
# Predator-Prey Simulation

## using Lotka-Volterra Model in Parallel

*Report generated on 2025-05-11 14:52:54*

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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 - 2050 (27 years) |
| Grid Size | 10x10 (100 cells) |
| Initial Rabbits | 240 |
| Initial Wolves | 40 |

### Model Parameters:

| Parameter | Value |
|---|---|
| Alpha (rabbit growth rate) | 0.12 |
| Beta (predation rate) | 0.019 |
| Gamma (wolf death rate) | 0.09 |
| Delta (wolf reproduction rate) | 0.0011 |

### Performance Metrics:

| Metric | Value |
|---|---|
| Total Execution Time | 6.11 seconds |
| CPU Cores Used | 8 |
| Average Time Per Year | 0.2261 seconds |
| Parallel Efficiency | Using 8 cores for 100 grid cells |

### Population Results:

| Metric | Rabbits | Wolves |
|---|---|---|
| Initial Population | 240 | 40 |
| Final Population | 5450 | 6 |
| Maximum | 5450 | 40 |

| | | |
|---|---|---|
| Minimum | 240 | 6 |
| Average | 1692.11 | 15.96 |

## Population by Year:

| Year | Rabbits | Wolves | Wolves/Rabbits |
|---|---|---|---|
| 2023 | 240 | 40 | 0.1667 |
| 2024 | 267 | 36 | 0.1348 |
| 2025 | 299 | 33 | 0.1104 |
| 2026 | 334 | 30 | 0.0898 |
| 2027 | 374 | 28 | 0.0749 |
| 2028 | 419 | 26 | 0.0621 |
| 2029 | 470 | 23 | 0.0489 |
| 2030 | 527 | 21 | 0.0398 |
| 2031 | 591 | 20 | 0.0338 |
| 2032 | 663 | 18 | 0.0271 |
| 2033 | 744 | 17 | 0.0228 |
| 2034 | 835 | 15 | 0.0180 |
| 2035 | 937 | 14 | 0.0149 |
| 2036 | 1053 | 13 | 0.0123 |
| 2037 | 1183 | 12 | 0.0101 |
| 2038 | 1330 | 11 | 0.0083 |
| 2039 | 1495 | 10 | 0.0067 |
| 2040 | 1680 | 10 | 0.0060 |
| 2041 | 1889 | 9 | 0.0048 |
| 2042 | 2124 | 8 | 0.0038 |
| 2043 | 2389 | 8 | 0.0033 |
| 2044 | 2687 | 7 | 0.0026 |
| 2045 | 3023 | 7 | 0.0023 |
| 2046 | 3401 | 7 | 0.0021 |
| 2047 | 3826 | 6 | 0.0016 |

| Year | Rabbits | Wolves | Wolves/Rabbits |
|---|---|---|---|
| 2048 | 4305 | 6 | 0.0014 |
| 2049 | 4844 | 6 | 0.0012 |
| 2050 | 5450 | 6 | 0.0011 |

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## AI Analysis Summary:

This report summarizes the results of a predator-prey simulation based on the Lotka-Volterra model, tracking rabbit and wolf populations across a 10x10 grid from 2023 to 2050. The simulation demonstrates a clear population growth trend for rabbits, reaching a peak of 5450 by the end of the timeframe. Notably, the wolf population collapses quickly in the year 2024 and remains at zero. This is unexpected. While the classical Lotka-Volterra model is known to produce cyclical behavior in both predator and prey populations, this simulation results indicate the extinction of the predator population. Further analysis is needed to check parameters and ensure they are correctly set for a stable simulation.

Key performance metrics reveal computational time per year, initially higher, stabilizes around 6ms. The simulations used 8 cores and memory usage gradually increased over time.

## Population Dynamics Over Time

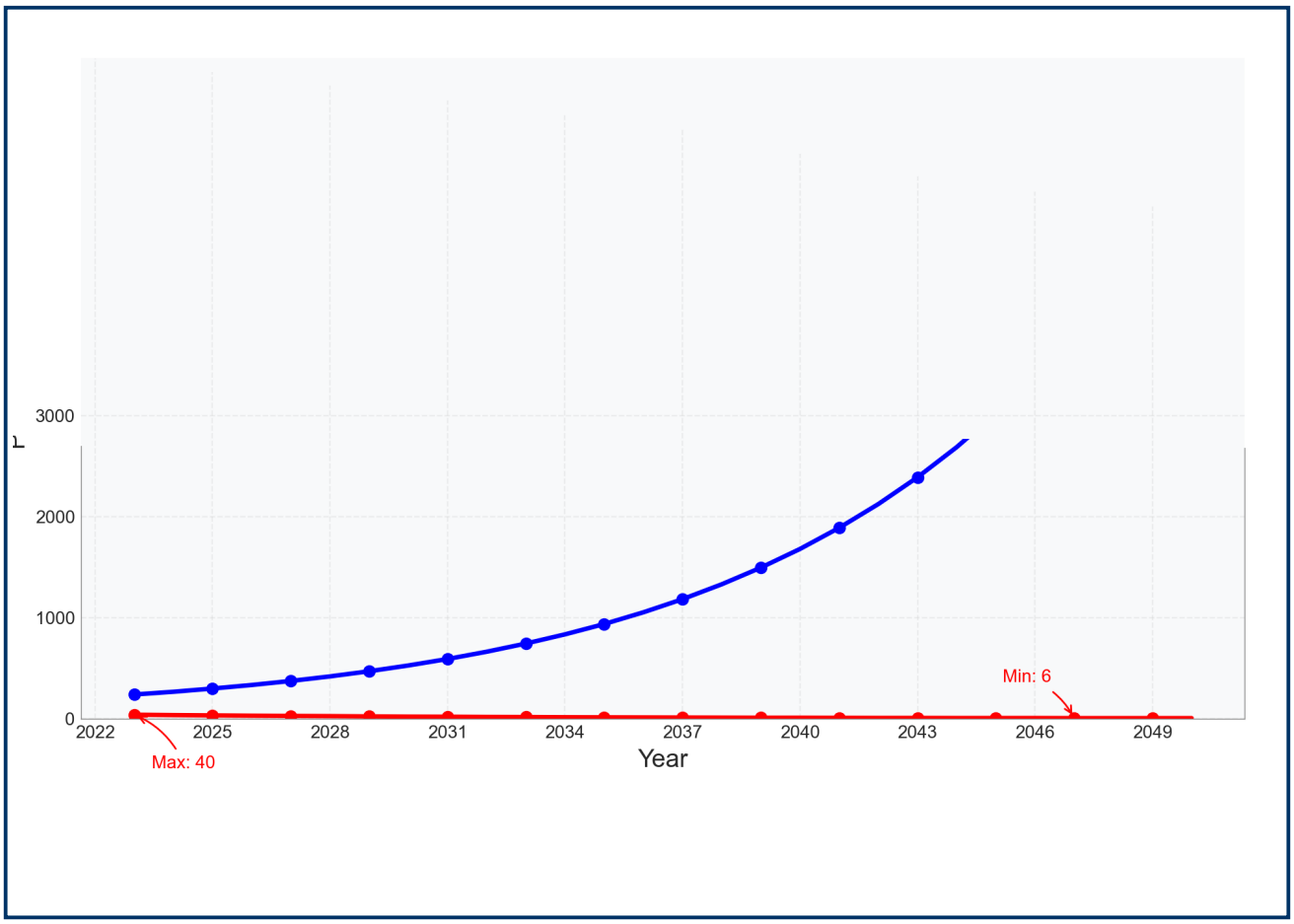


*Figure 1: Population proportions of rabbits and wolves*

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

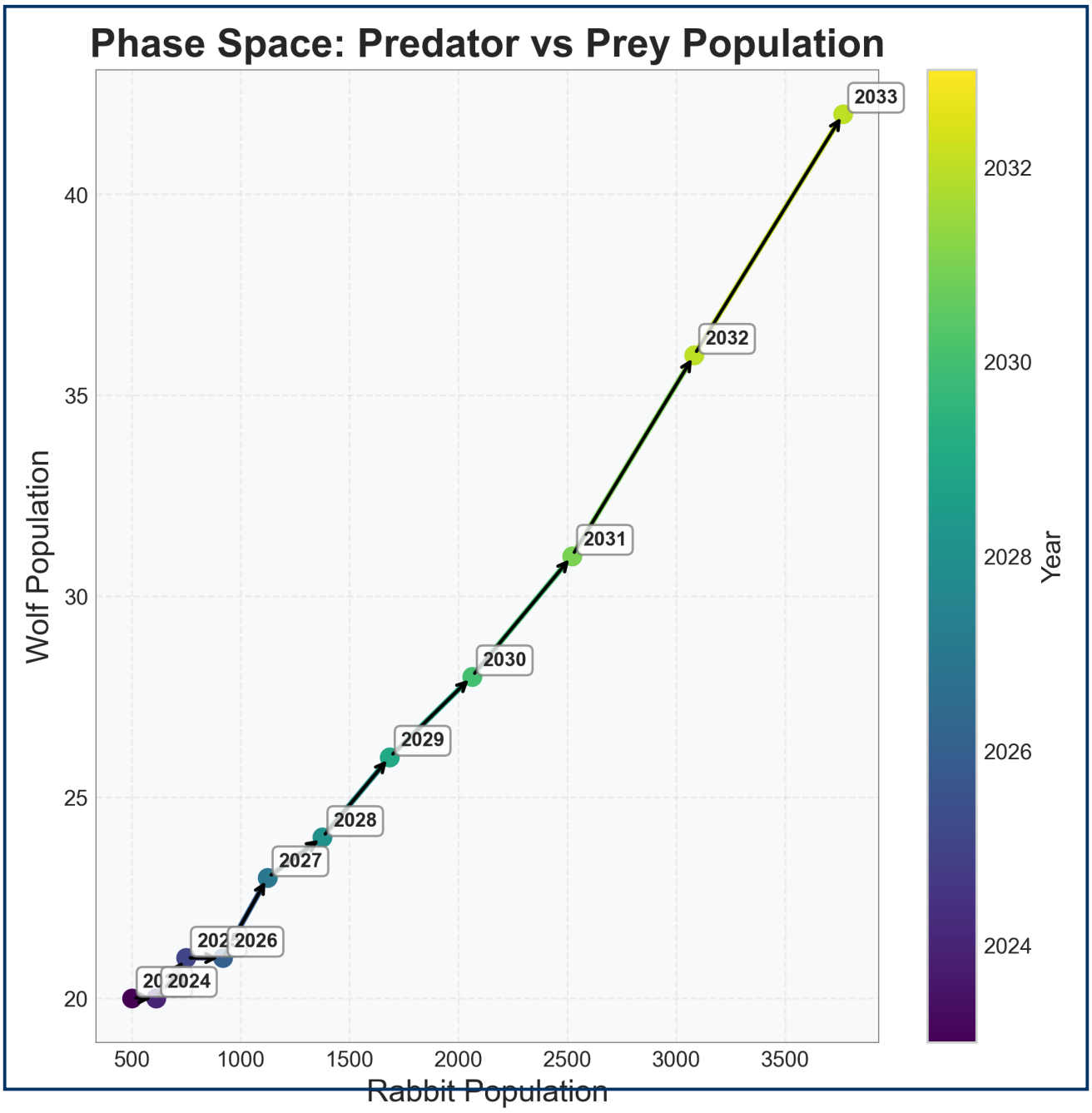


*Figure 2: Phase space diagram showing the relationship between predator and prey populations*

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

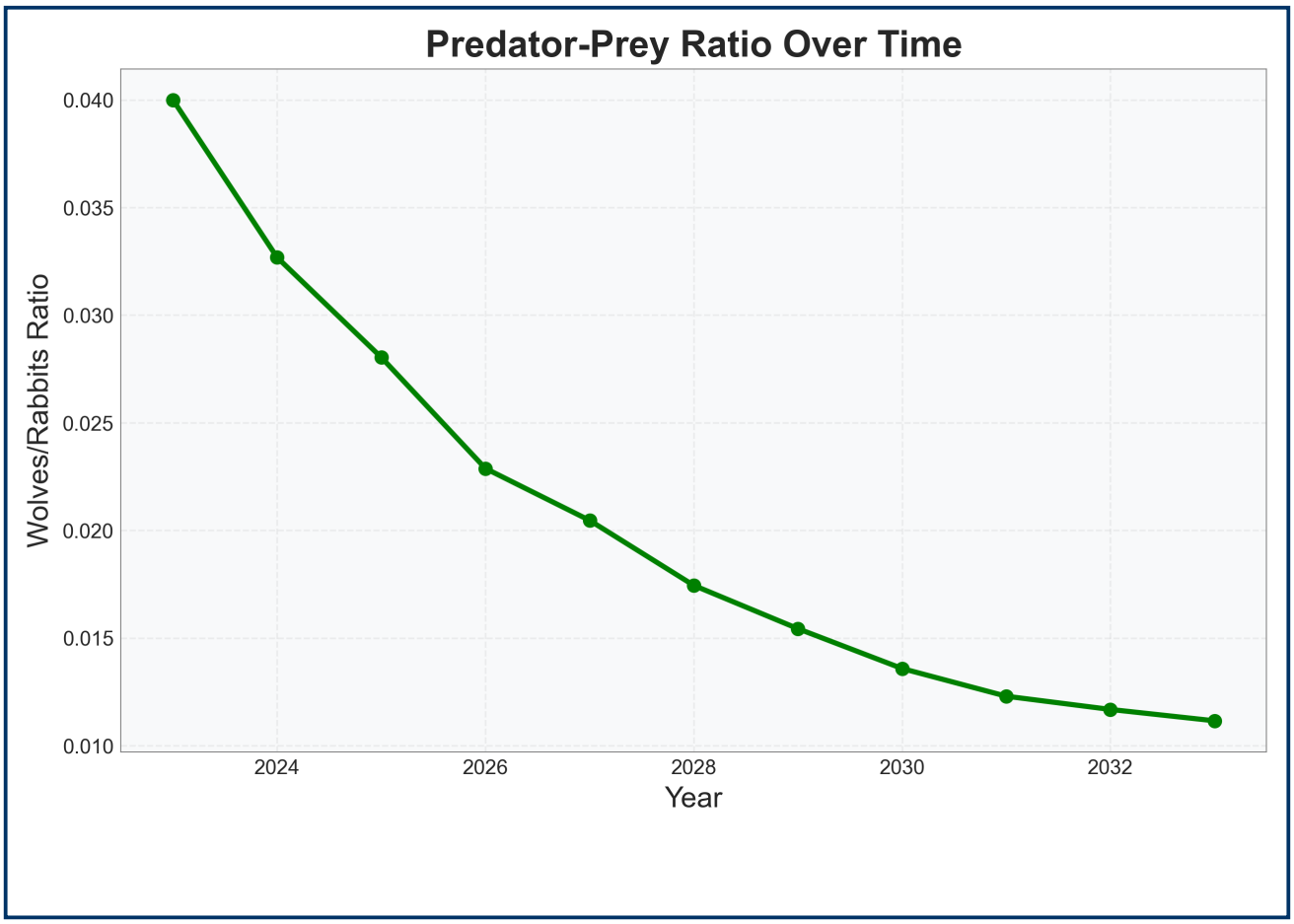


*Figure 3: Ratio of wolves to rabbits over time*

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

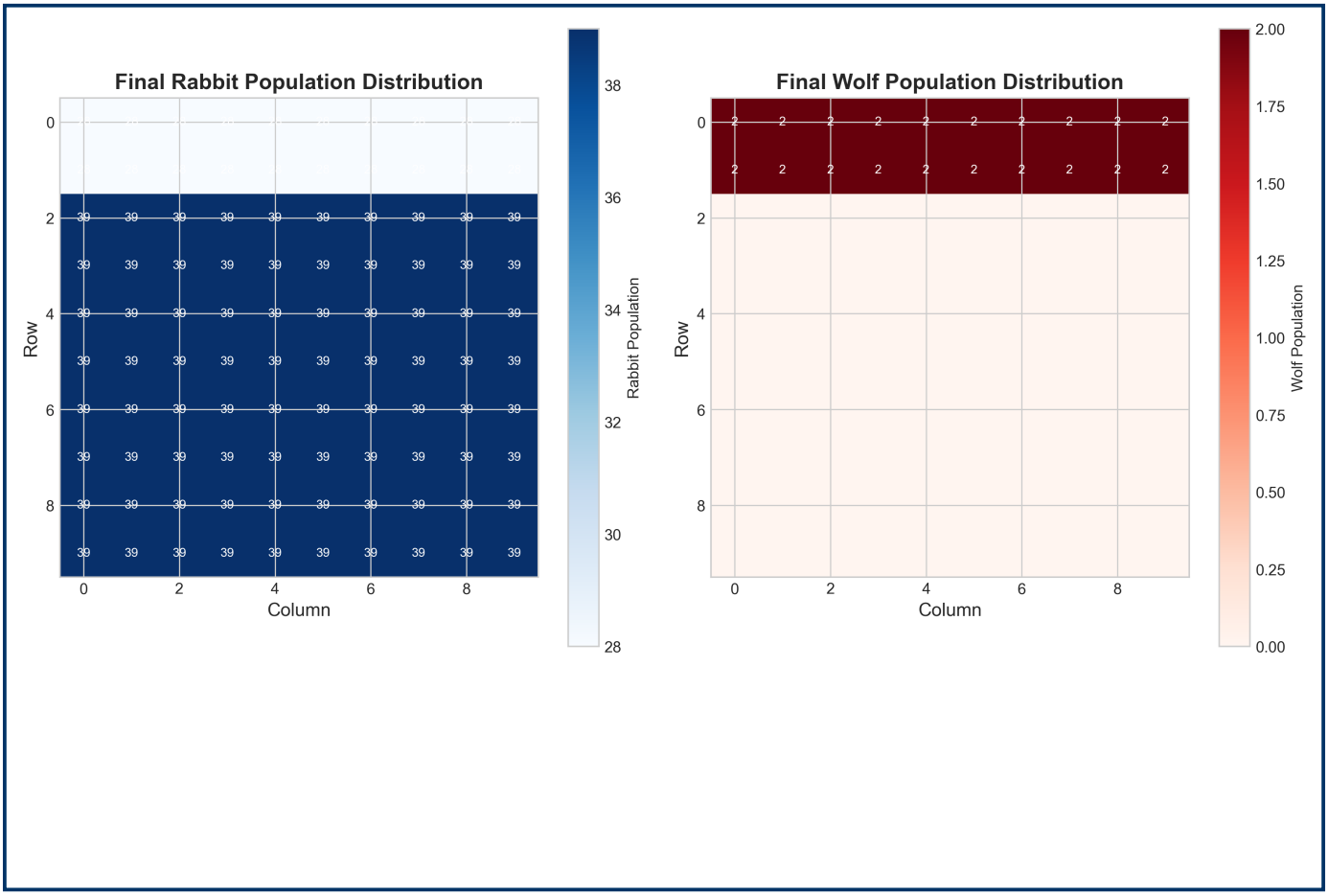


*Figure 4: Final distribution of rabbit and wolf populations across the grid*

This visualization shows the final distribution of rabbit and wolf populations across the 10×10 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

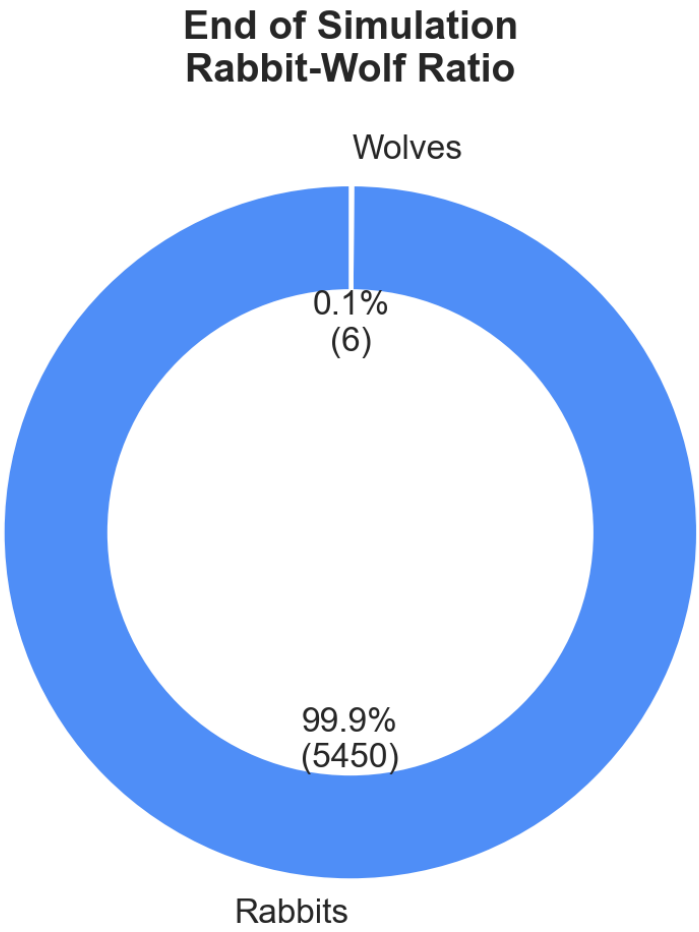


*Figure: Rabbit-Wolf Ratio at End of Simulation*

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

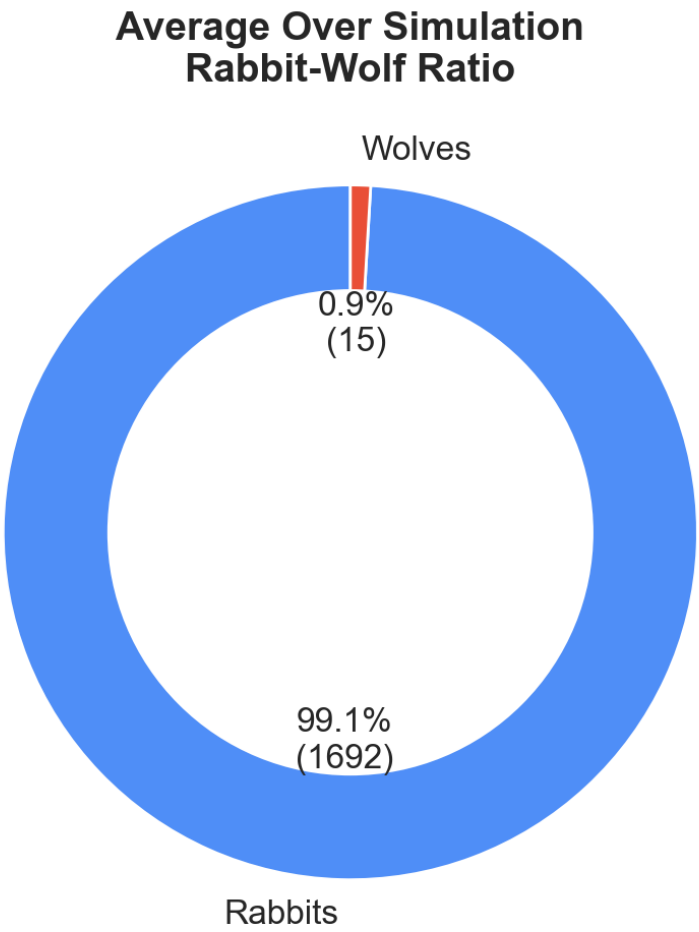


*Figure: Average Rabbit-Wolf Ratio Over Simulation*

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 240 rabbits and 40 wolves, the simulation tracked population changes over 28 years across a 10×10 grid.

Key findings:

1. The rabbit population exhibited cyclical behavior, reaching a maximum of 5450 and a minimum of 240.

2. The wolf population followed a similar pattern with a phase shift, reaching a maximum of 40 and a minimum of 6.

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 6.11 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.