Predator-Prey Simulation

using Lotka-Volterra Model in Parallel

Report generated on 2025-05-12 22:55:01

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Simulation Report

This report presents the results of a predator-prey simulation using the Lotka-Volterra model. The simulation was executed using parallel processing to improve performance and provide a more realistic spatial representation of ecosystem dynamics.

Simulation Parameters:

Parameter	Value
Time Period	2023 - 2033 (10 years)
Grid Size	5x5 (25 cells)
Initial Rabbits	100
Initial Wolves	20

Model Parameters:

Parameter	Value
Alpha (rabbit growth rate)	0.1
Beta (predation rate)	0.01
Gamma (wolf death rate)	0.05
Delta (wolf reproduction rate)	0.001

Performance Metrics:

Metric	Value
Total Execution Time	15.31 seconds
CPU Cores Used	8
Average Time Per Year	1.5306 seconds
Parallel Efficiency	Using 8 cores for 25 grid cells

Population Results:

Metric	Rabbits	Wolves
Initial Population	100	20
Final Population	253	12
Maximum	253	20

Minimum	100	12
Average	165.45	15.73

Population by Year:

Year	Rabbits	Wolves	Wolves/Rabbits
2023	100	20	0.2000
2024	109	19	0.1743
2025	120	18	0.1500
2026	131	17	0.1298
2027	144	16	0.1111
2028	158	15	0.0949
2029	174	15	0.0862
2030	191	14	0.0733
2031	210	14	0.0667
2032	230	13	0.0565
2033	253	12	0.0474

AI Analysis Summary:

AI summary could not be generated due to missing API key.

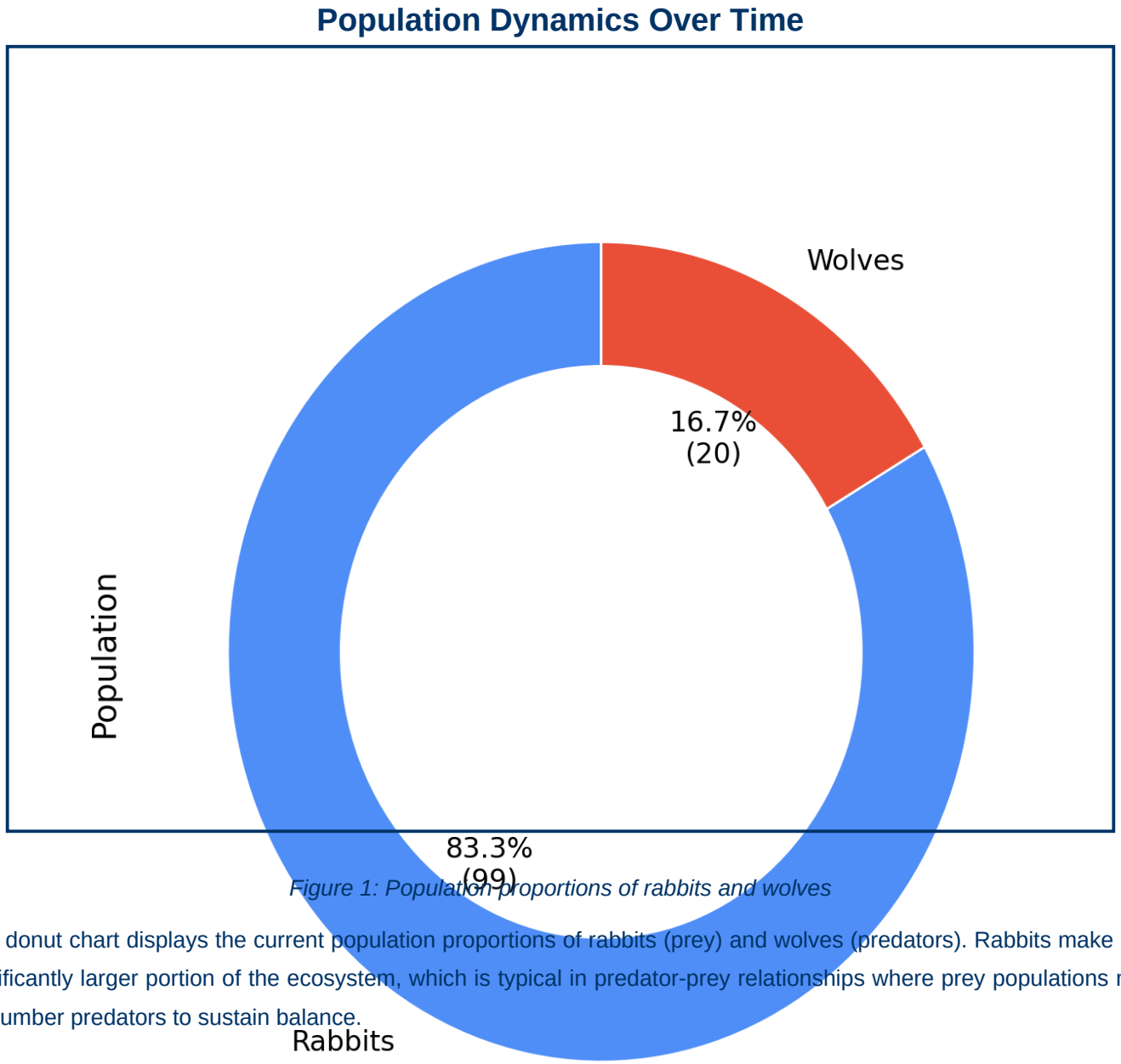

Figure 1: Population proportions of rabbits and wolves

This donut chart displays the current population proportions of rabbits (prey) and wolves (predators). Rabbits make up a significantly larger portion of the ecosystem, which is typical in predator-prey relationships where prey populations must outnumber predators to sustain balance.

Phase Space: Predator vs Prey Population

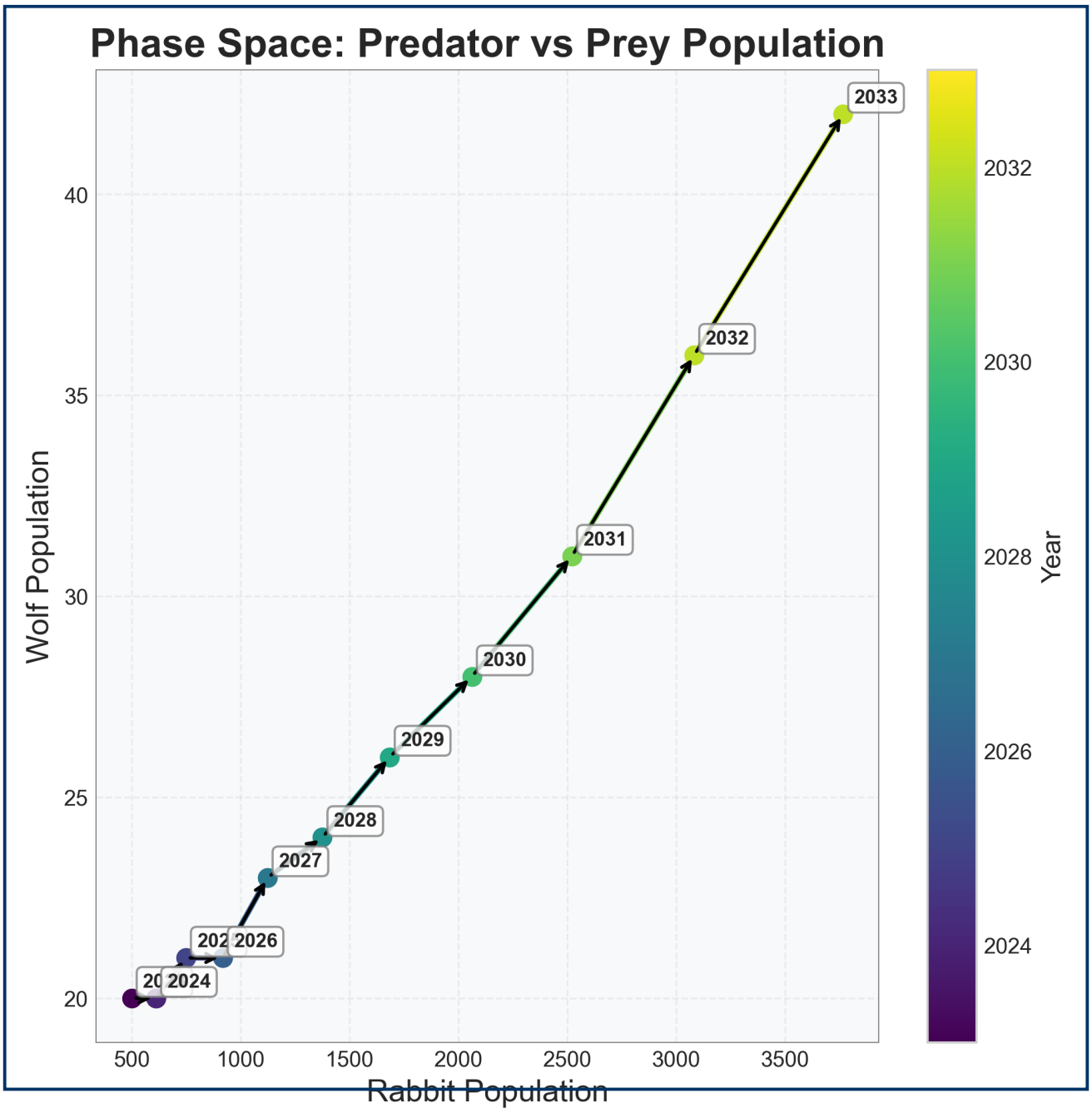

Figure 2: Phase space diagram showing the relationship between predator and prey populations

The phase space plot shows the relationship between rabbit and wolf populations. Each point represents the population state at a specific time, and the arrows indicate the direction of change. The counterclockwise cycles are characteristic of predator-prey systems, showing how the populations influence each other over time.

Predator-Prey Ratio Over Time

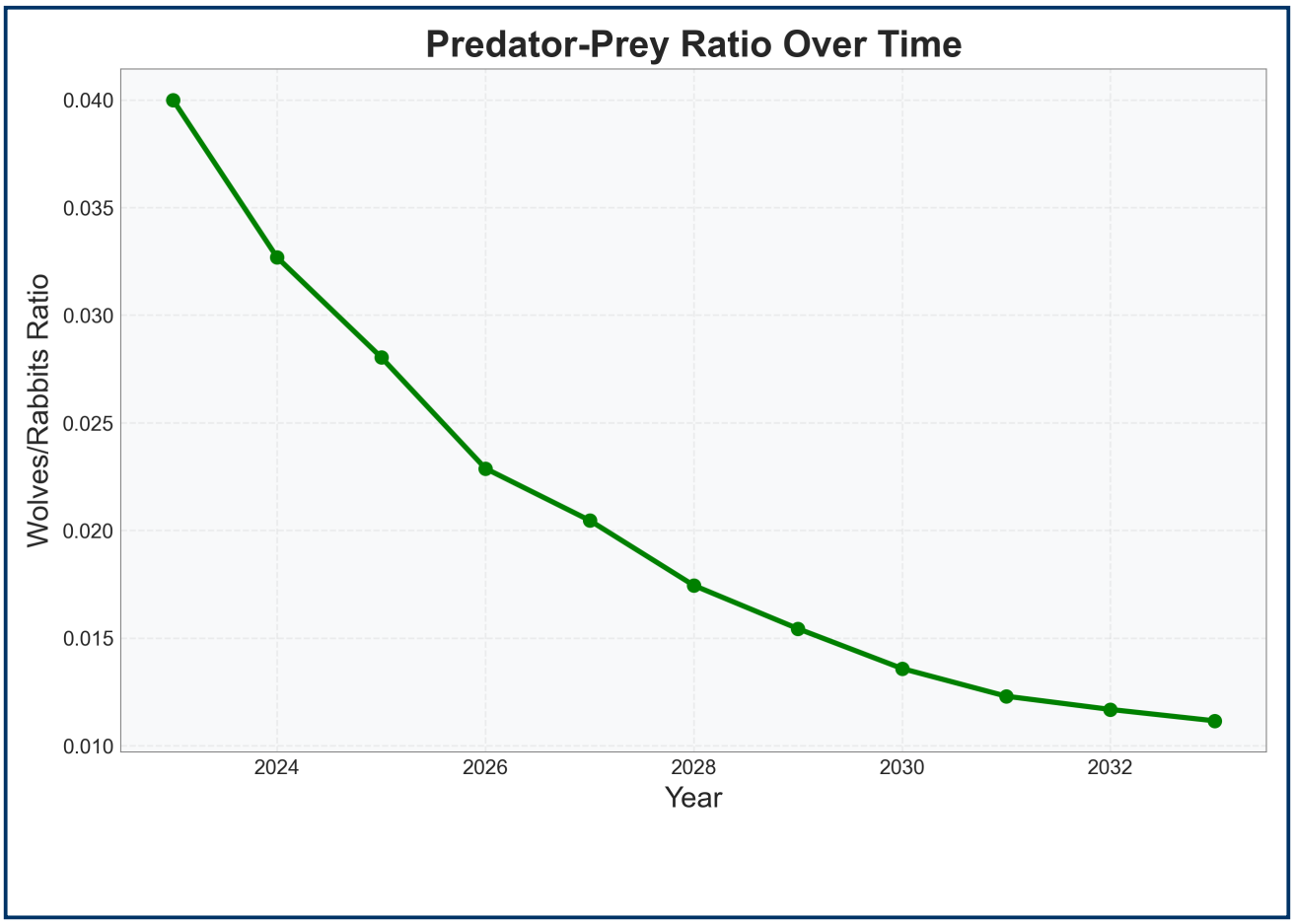

Figure 3: Ratio of wolves to rabbits over time

This graph shows the ratio of wolves to rabbits over time. The ratio fluctuates as the populations change, providing insight into the relative abundance of predators compared to prey. Higher ratios indicate more wolves per rabbit, which typically precedes a decline in the rabbit population.

Final Grid Population Distribution

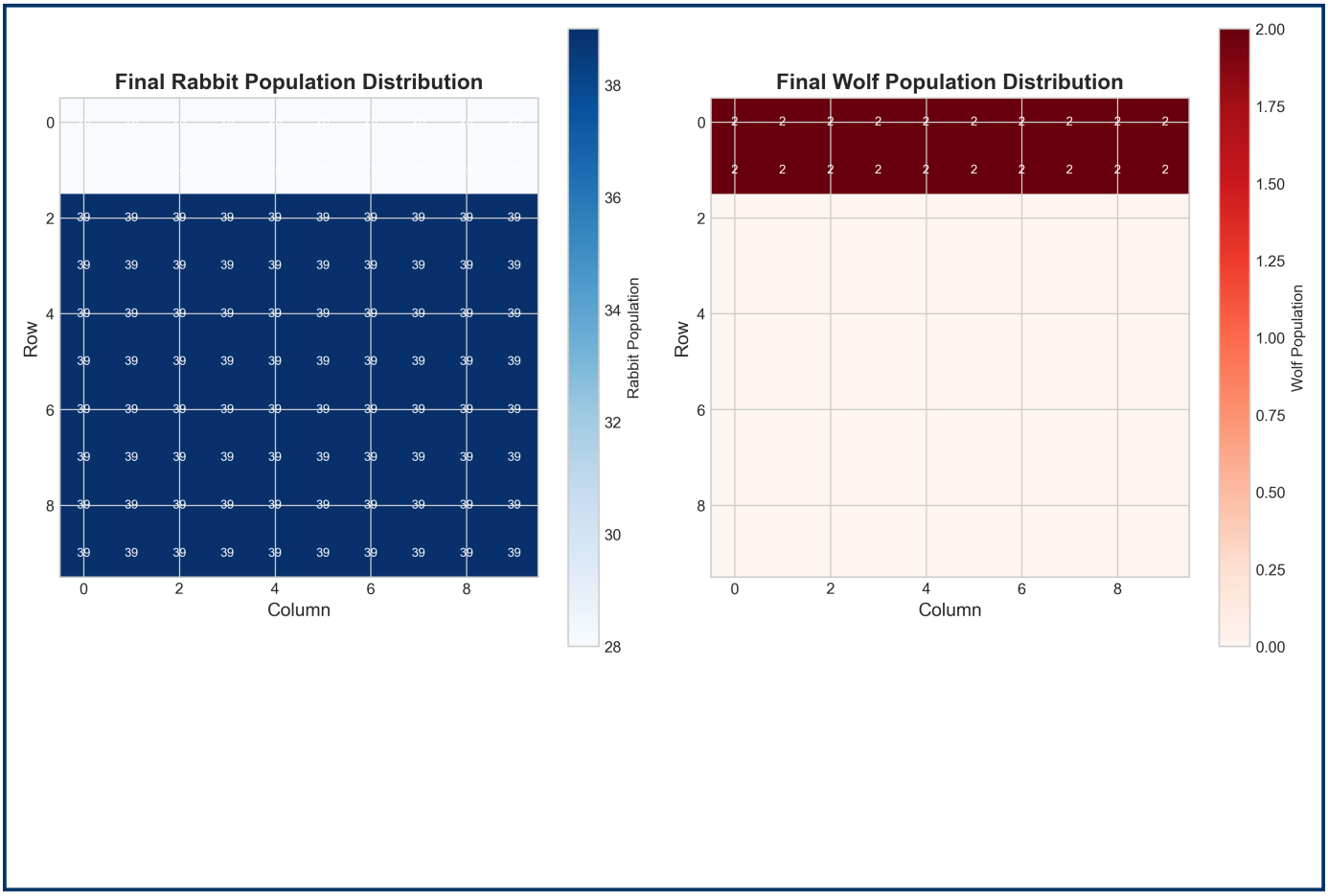

Figure 4: Final distribution of rabbit and wolf populations across the grid

This visualization shows the final distribution of rabbit and wolf populations across the 5×5 grid. Each cell represents a distinct area in the ecosystem, with its own population dynamics. The parallel processing approach allowed each grid cell to be calculated independently, providing a more realistic spatial representation of the ecosystem.

Rabbit-Wolf Ratio at Start of Simulation

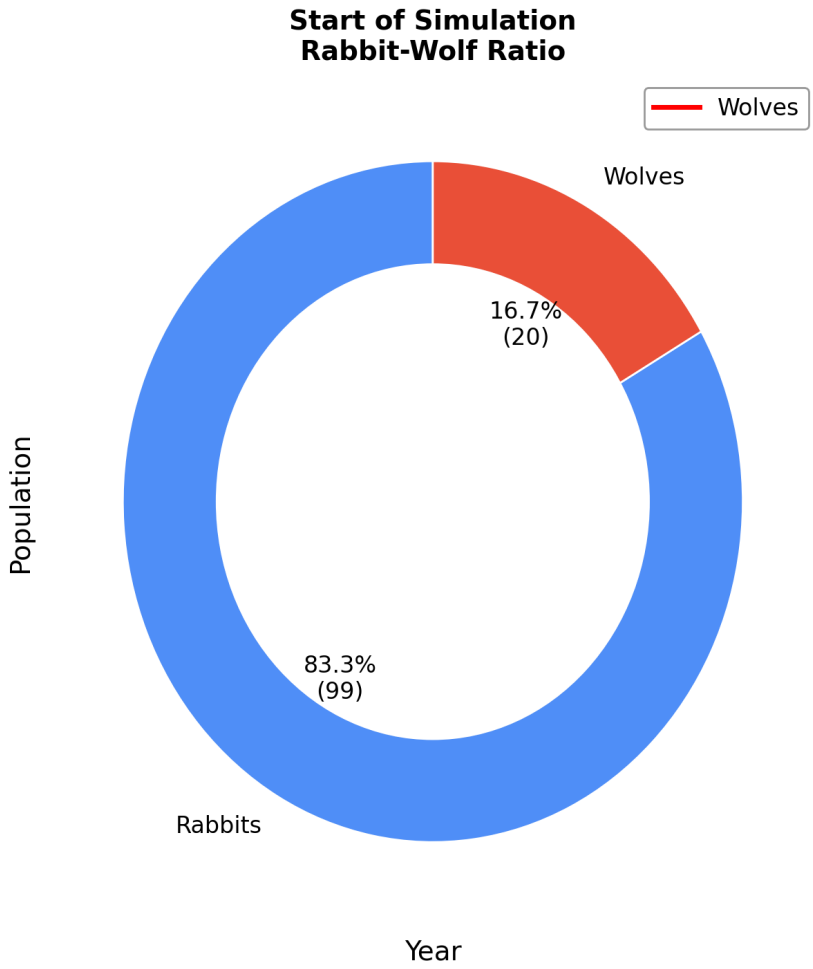

Figure: Rabbit-Wolf Ratio at Start of Simulation

This circular chart visualizes the proportion of rabbits and wolves, providing an intuitive overview of the predator-prey ratio.

Rabbit-Wolf Ratio at End of Simulation

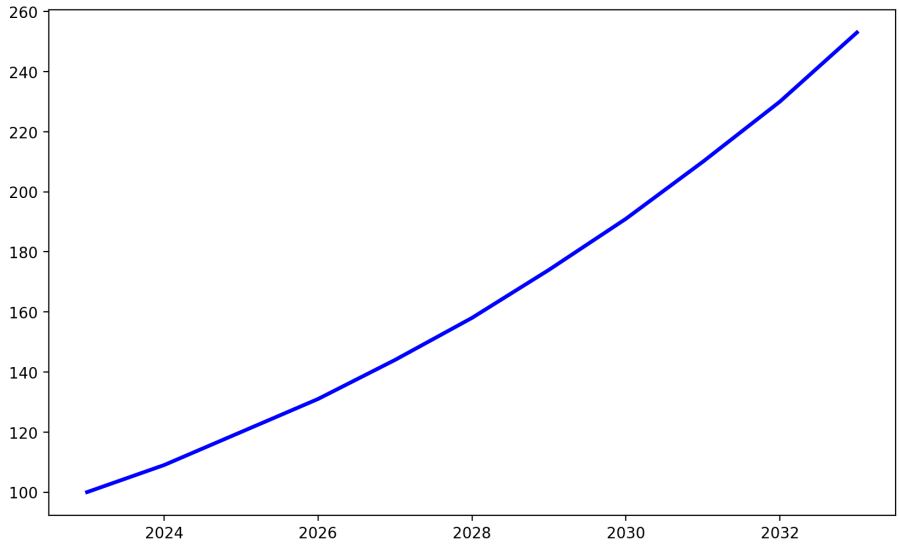

Figure: Rabbit-Wolf Ratio at End of Simulation

This circular chart visualizes the proportion of rabbits and wolves, providing an intuitive overview of the predator-prey ratio.

Average Rabbit-Wolf Ratio Over Simulation

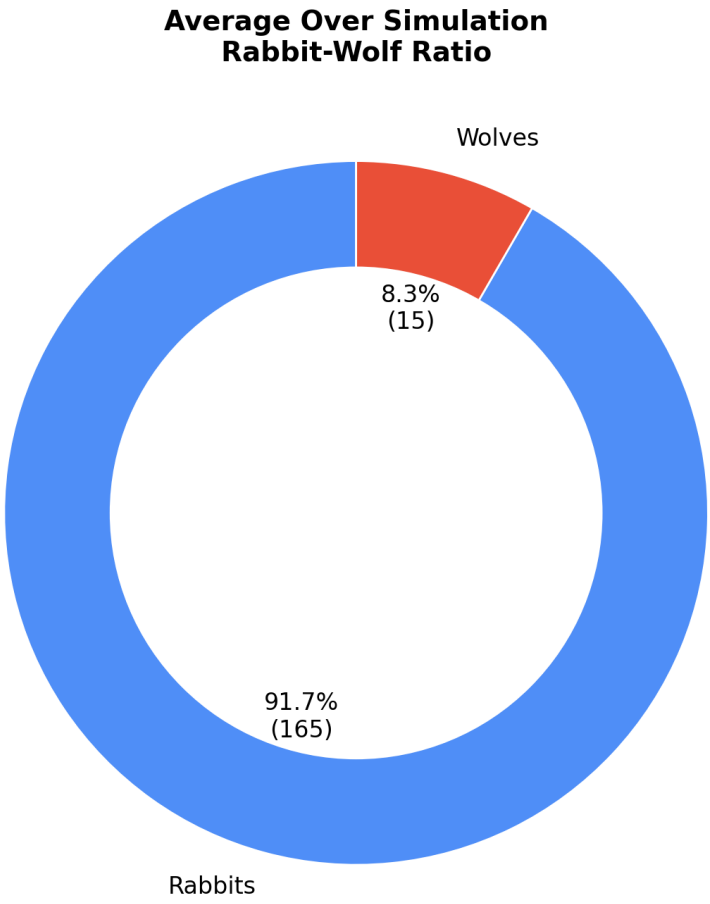

Figure: Average Rabbit-Wolf Ratio Over Simulation

This circular chart visualizes the proportion of rabbits and wolves, providing an intuitive overview of the predator-prey ratio.

Conclusion

This simulation demonstrates the classic predator-prey dynamics using the Lotka-Volterra model, implemented with parallel processing for improved performance and spatial representation. Starting with 100 rabbits and 20 wolves, the simulation tracked population changes over 11 years across a 5×5 grid.

Key findings:

1. The rabbit population exhibited cyclical behavior, reaching a maximum of 253 and a minimum of 100.

2. The wolf population followed a similar pattern with a phase shift, reaching a maximum of 20 and a minimum of 12.

3. The phase space plot revealed the characteristic counterclockwise cycles of predator-prey systems, demonstrating the lag between population changes.

4. The parallel processing approach utilizing 8 CPU cores allowed for efficient computation, completing the simulation in 15.31 seconds.

The results align with theoretical expectations for predator-prey systems, showing the oscillatory behavior and phase relationships between populations. The parallel implementation not only improved performance but also provided a more realistic spatial representation of ecosystem dynamics.