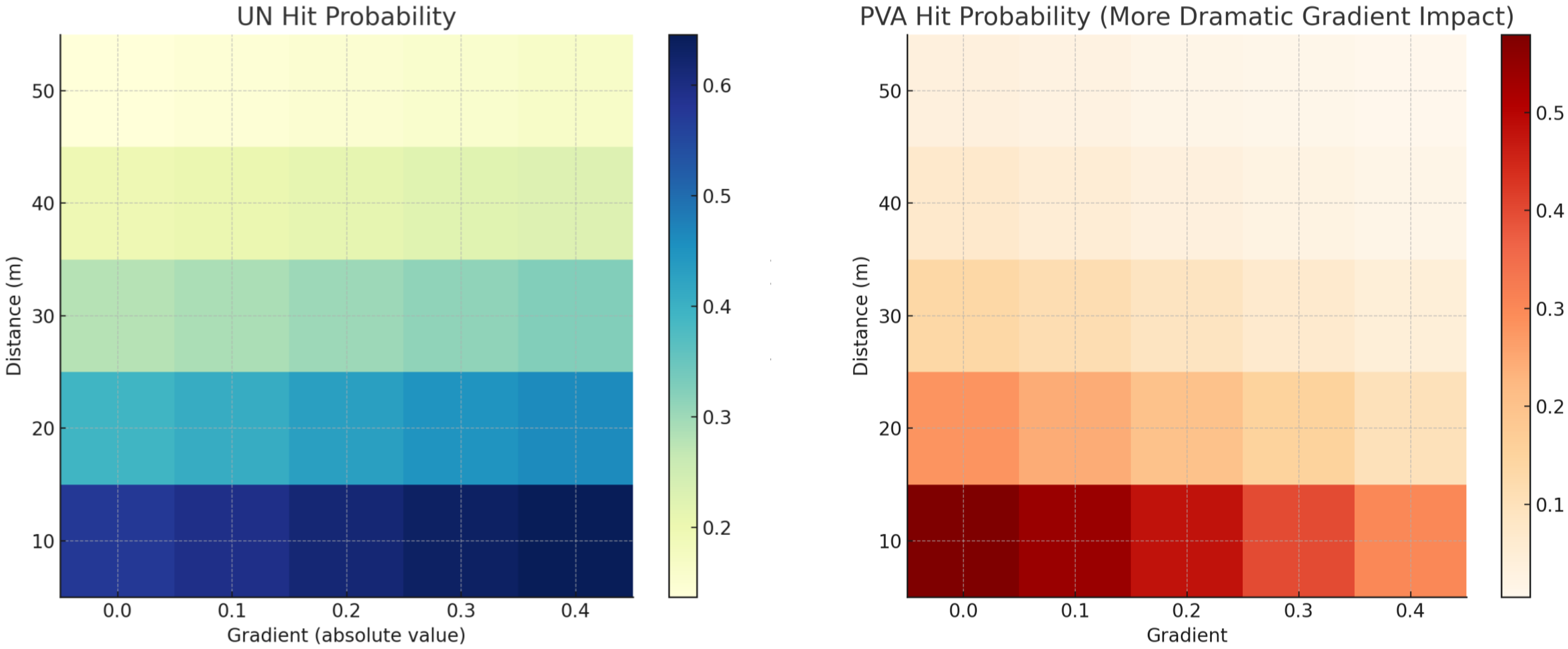
Type	Count	Varies? (Y/N)
Soldier	2000**	N

Weaponry
Sub-machine gun

*2 PPCLI consisted of 700 troops total; we estimate D company had 100 [13].
**PVA assault consisted of 5,000 troops total; we estimate D company fought 2,000 [4,11,13].

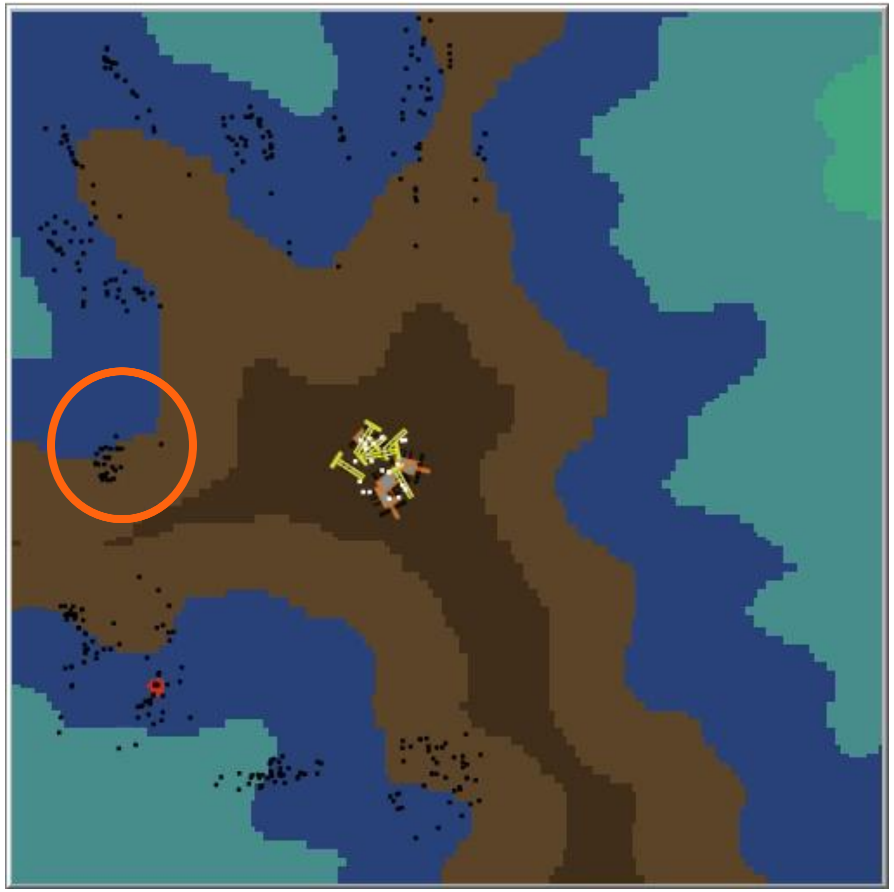

N
W
E
S
setup
go
respawn forces
hill_multiplier 0.97
hill_cover 0.07
On
Off
use-custom-sliders
steepness 1.00
weapons 0.25
*25% is historically accurate
total sim. time (hours)
0.13
UN machine guns
2
UN mortars
3
troops per agent
5
UN:
initial troops
100
remaining
100
current un hit rate (troops/hr)
0
un hit rate (troops/hr)
kill rate
ticks
total un hits
kills
un fatigue
fatigue
un soldier hits
un machine gun hits
un artillery hits
un mortar hits
PVA:
initial troops
2000
remaining
1995
current pva hit rate (troops/hr)
0
pva hit rate (troops/hr)
total pva hits

Model Dynamics: Rifles & Machine Guns

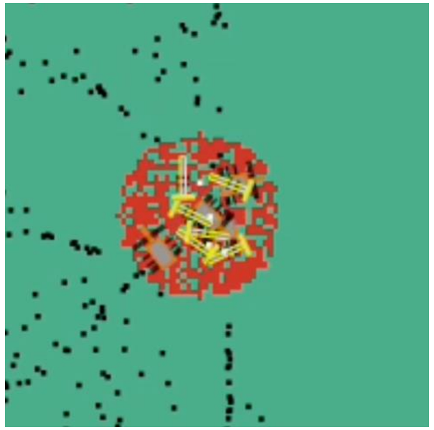


Shooting downhill is more effective than uphill.

Model Dynamics: Artillery & Mortars

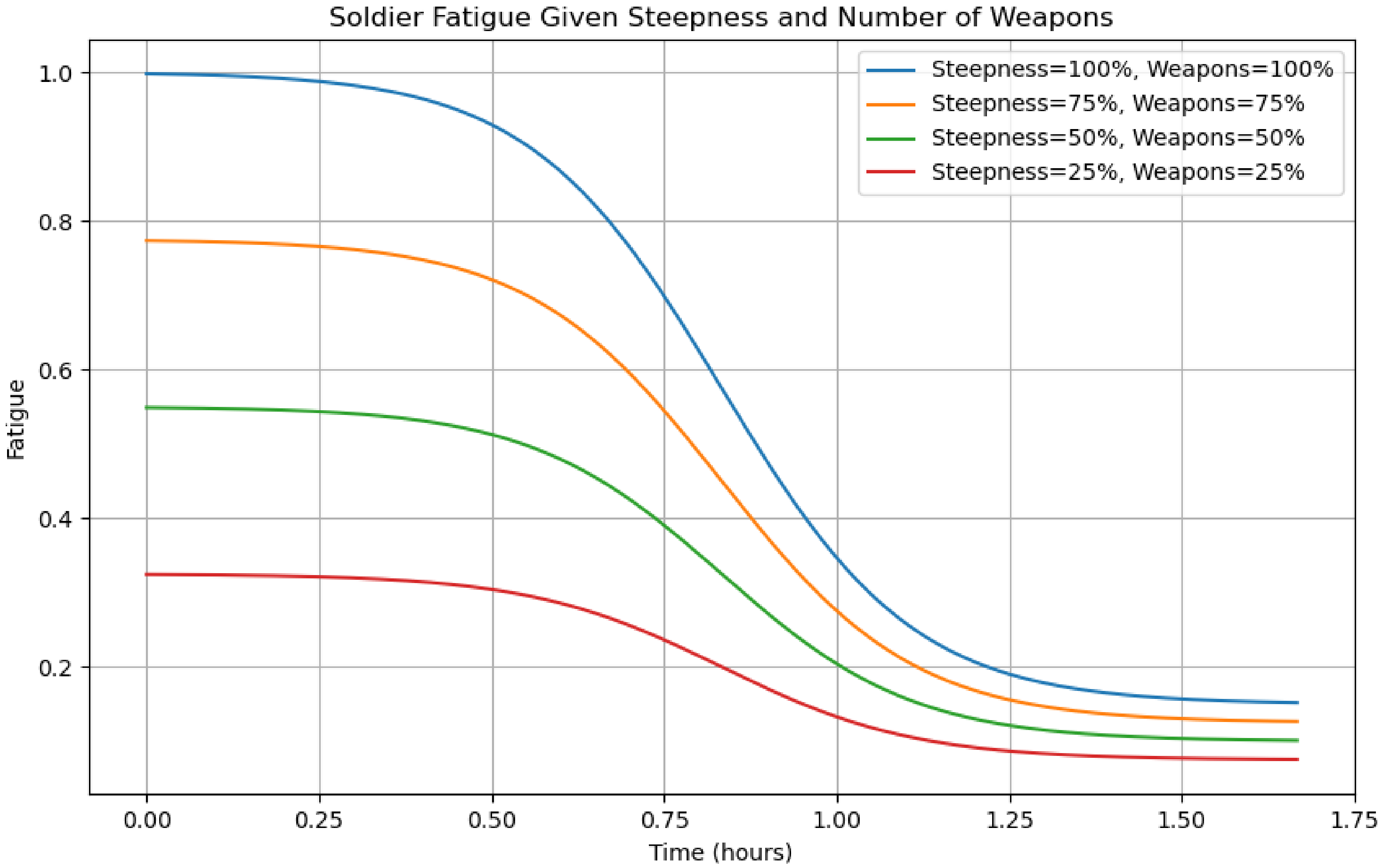


Artillery Barrage

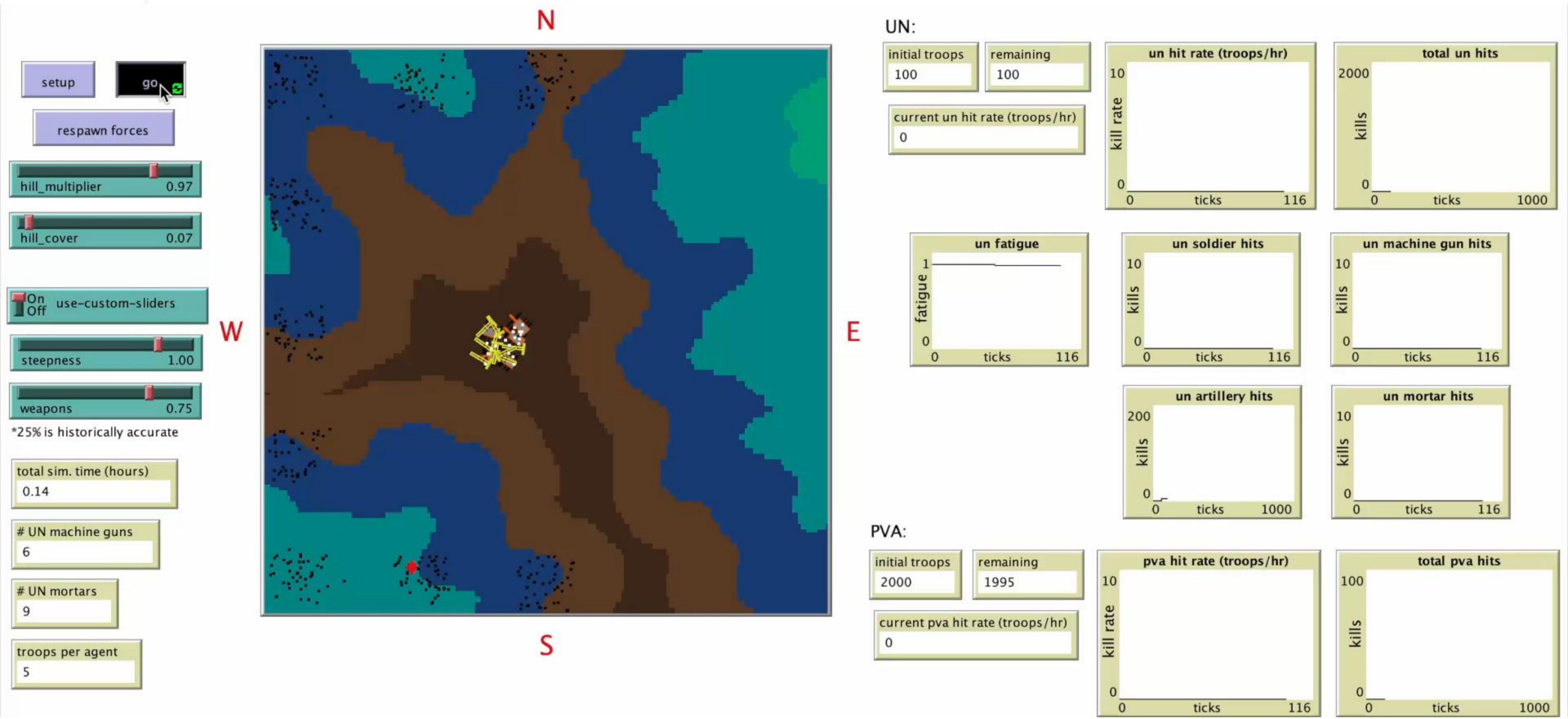


Artillery and mortars target denser areas of troops.

Model Dynamics: Soldier Fatigue



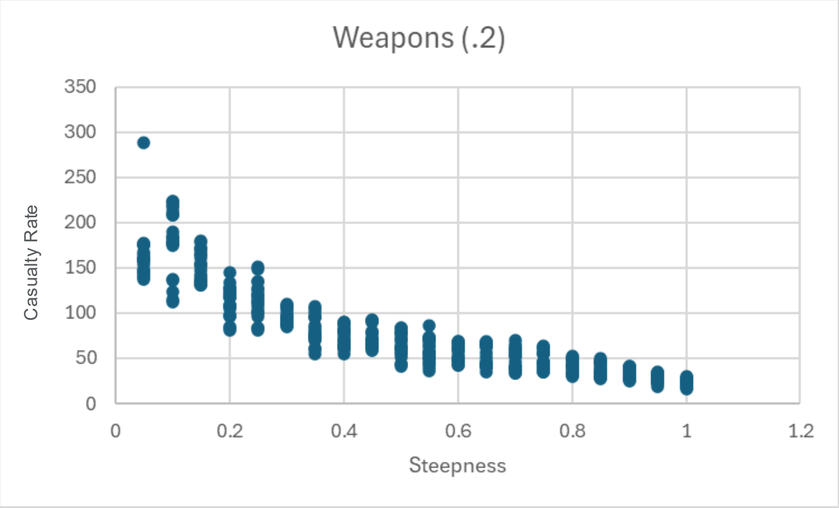
Based on military and physiological research [1,3,8,10].

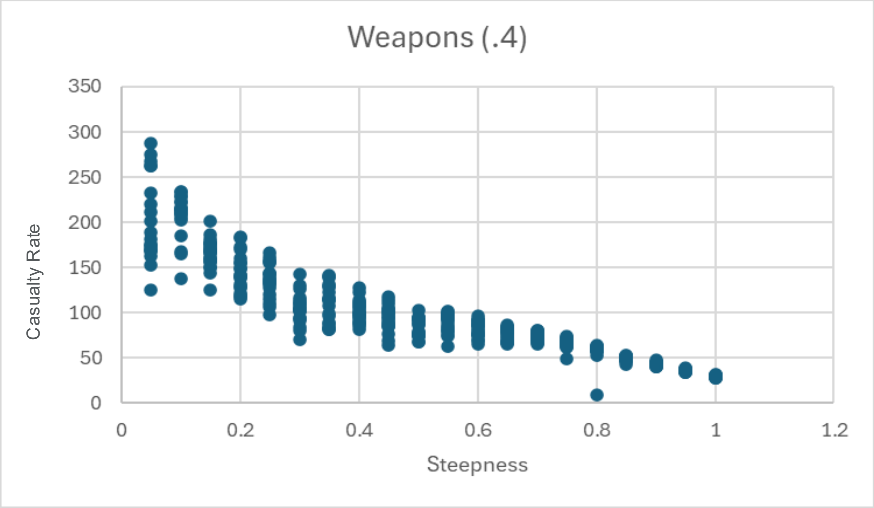

setup
go
respawn forces
hill_multiplier 0.97
hill_cover 0.07
On
Off
use-custom-sliders
steepness 1.00
weapons 0.75
*25% is historically accurate
total sim. time (hours)
0.14
UN machine guns
6
UN mortars
9
troops per agent
5
N
W
E
S
UN:
initial troops
100
remaining
100
current un hit rate (troops/hr)
0
un hit rate (troops/hr)
kill rate
ticks
total un hits
kills
un fatigue
fatigue
un soldier hits
un machine gun hits
un artillery hits
un mortar hits
PVA:
initial troops
2000
remaining
1995
current pva hit rate (troops/hr)
0
pva hit rate (troops/hr)
total pva hits

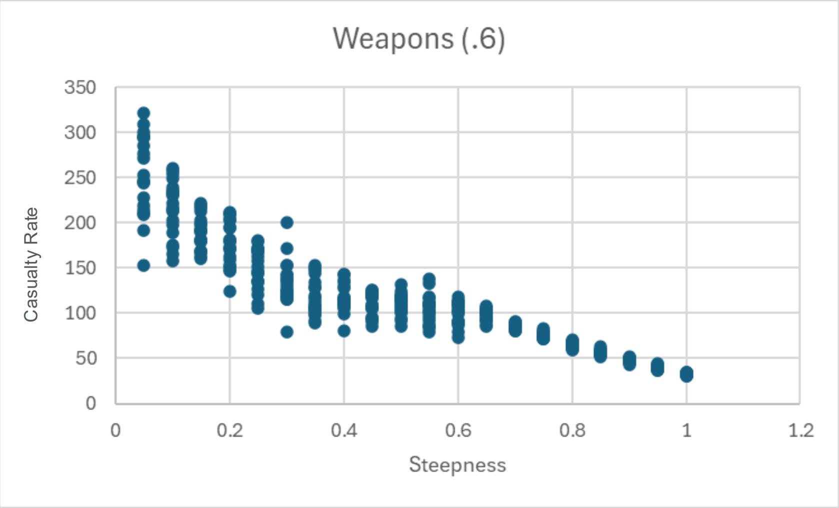
Analysis

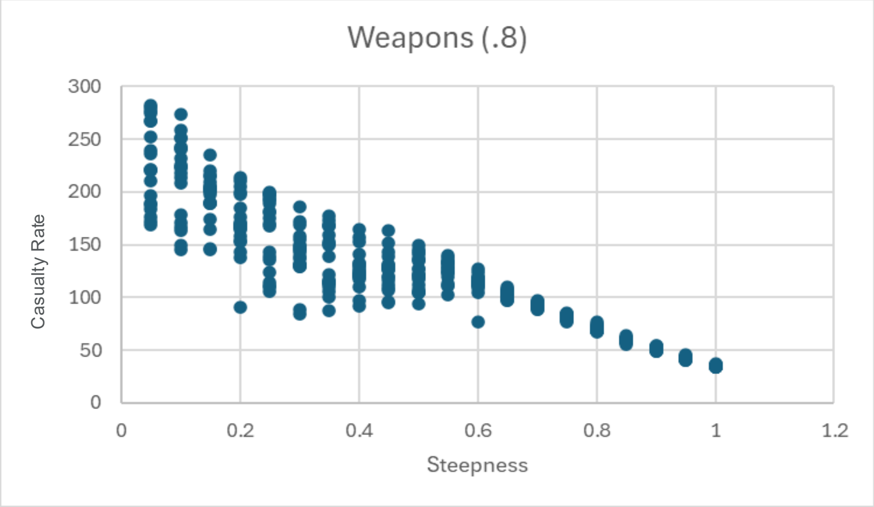
Analysis: Casualty Rate vs. Steepness

Increasing Steepness Lowered Casualty Rate









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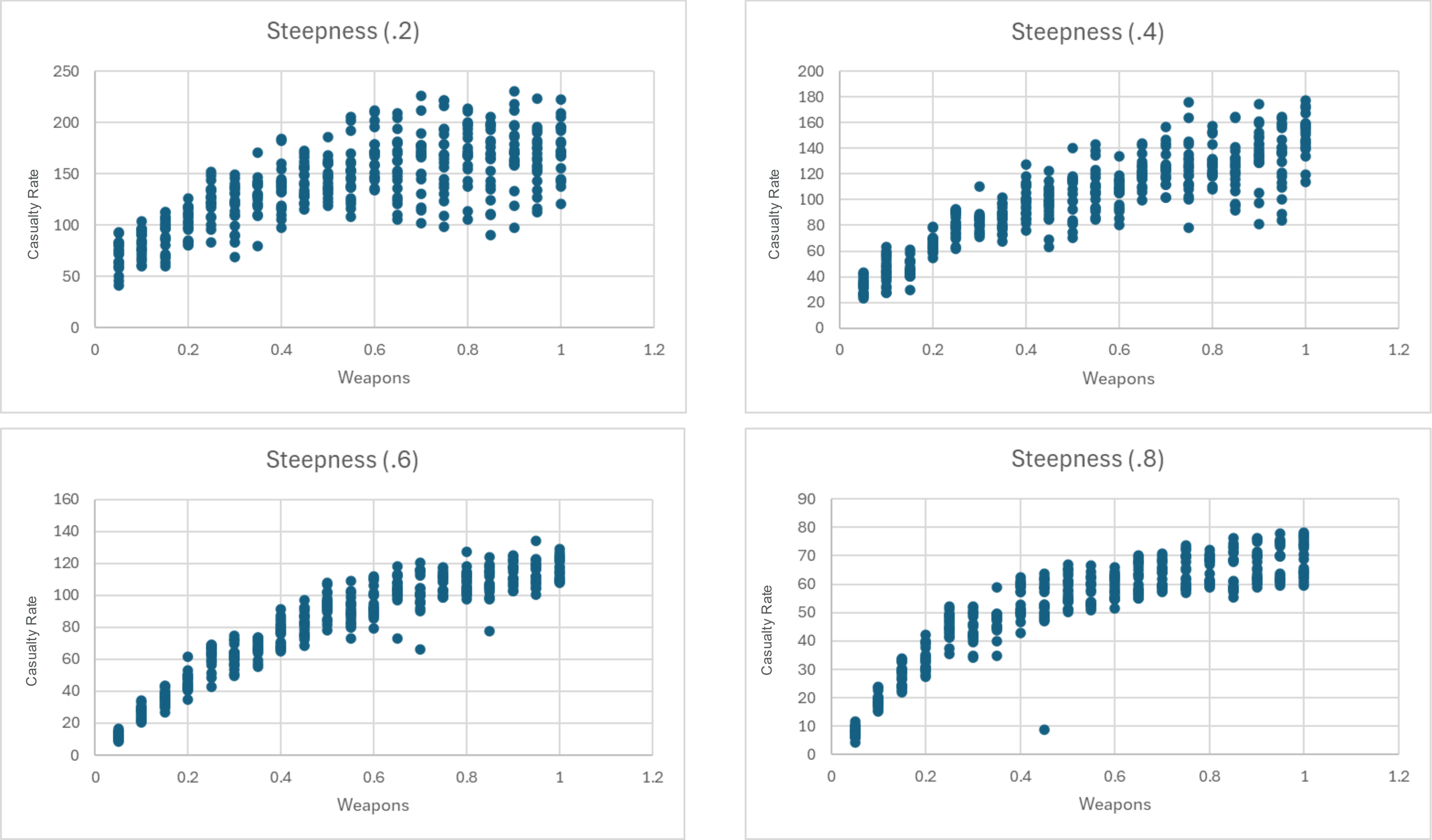
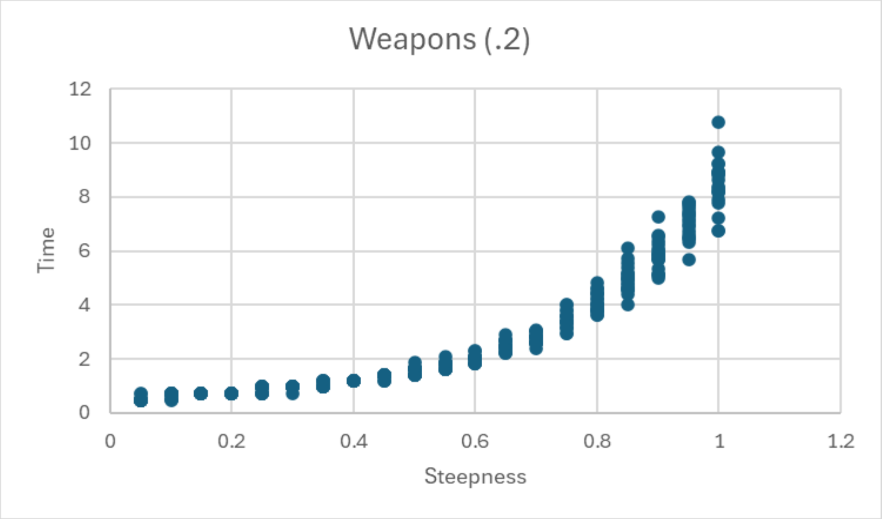
Analysis: Casualty Rate vs. Weapons

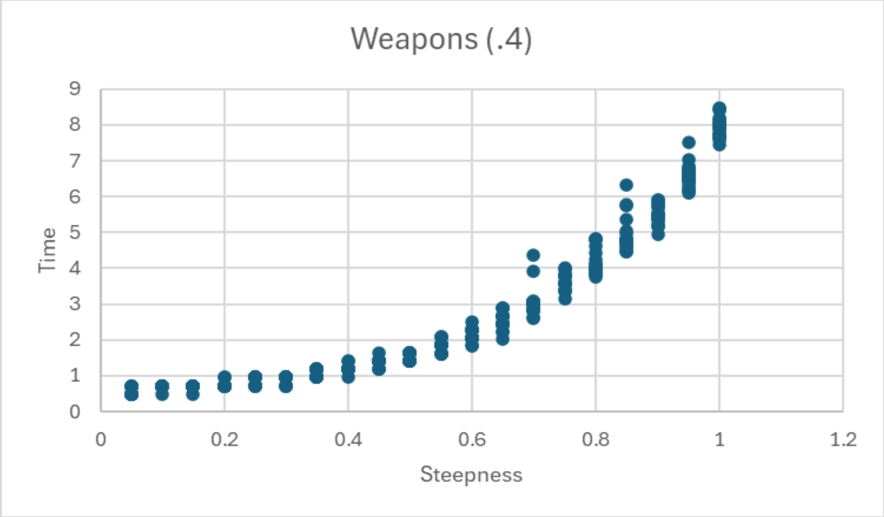
Increasing Weapons Increased Casualty Rate

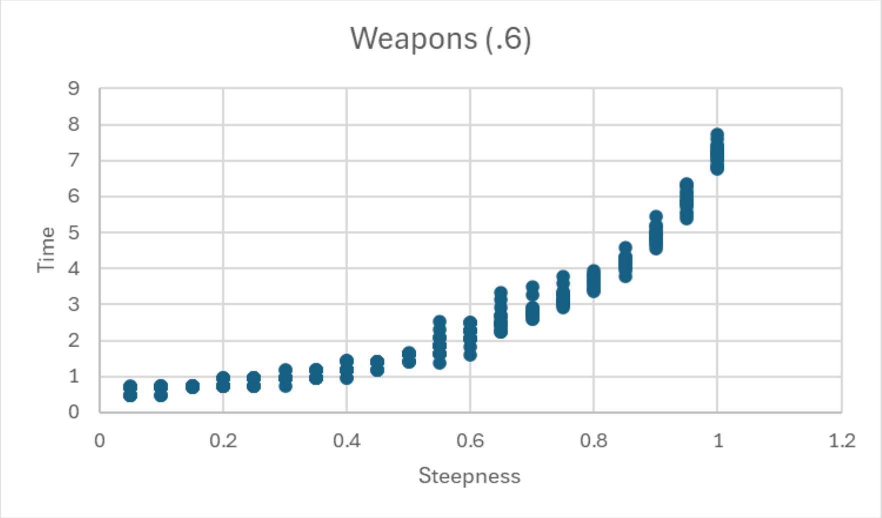


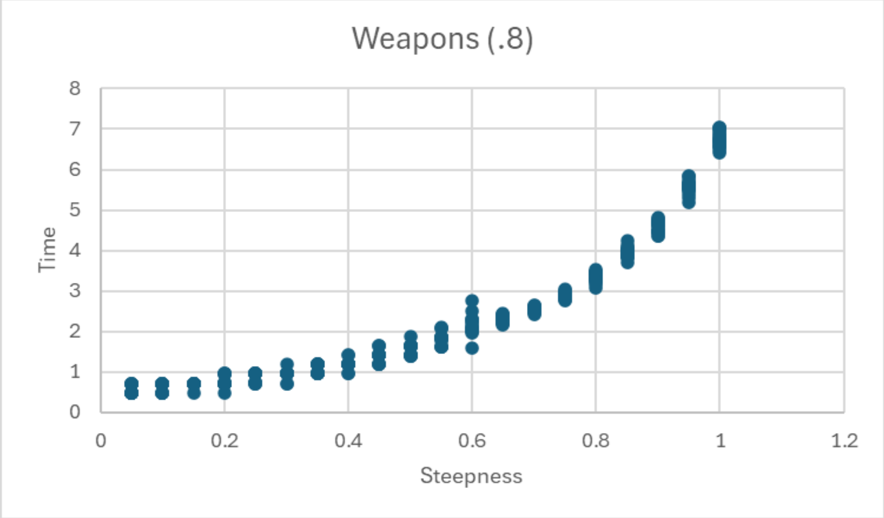
Analysis: Time vs. Steepness

Time and Steepness positively correlated; exponential relationship



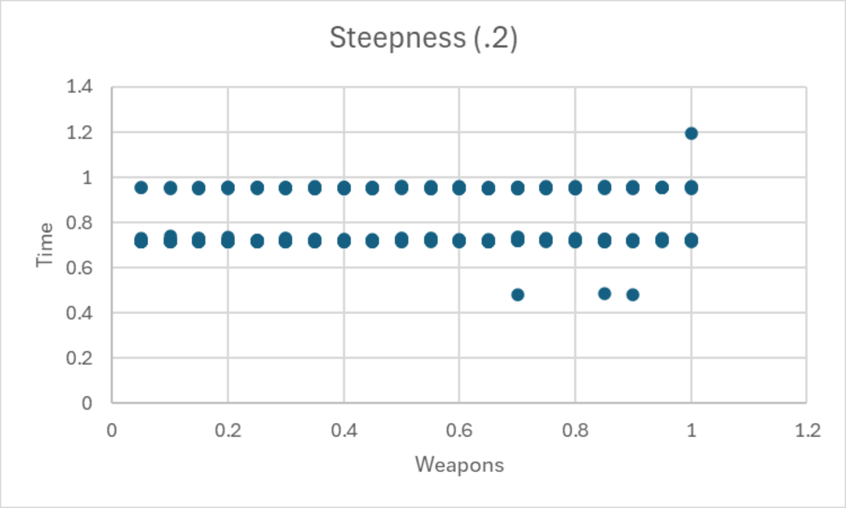


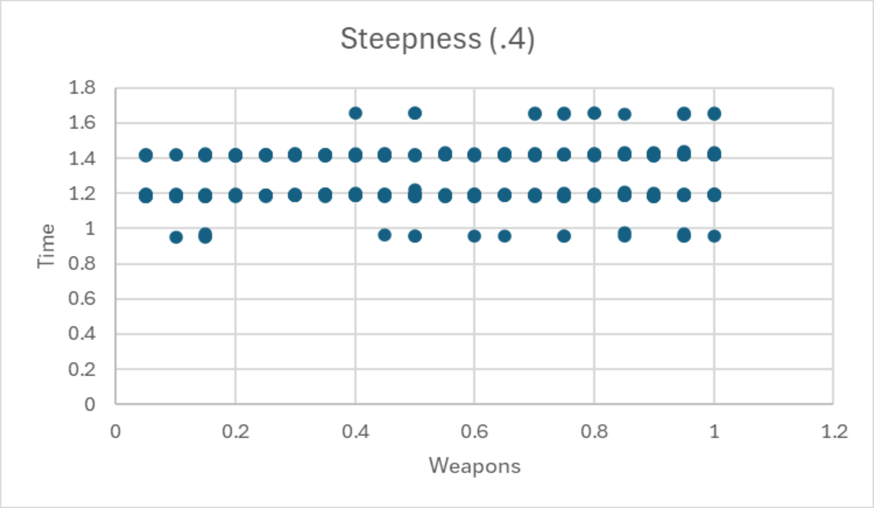


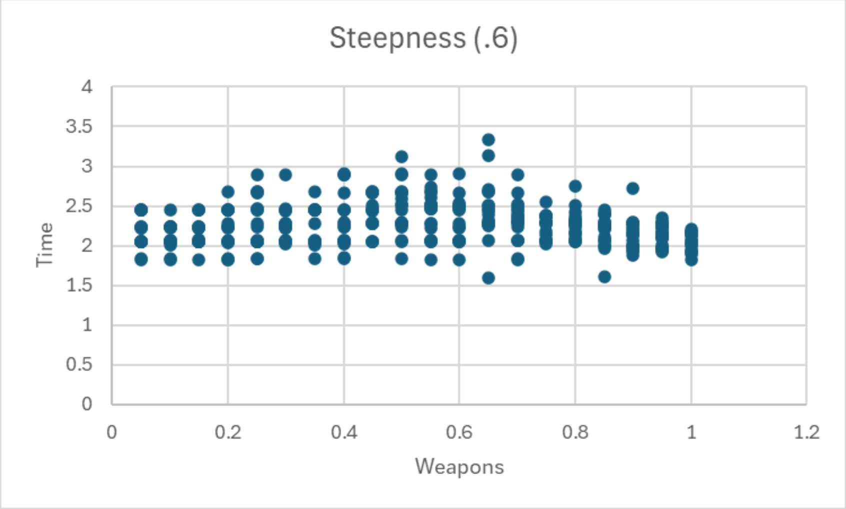


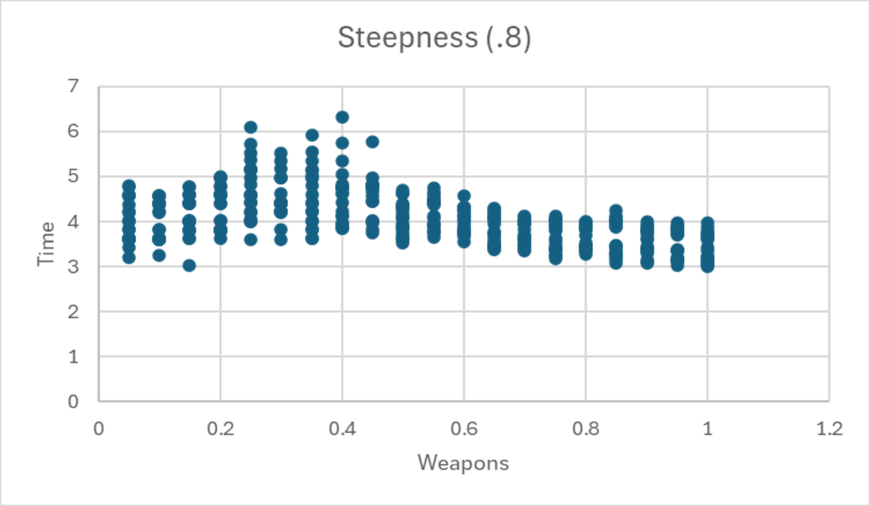
Analysis: Time vs. Weapons

No Clear Correlation



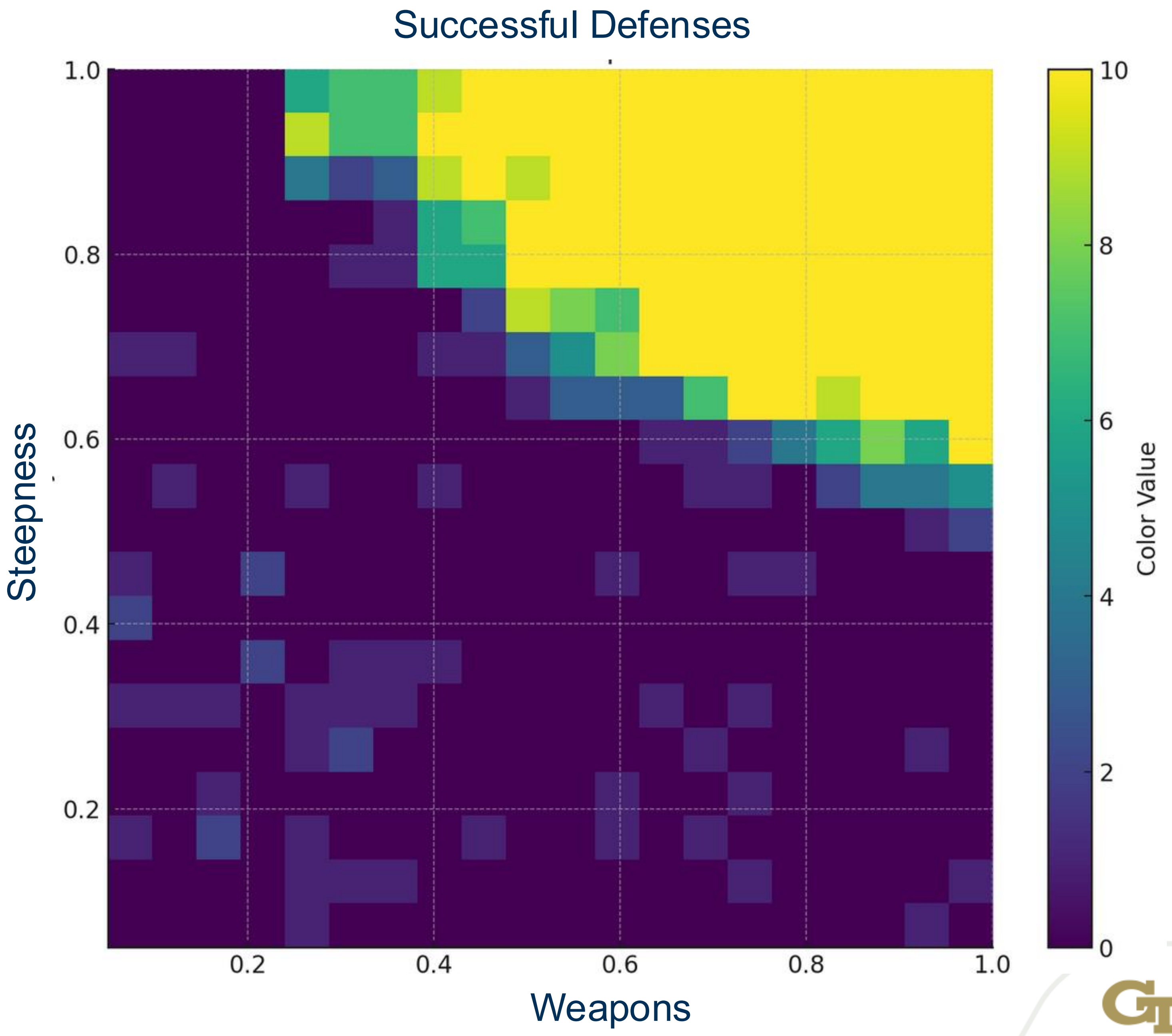






Overall Findings

- < 50% steepness (15°)
  → **rarely successful**
- < 25% weapons (2 MGs, 3 mortars)
  → **rarely successful**
- Favor Mixed Strategy
- Historical case: 100% steepness (30°), 25% weapons



Conclusion

- **Research Question**
  - How does the steepness of a defensive position and the amount of weaponry affect the casualty rate in battle, considering soldier fatigue?

- **Results**
  - Steeper terrain prolongs the battle; weapons increase lethality
  - Steeper position leads to lower casualty rate; weapons to higher rate
  - Steepness is the most important factor for victory

- **Key Takeway**
  - Take the steepest hill, and bring as much weaponry as possible - provided you can make it to the top

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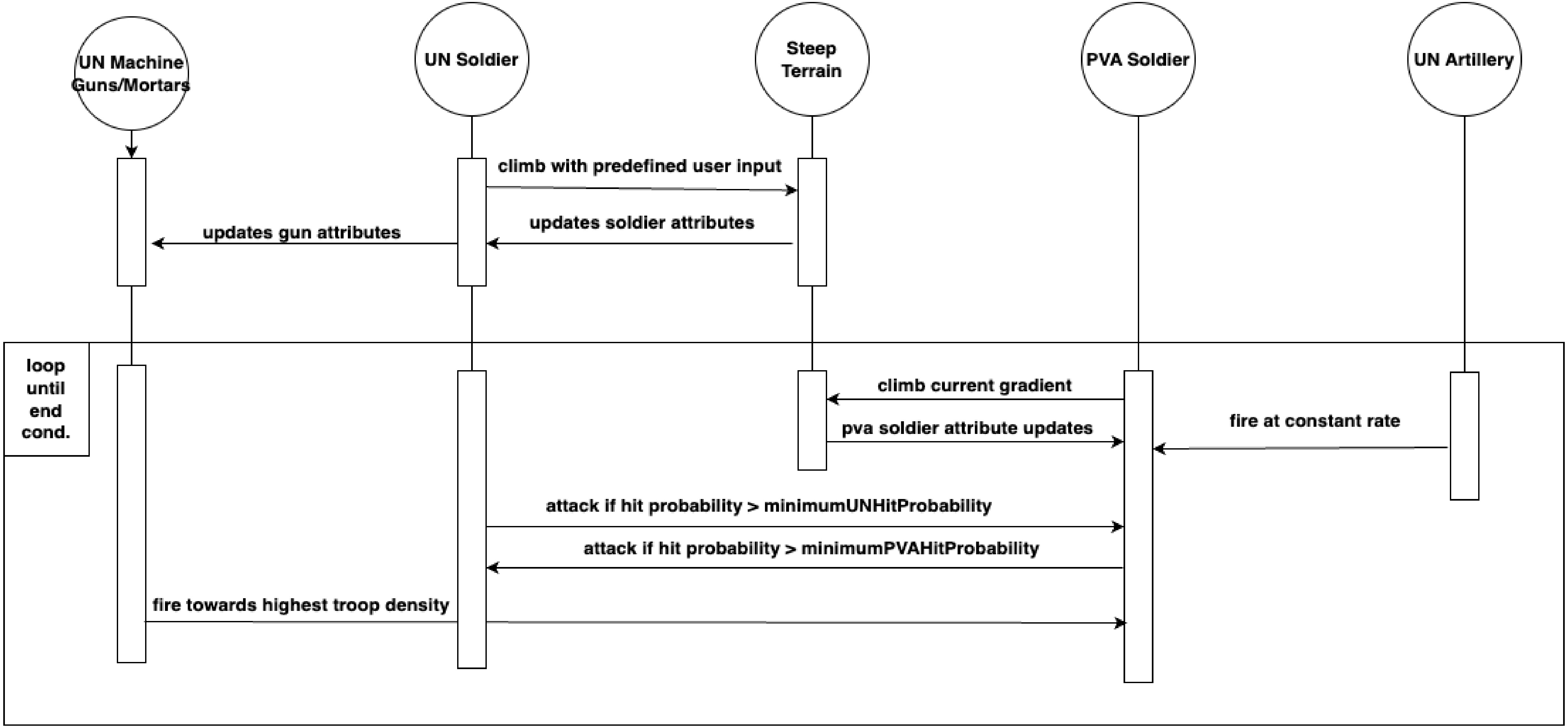
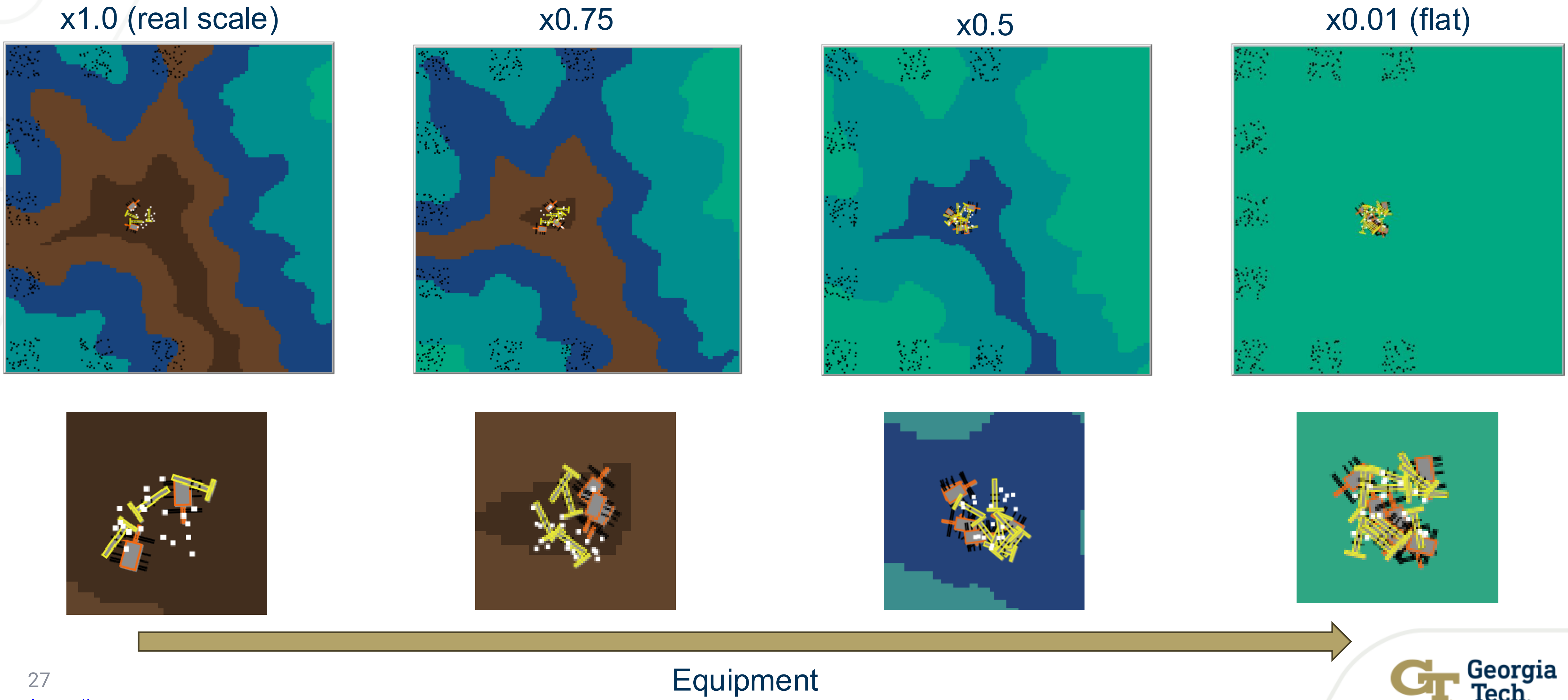
Appendix

1. Model Overview (Flowchart)
2. Steepness vs. Equipment
3. Soldier Fatigue
4. Exercise Recovery Over Time
5. Additional Analysis

Model Overview

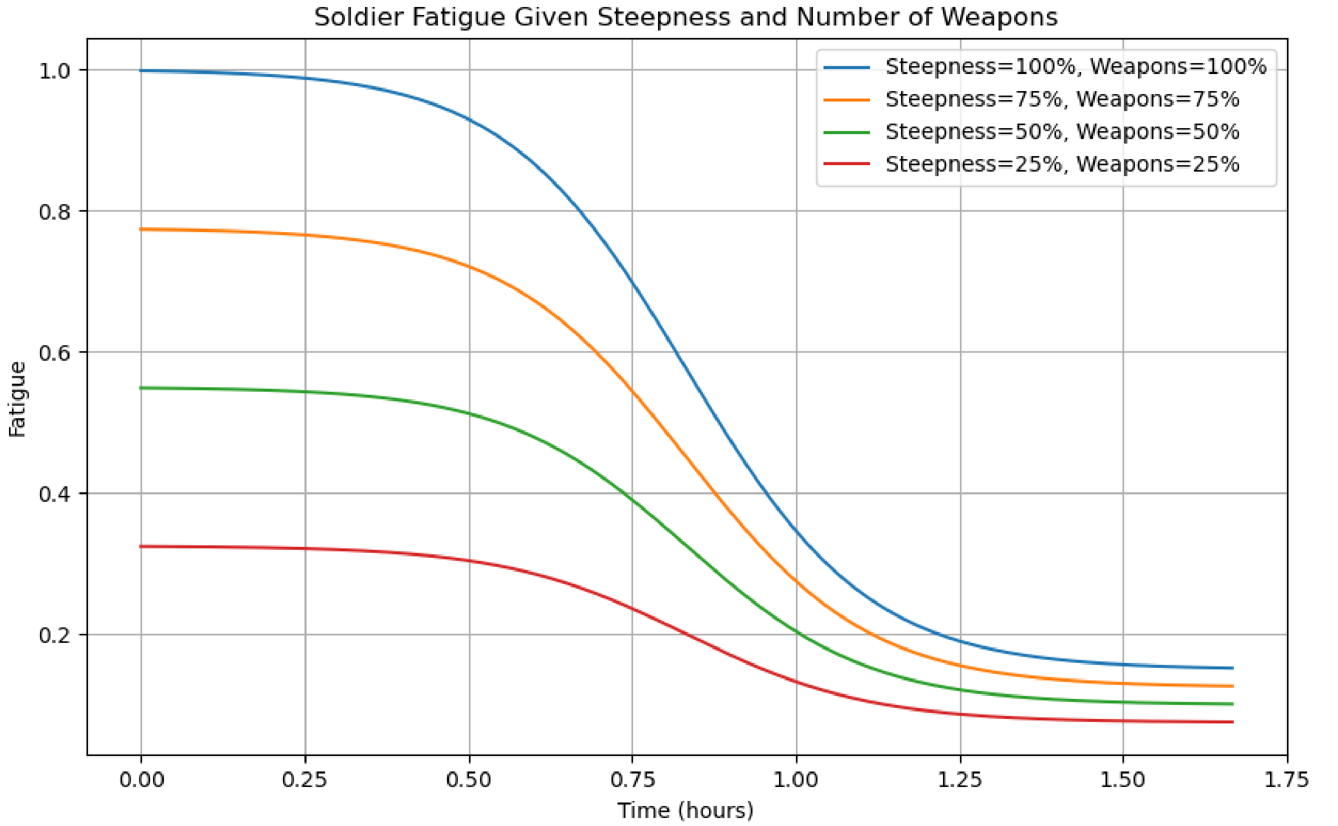


Steepness vs. Equipment



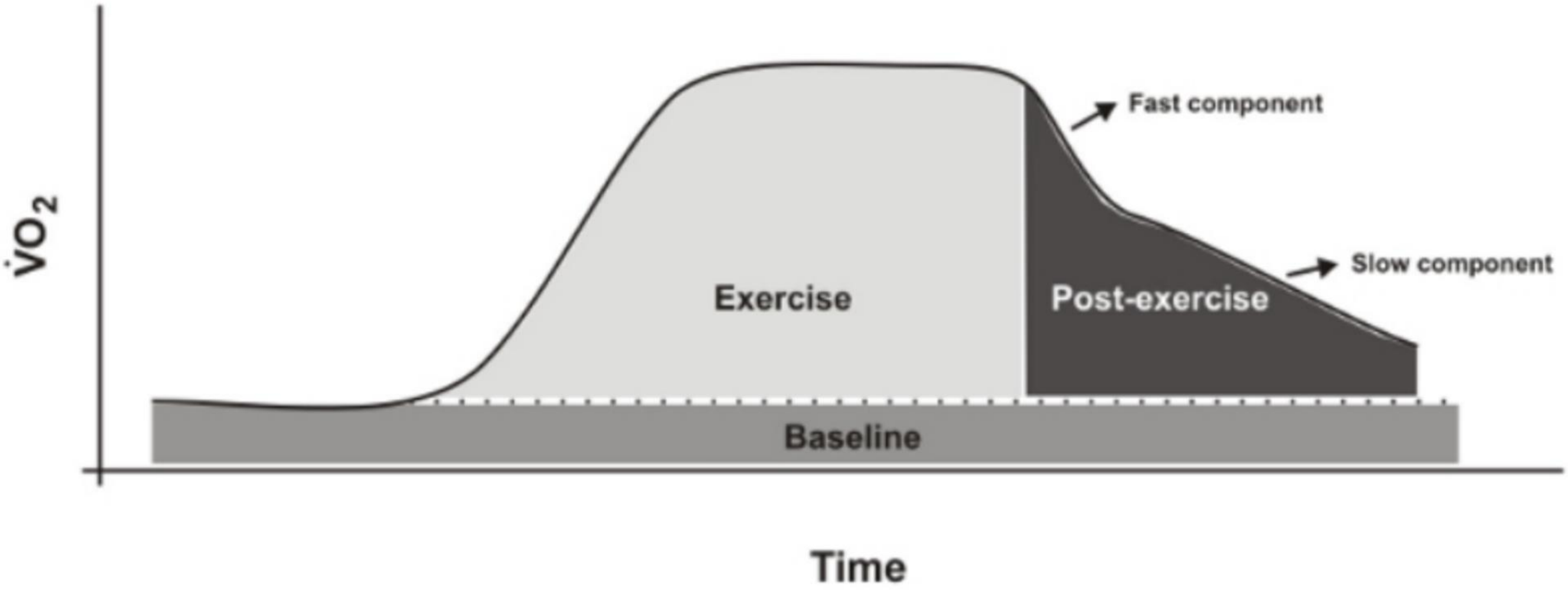
Soldier Fatigue

- **Key Assumptions**
  - Initial fatigue depends on both hill steepness and number of weapons [3,8,10]
  - Baseline fatigue increases with initial fatigue [1]
  - Fatigue reduces overall effectiveness [3]
    - Accuracy
    - Fire rate



Note: Only considering fatigue from physical exertion.

Exercise Recovery Over Time



According to the School of Physical Education and Sport at the University of Sao Paolo. [1]

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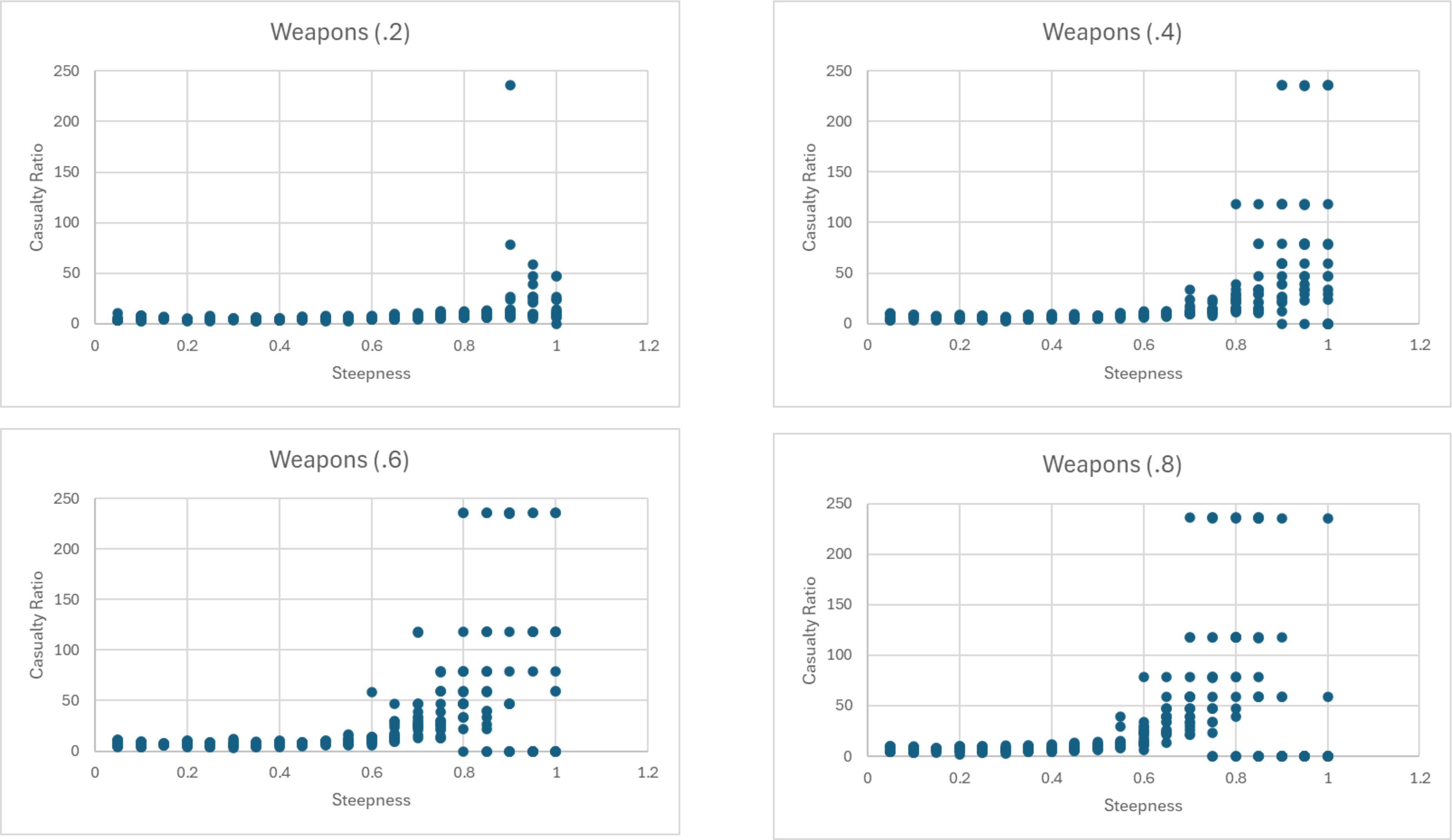
Analysis: Casualty Ratio vs. Steepness



Casualty Ratio is PVA Deaths / UN Deaths

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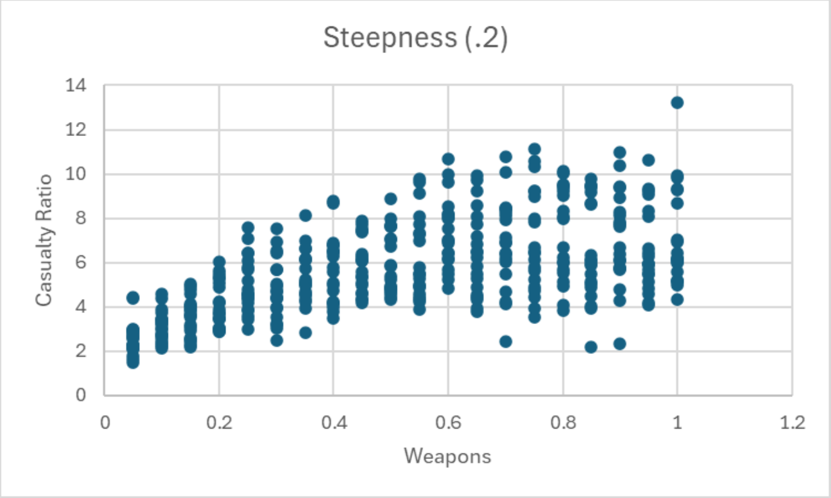
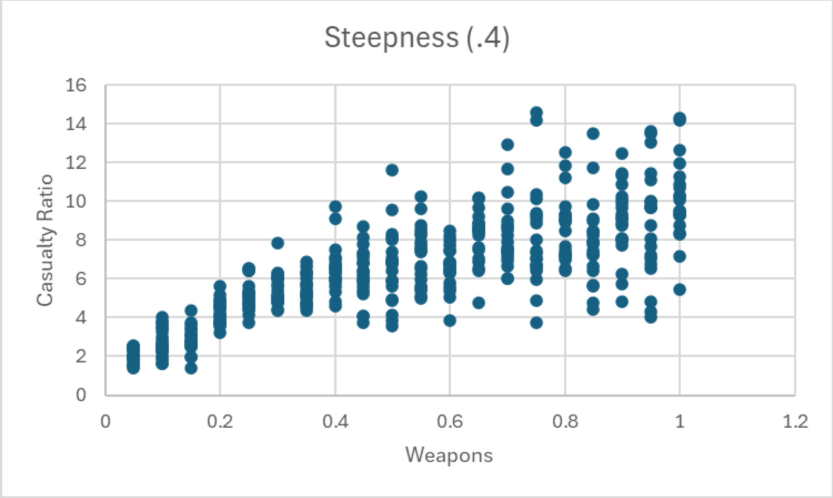
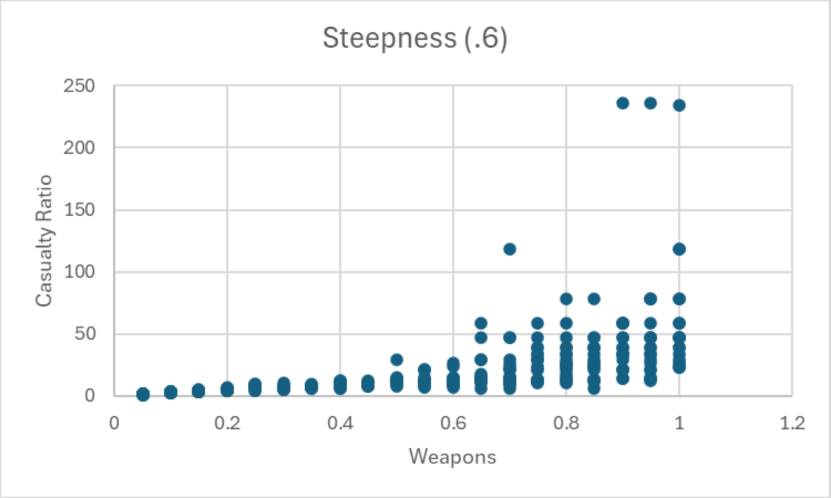
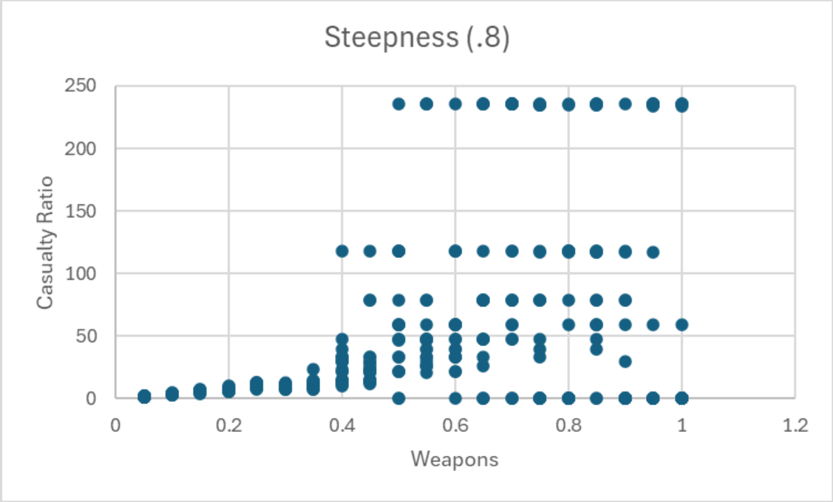
Analysis: Casualty Ratio vs. Weapons









- Casualty Ratio is
- PVA Deaths / UN Deaths
- Higher Steepness, lower variance
- Higher weapons, higher casualty ratio
- Casualty ratio is low for steepness below .5 regardless of weapons