# Summary results of the theoritical model

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## 3.2 Model with local competition

### 3.2.1 Équations de colonisation

$$w_{\{0,+_n\}} = \left(\delta_n \rho_{+_N} + (1-\delta_n)\, q_{+_n|0}\right)\left(b_n - c_n q_{+_n|+_n} - c_{pn} q_{+_p|0}\right) \tag{1}$$

$$w_{\{0,+_p\}} = \left(\delta_p \rho_{+_p} + (1-\delta_p)\, q_{+_p|0}\right)\left(b_p - c_p q_{+_p|0} - c_{np} q_{+_n|0} - g(1 - q_{+_n|0} n)\right) \tag{2}$$

### 3.2.2 Pair approximation with 3 states

There are 3 states: nurse, protégée and empty

- Parameters used

Table 1: Listes des paramètres utilisées et de leur valeurs

| | Min | Max |
|---|---|---|
| del | 0.10 | 0.1 |
| m | 0.02 | 0.1 |
| n | 0.00 | 1.0 |
| b | 0.40 | 0.8 |
| cn | 0.20 | 0.2 |
| cp | 0.20 | 0.2 |
| cnp | 0.10 | 0.1 |
| cpn | 0.10 | 0.9 |
| g | 0.00 | 0.9 |

- Coexistence
- Effect of mortality
- Effect of competitive ability of the protégée
- Co-occurences
- Statistics

Which parameter combination gives positive co-occurences (i.e. $Cnp >= 1.1$) between two species when the density of the two species is superior to 0?

```
##        m              n           b               cnp
##  Min.   :0.02   Min.   :1   Min.   :0.4000   Min.   :0.1
##  1st Qu.:0.02   1st Qu.:1   1st Qu.:0.5000   1st Qu.:0.1
##  Median :0.02   Median :1   Median :0.6000   Median :0.1
##  Mean   :0.02   Mean   :1   Mean   :0.5786   Mean   :0.1
##  3rd Qu.:0.02   3rd Qu.:1   3rd Qu.:0.6000   3rd Qu.:0.1
##  Max.   :0.02   Max.   :1   Max.   :0.8000   Max.   :0.1
##       cpn               g              Cnp
##  Min.   :0.6000   Min.   :0.500   Min.   :1.100
##  1st Qu.:0.7500   1st Qu.:0.700   1st Qu.:1.114
##  Median :0.8500   Median :0.750   Median :1.135
##  Mean   :0.8173   Mean   :0.753   Mean   :1.148
##  3rd Qu.:0.9000   3rd Qu.:0.850   3rd Qu.:1.176
##  Max.   :0.9000   Max.   :0.900   Max.   :1.263
```

The positive co-occurences arises when the grazing pressure and the competition of the nurse on the protégée is also high. A longer lifespan seems also promote coexistence.

- The dynamic of co-occurences

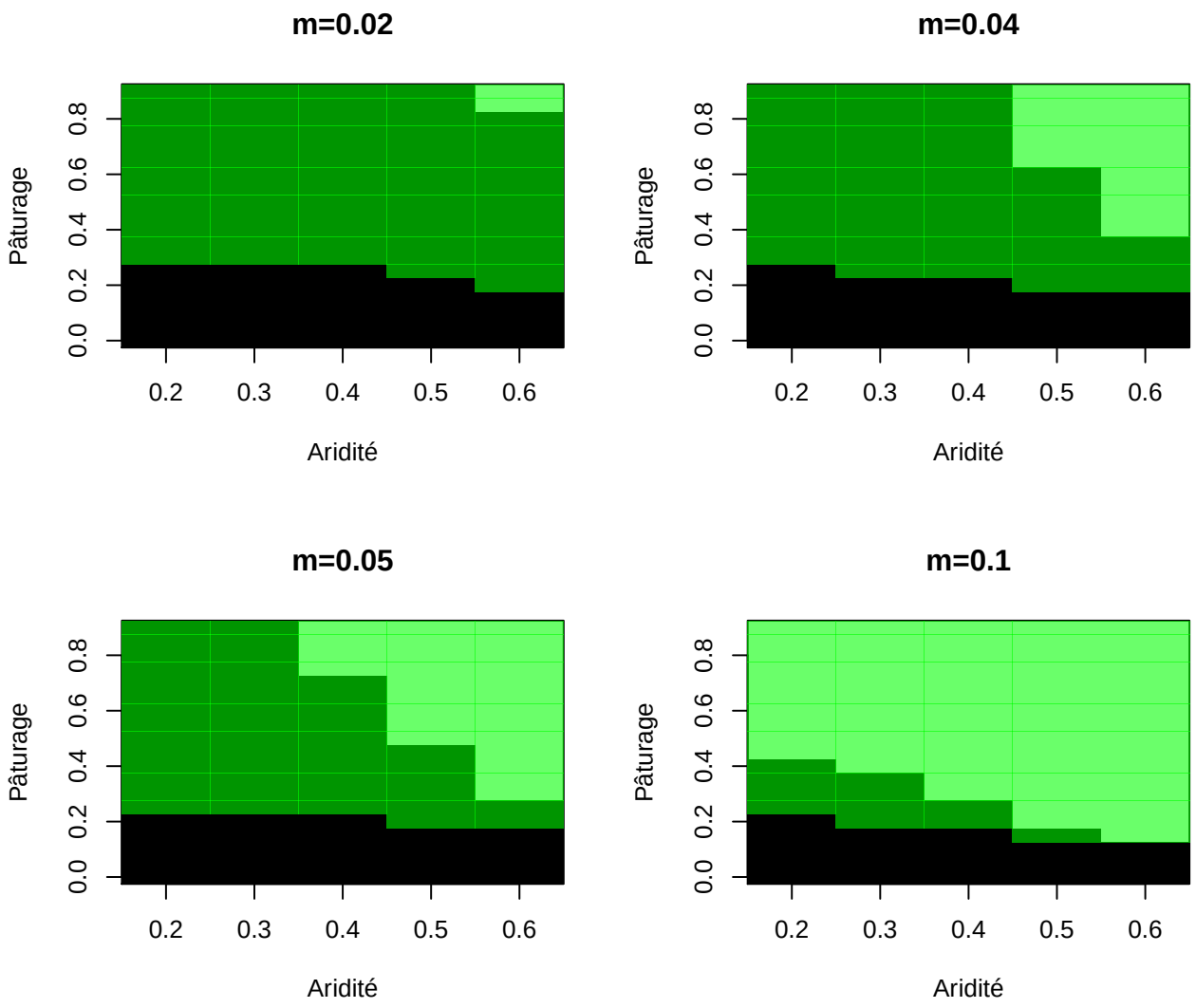


Figure 1: Green light: nurse alone, green dark: coexistence, black: protégée alone

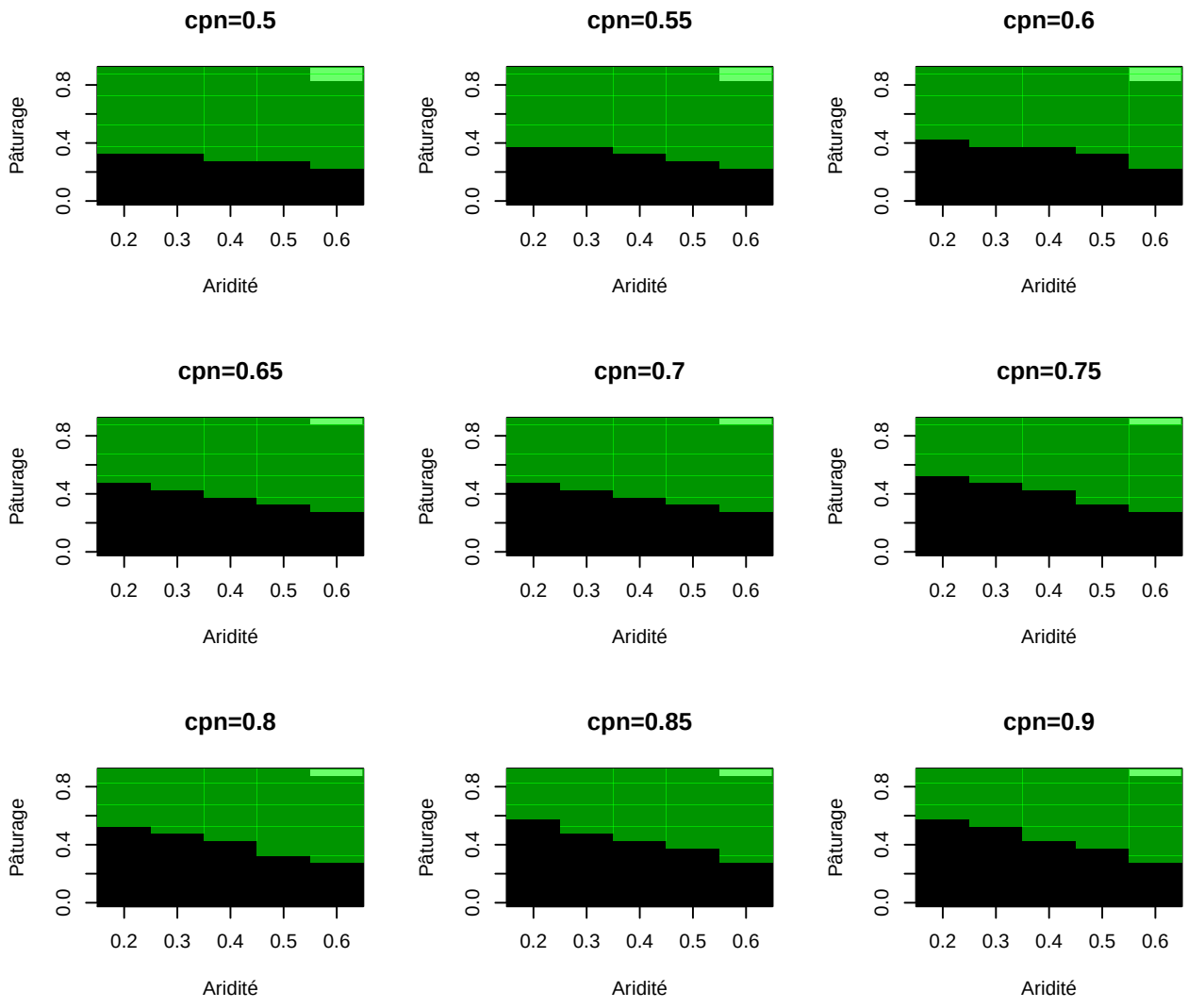


Figure 2: Green light: nurse alone, green dark: coexistence, black: protégée alone

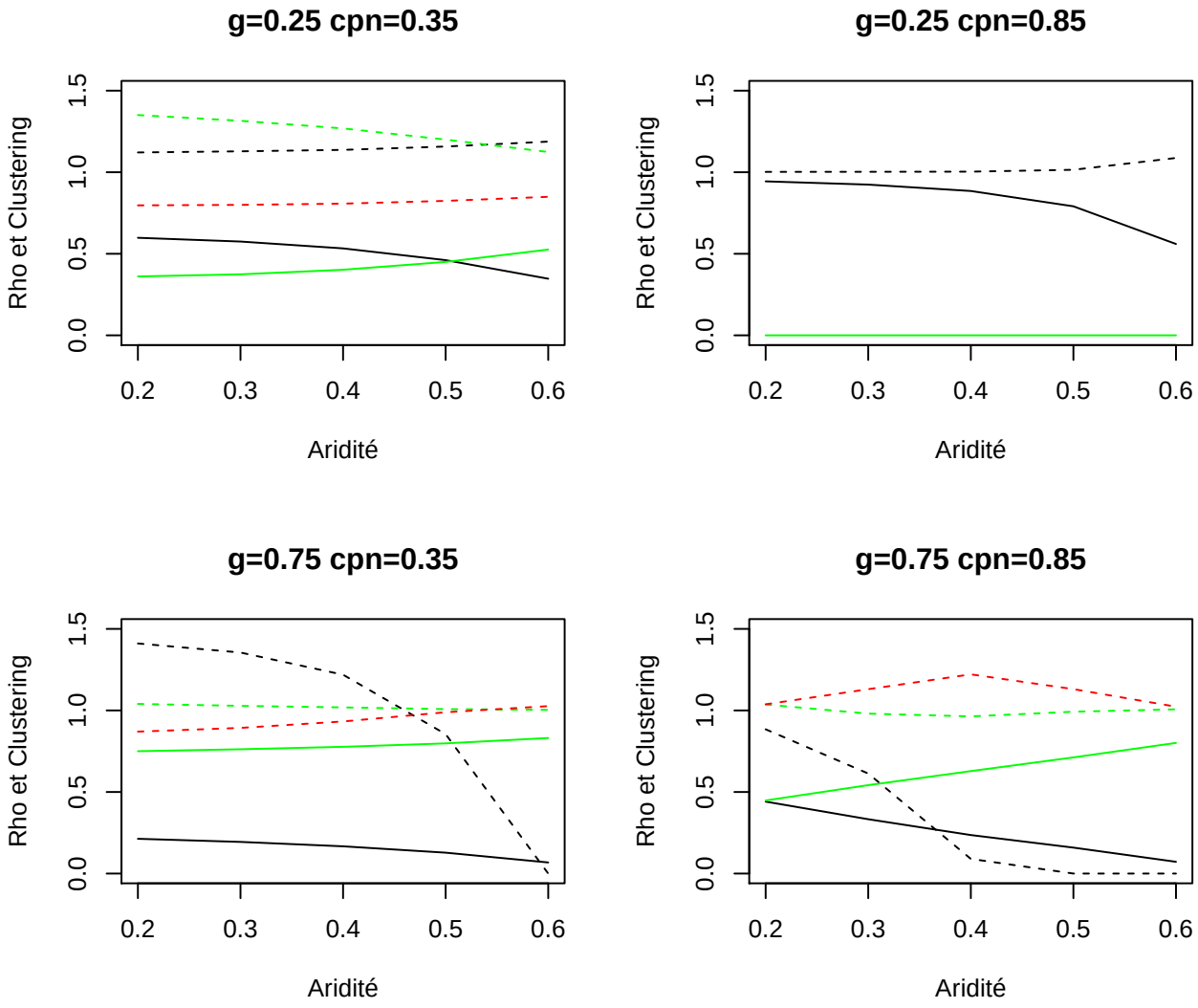
g=0.25 cpn=0.35
g=0.25 cpn=0.85
g=0.75 cpn=0.35
g=0.75 cpn=0.85
Rho et Clustering
Aridité
0.0
0.5
1.0
1.5
0.2
0.3
0.4
0.5
0.6

Figure 3:

### 3.2.3 Cellular automata with 4 states

There are 4 states: nurse, protégée, empty and degraded

- Parameters used

Same as pair approximation! But we add $f = 0.9$,$r = 0.01$, $d = 0.1$.

- Results

No positive co-occurence occurs! Fuck, fuck, fuck. Futhermore, the use of a low mortality ( m= 0.02) made the vegetal cover very high.

```
##    rho_nurse        rho_protege           c_1           c_2
##  Min.   :0.05173   Min.   :0.05017   Min.   :0.2   Min.   :0.2
##  1st Qu.:0.44111   1st Qu.:0.14060   1st Qu.:0.2   1st Qu.:0.2
##  Median :0.60916   Median :0.30831   Median :0.2   Median :0.2
##  Mean   :0.59733   Mean   :0.32992   Mean   :0.2   Mean   :0.2
##  3rd Qu.:0.80218   3rd Qu.:0.47437   3rd Qu.:0.2   3rd Qu.:0.2
##  Max.   :0.91649   Max.   :0.90126   Max.   :0.2   Max.   :0.2
##       c_21             c_12           b                m
##  Min.   :0.1000   Min.   :0.1   Min.   :0.4000   Min.   :0.02
##  1st Qu.:0.2500   1st Qu.:0.1   1st Qu.:0.6000   1st Qu.:0.02
##  Median :0.4000   Median :0.1   Median :0.7000   Median :0.02
##  Mean   :0.4452   Mean   :0.1   Mean   :0.6991   Mean   :0.02
##  3rd Qu.:0.6500   3rd Qu.:0.1   3rd Qu.:0.8000   3rd Qu.:0.02
##  Max.   :0.9000   Max.   :0.1   Max.   :0.9000   Max.   :0.02
##        g           clus_2_1
##  Min.   :0.00   Min.   :0.6072
##  1st Qu.:0.15   1st Qu.:0.6738
##  Median :0.25   Median :0.6886
##  Mean   :0.28   Mean   :0.6847
##  3rd Qu.:0.40   3rd Qu.:0.6980
##  Max.   :0.80   Max.   :0.7740
```

- Coexistence
- Effect of the competition of the protégée on the nurse

We can see that the inter competition of the protégée on the nurse doesn't have a great impact on the size of the area of coexistence. I think it is because I put a too weak mortality. It's may be on of the reason why I don't have positive co-occurence between the two species.

- Stability

### 3.2.4 Cellular automata with 4 states

#### 3.2.4.1 Model with local competition: intraspecific competition and interspecific facilitation

Here, I tested the effect of interspecific facilitation for establishment on the co-occurence between the two species. I did it by setting the intercompetition to negative values and intracompetition to 0.3.

- Parameters used

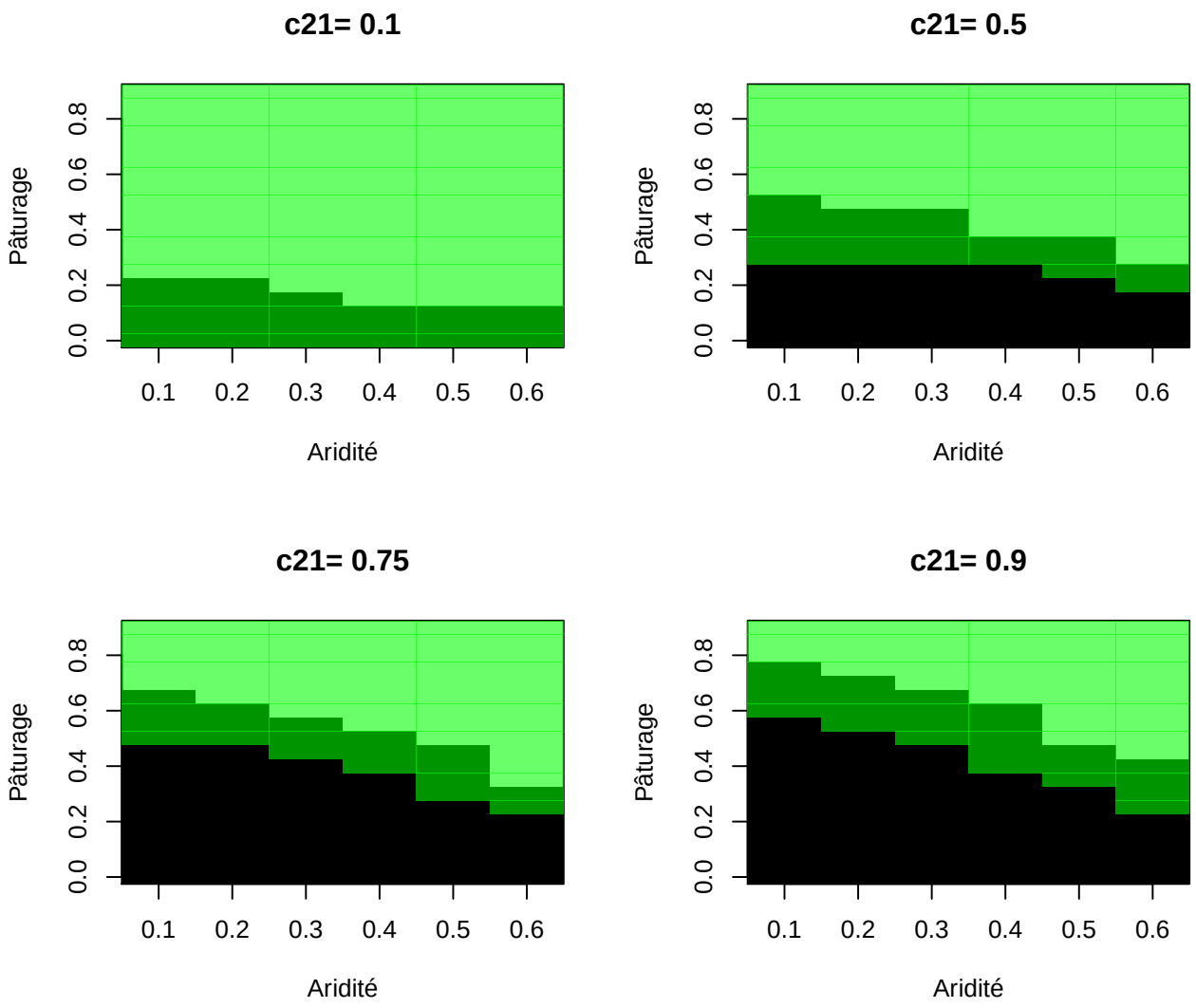


Figure 4: Green light: nurse alone, green dark: coexistence, black: protégée alone

Table 2: Listes des paramètres utilisées et de leur valeurs

| | Min | Max |
|---|---|---|
| del | 0.1 | 0.1 |
| m | 0.1 | 0.1 |
| n | 0.0 | 1.0 |
| b | 0.2 | 0.9 |
| c1 | 0.3 | 0.3 |
| c2 | 0.3 | 0.3 |
| c12 | -1.0 | 0.0 |
| c21 | -1.0 | 0.0 |
| g | 0.0 | 0.3 |

- Coexistence

```
##    rho.nurse       rho.protege            c1            c2
##  Min.   :0.1639   Min.   :0.06739   Min.   :0.3   Min.   :0.3
##  1st Qu.:0.2853   1st Qu.:0.15039   1st Qu.:0.3   1st Qu.:0.3
##  Median :0.3486   Median :0.19472   Median :0.3   Median :0.3
##  Mean   :0.3331   Mean   :0.19566   Mean   :0.3   Mean   :0.3
##  3rd Qu.:0.3978   3rd Qu.:0.24051   3rd Qu.:0.3   3rd Qu.:0.3
##  Max.   :0.4272   Max.   :0.29314   Max.   :0.3   Max.   :0.3
##       c21               c12                b
##  Min.   :-1.0000   Min.   :-1.0000   Min.   :0.3000
##  1st Qu.:-1.0000   1st Qu.:-1.0000   1st Qu.:0.3000
##  Median :-1.0000   Median :-1.0000   Median :0.3500
##  Mean   :-0.9444   Mean   :-0.9444   Mean   :0.3472
##  3rd Qu.:-1.0000   3rd Qu.:-1.0000   3rd Qu.:0.3875
##  Max.   :-0.5000   Max.   :-0.5000   Max.   :0.4000
##        m             g             clus.2.1
##  Min.   :0.1   Min.   :0.0000   Min.   :1.005
##  1st Qu.:0.1   1st Qu.:0.0500   1st Qu.:1.008
##  Median :0.1   Median :0.1000   Median :1.039
##  Mean   :0.1   Mean   :0.1167   Mean   :1.046
##  3rd Qu.:0.1   3rd Qu.:0.2000   3rd Qu.:1.063
##  Max.   :0.1   Max.   :0.3000   Max.   :1.133
```

We see that coexistence occurs but obsviously, in the state diagram, we lost the part where the protégée survive alone because the intercompetition is below 0.

- Stability

# 4 Discussion

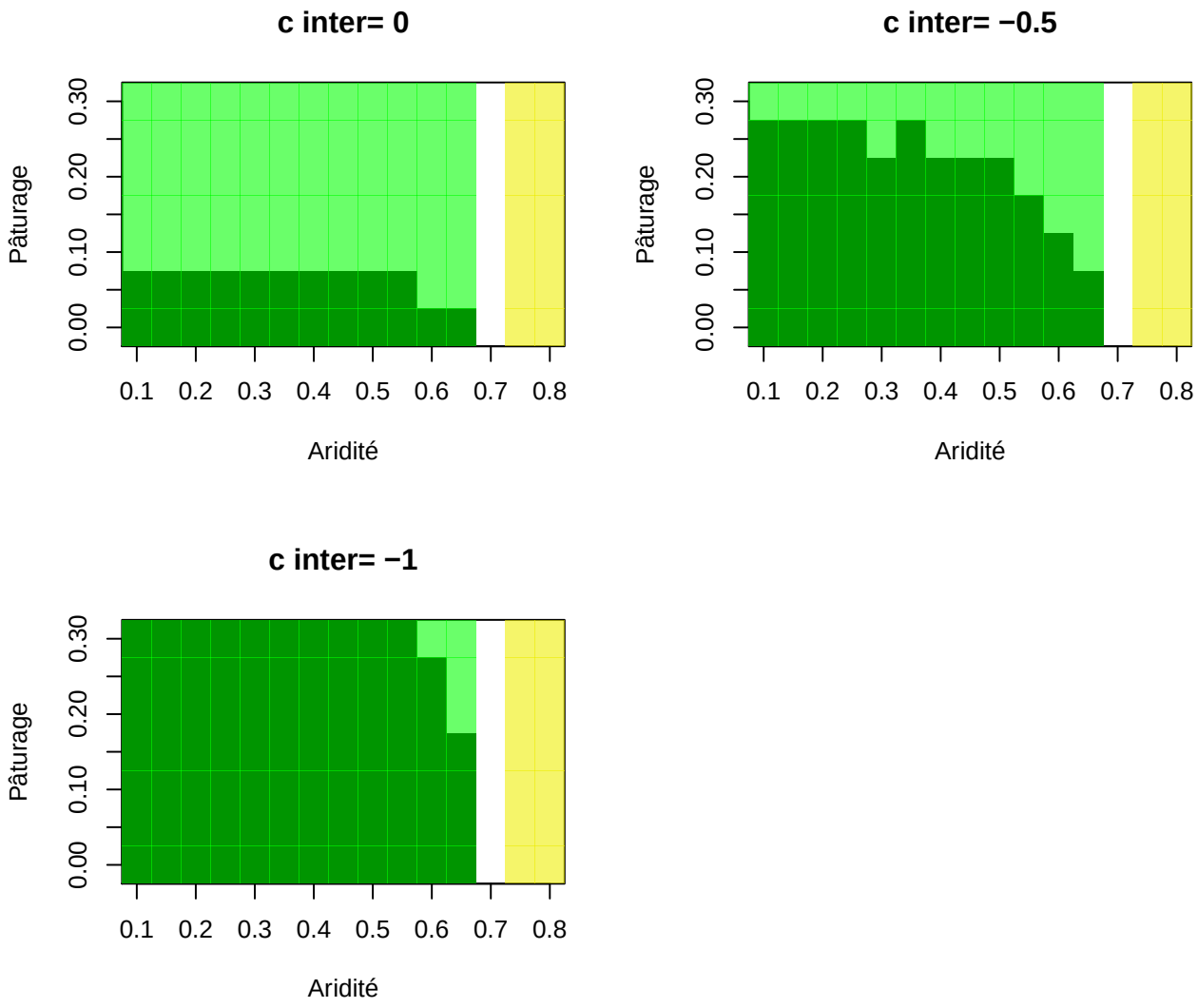
c inter= 0
Pâturage
0.00
0.10
0.20
0.30
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Aridité
c inter= −0.5
Pâturage
0.00
0.10
0.20
0.30
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Aridité
c inter= −1
Pâturage
0.00
0.10
0.20
0.30
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Aridité

Figure 5: