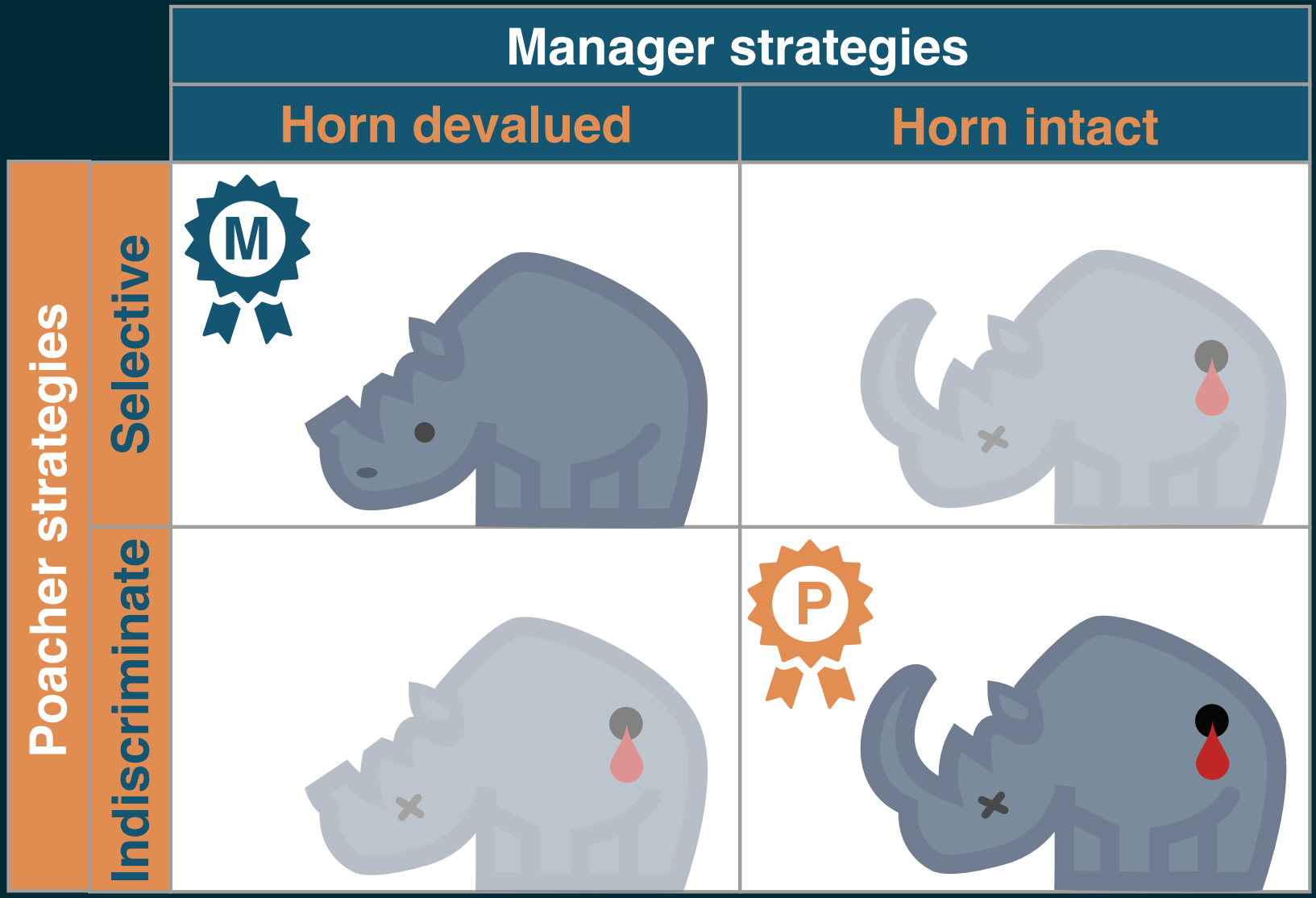
# Rhinos with a bit of Python

@NikoletaGlyn

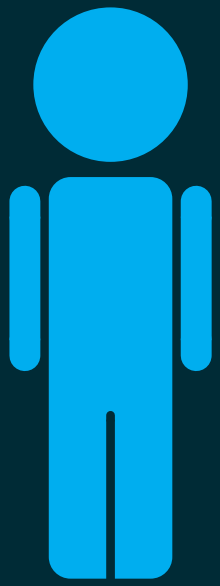

Tamsin E. Lee  Vincent Knight

# rhino-ceros

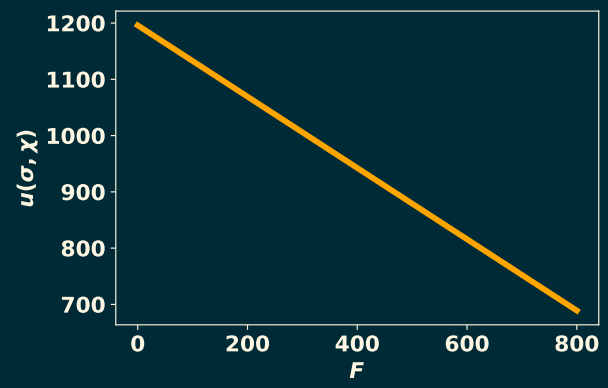


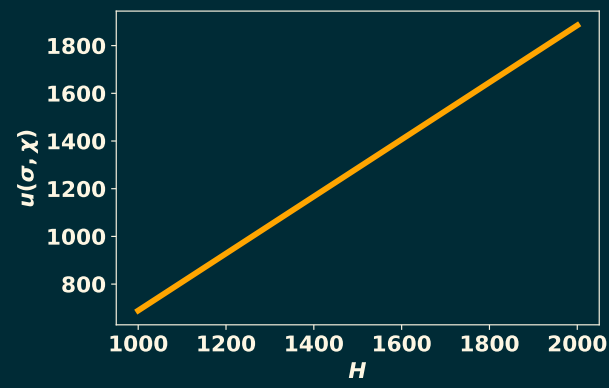

Devaluing rhino horns as a theoretical game. Tamsin E. Lee, David L. Roberts. 2016

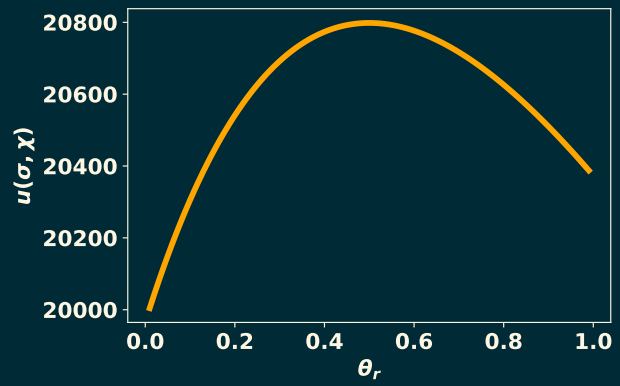
selective

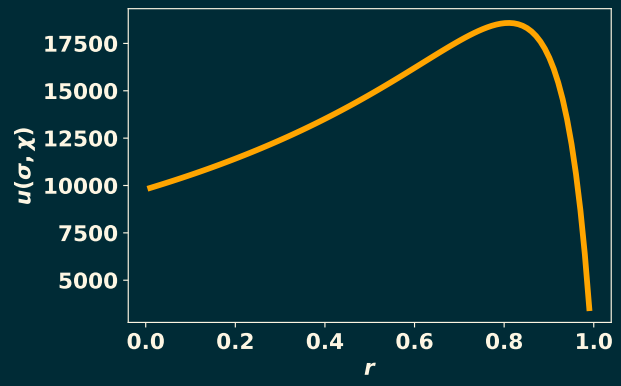


indiscriminate


1200
1100
1000
900
800
700
u(σ, χ)
0
200
400
600
800
F


1800
1600
1400
1200
1000
800
u(σ, χ)
1000
1200
1400
1600
1800
2000
H


20800
20600
20400
20200
20000
u(σ, χ)
0.0
0.2
0.4
0.6
0.8
1.0
θr


17500
15000
12500
10000
7500
5000
u(σ, χ)
0.0
0.2
0.4
0.6
0.8
1.0
r

## Theorem (Selective)

*A population of selective poachers is unstable.*

## Proof.

$$u(1,1) > u(0,1),$$

where

$$u(1,1) = H(1-r)^{1-\alpha} F(1-r)^{\beta+\gamma-1}$$

and

$$u(0,1) = H(\theta_r r + 1 - r)(1-r)^{-\alpha} - F(1-r)^{\beta+\gamma}.$$

This gives the condition,

$$H\theta_r < -F(1-r)^{\gamma+\beta+\alpha-1}$$

□

```
>>> import sympy as sym
```

```
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```
>>> (2 + 3) ** 2
25
```

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```
>>> a, b = sym.symbols('a, b')
>>> expr = (a + b) ** 2
>>> expr.expand()
a**2 + 2*a*b + b**2
```

```
>>> import imp
>>> tools = imp.load_source('tools', '../tools.py')

>>> tools.utility(1, 1)
-F*(-r + 1)**beta*(-r + 1)**gamma/(-r + 1) + H*(-r + 1)*(-r + 1)**(-alpha)

>>> tools.utility(0, 1)
-F*(-r + 1)**beta*(-r + 1)**gamma + H*(-r + 1)**(-alpha)*(r*(theta_r - 1) + 1)
```

## Theorem (Mixed)

*A mixed stable strategy* ($s = s^\star$) *never exists for* $0 < r < 1$.

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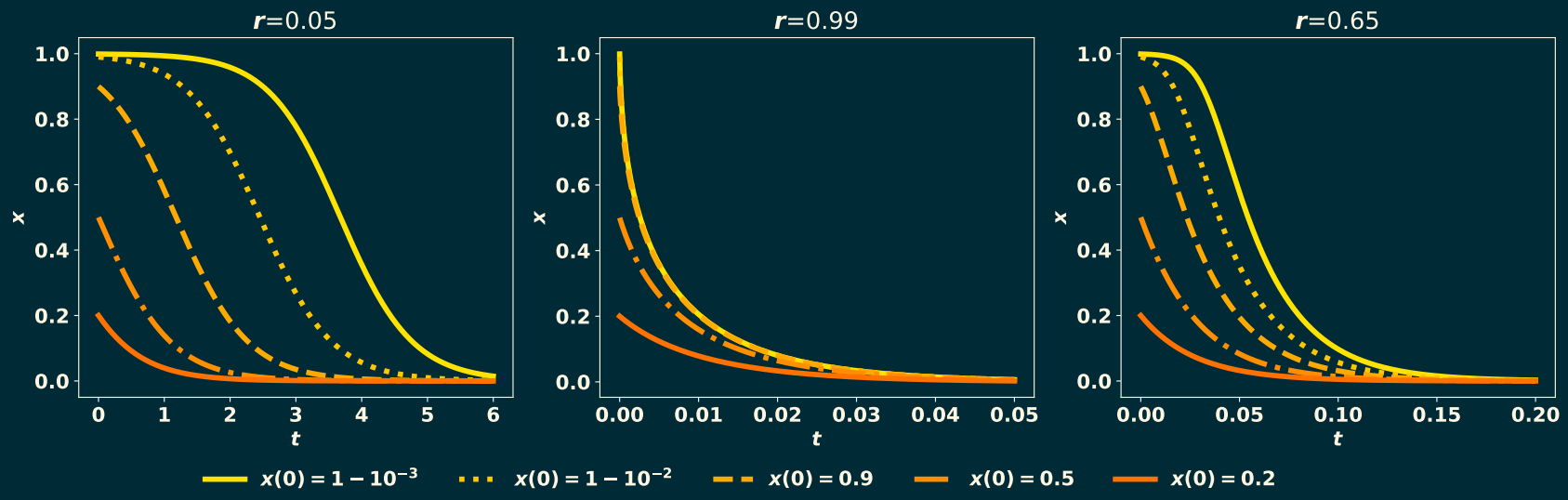
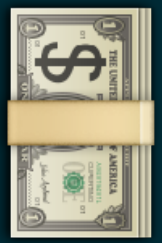
*A mixed stable strategy* ($s = s^\star$) *never exists for* $0 < r < 1$.

## Theorem (Indiscriminate)

*A population of indiscriminate poachers is evolutionarily stable.*


r=0.05
r=0.99
r=0.65
x
t
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
0.00
0.01
0.02
0.03
0.04
0.05
0.00
0.05
0.10
0.15
0.20
x(0) = 1 − 10^−3
x(0) = 1 − 10^−2
x(0) = 0.9
x(0) = 0.5
x(0) = 0.2



Dear Kate,

Here's to the crazy ones. The [illegible]. The rebels. The troublemakers. The round pegs in the square holes. The ones who see things differently. They're not fond of rules. And they have no respect for the status quo. You can quote them, disagree with them, glorify or vilify them. About the only thing you can't do is ignore them. Because they change things. They push the human race forward. And while some may see them as the crazy ones, we see genius. Because the people who are crazy enough to think they can change the world, are the ones who do.

Take care,
John Appleseed

## Theorem (Disincentive)

*Using the modified utility model, a population of selective poachers is stable if and only if:*

$$\frac{r(\theta_r H - F(1-r)^{\gamma+\beta+\alpha-1})}{(1-r)^{\alpha}} < \Gamma$$

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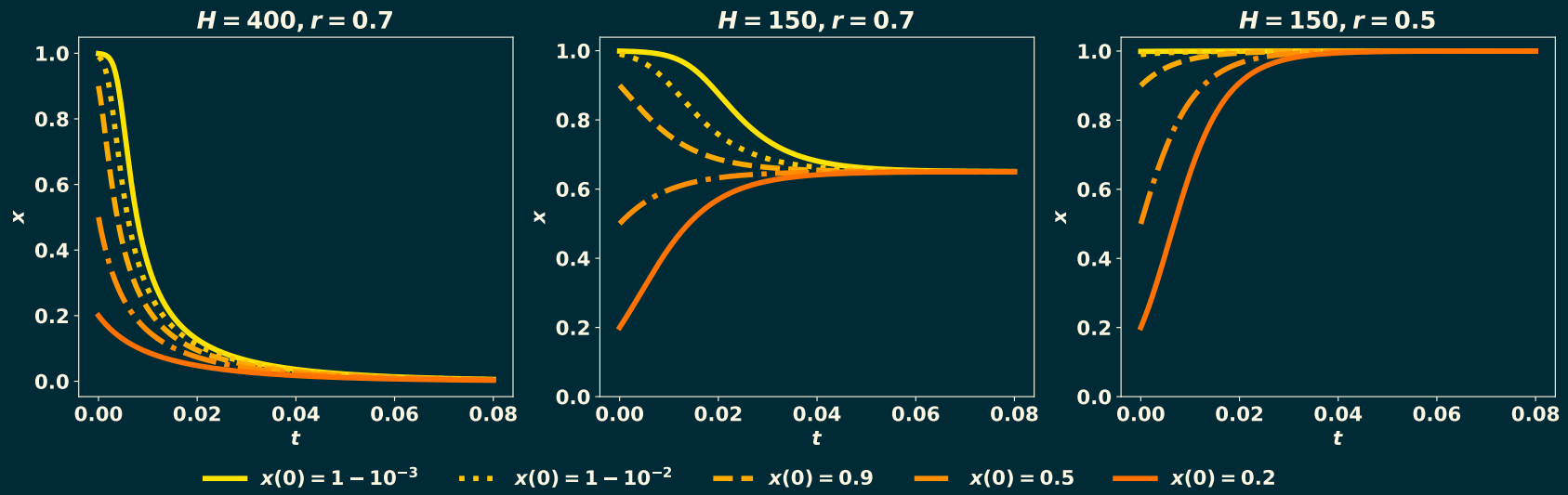
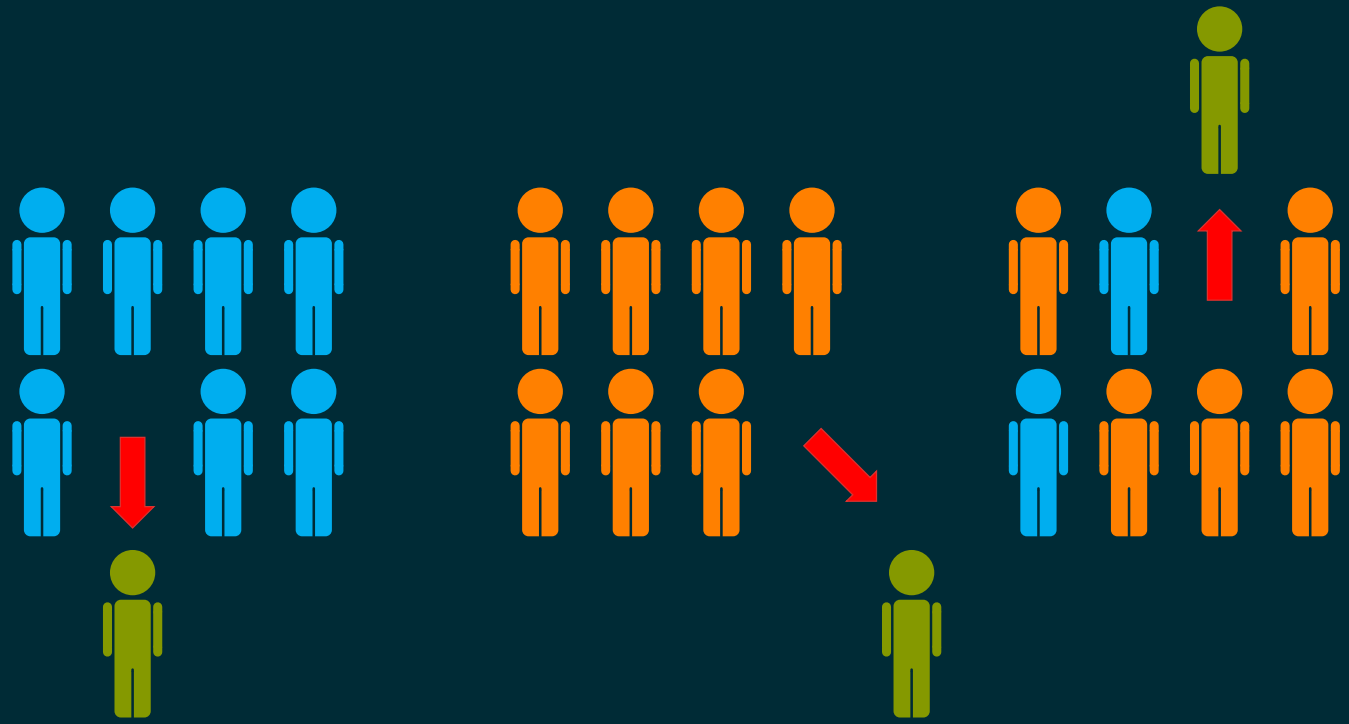


```
>>> import numpy as np
>>> from scipy.integrate import odeint
```

| | $r$ | $\theta_r$ | $H$ | $F$ | $\gamma$ | $\alpha$ | $\beta$ | indiscriminate | selective | mixed | indiscriminate ESS | selective ESS | mixed ESS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.556 | 0.0 | 0.000 | 0.667 | 0.0 | 0.667 | 0.000 | True | False | NaN | True | False | False |
| 1 | 0.242 | 0.0 | 0.500 | 0.000 | 1.0 | 0.500 | 0.000 | True | False | NaN | True | False | False |
| 2 | 0.879 | 0.0 | 1.000 | 1.000 | 0.0 | 0.333 | 0.333 | True | False | NaN | True | False | False |
| 3 | 0.758 | 0.0 | 0.667 | 1.000 | 0.0 | 0.333 | 1.000 | True | False | NaN | True | False | False |
| 4 | 0.788 | 0.0 | 0.250 | 0.000 | 1.0 | 0.250 | 1.000 | True | False | NaN | True | False | False |



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https://github.com/Nikoleta-v3

https://arxiv.org/abs/1712.07640