Survival Rate Estimation from Fdc35 Red Fox Populations

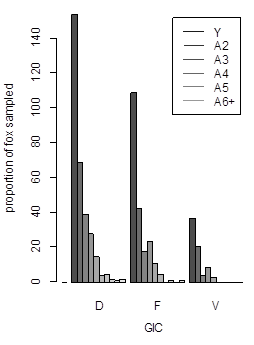
# Introduction on data structure



C : Chasse (Hunting);

D: Déterrage (Digging out);

P: Piégeage (Trapping); R : Route (Road)

The data collection of FDC35 is size impressive and presents a diversity of site, time and mode sampling. However, the age structure is highly biased depending on the sampling method [above]. Digging out removes only juveniles whereas trapping selects for yearlings and adults. As a consequence, our survival estimates based on this age structure should be highly biased. So, Digging out and Road data will be removed firstly from the data set, and juvenile won’t be taken into account. The resulting data set shows a more fairly age structures even if trapping samples are three times larger than hunting samples. Moreover, yearling proportion is a bit smaller with hunting (58%) than trapping (65%). An average 60% of yearlings correspond to the literature information.

The data collection is composed only by female on which we have reproduction information through uterus sampling and analysis. The age structure of the sampling is fairly constant between site whatever the sampling method applied [above, χ²=36.08, p=0.46]. Some GIC present more samples than other but only Vendelais presents a low sampling, particularly for old ages.

Y: yearlings (1st year); A: Adults 2nd year; B: Barrois; D: Domagne; F: Fougères; S: Sarce; V: Vendelais

# Survival

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Age** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** |
| 1 | 104 | 160 | 167 | 138 | 118 | 154 | 78 |
| 2 | 48 | 90 | 48 | 66 | 47 | 71 | 31 |
| 3 | 36 | 51 | 28 | 20 | 32 | 20 | 13 |
| 4 | 30 | 33 | 19 | 20 | 13 | 13 | 7 |
| 5 | 14 | 16 | 10 | 3 | 5 | 7 | 6 |
| 6 | 5 | 13 | 4 | 6 | 2 | 4 | 1 |
| 7 | 4 | 3 | 4 | 3 | 2 | 2 | 0 |
| 8 | 1 | 1 | 1 | 0 | 0 | 1 | 0 |
| 9 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 10 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| **Total** | 244 | 368 | 282 | 257 | 219 | 273 | 136 |

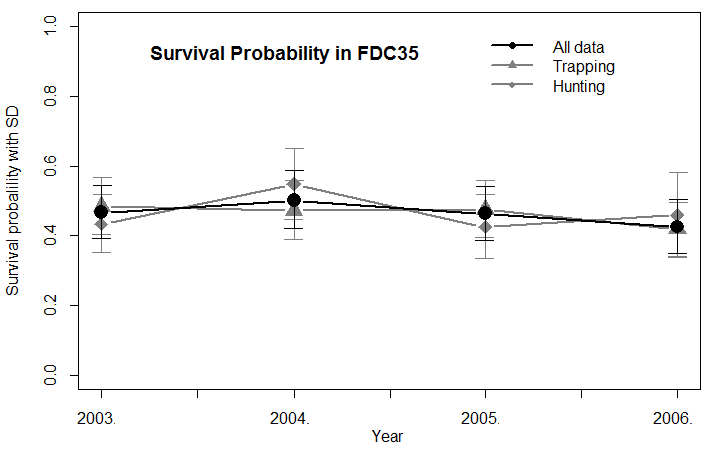
The age-at-harvest data are sampled from hunting and intensive trapping effort during 2001 and 2007. This effort is not constant between years but the average proportion of yearlings stays around 60%. However, the age structure is not fairly stable between years [χ²=61.42, df=45, p=0.05]. However, between 2003 and 2007, the times period on which we will work, the age structure is very stable [χ²=21, df=16, p=0.22]. As a consequence, the usual life table method to estimate survival can be used here. However, under culling pressure, red fox population used to fluctuate and the usual assumption of stationary dynamics is violated. But, the method of Udevitz and Gogan 2012 release the assumptions of a stable dynamic by using lambda estimation from independent data (Distance sampling between 2002 and 2010). We remove digging out data and the juvenile class from these data to avoid strong bias in the population composition. We work only between 2003 and 2007 as lambda estimate is measured at VEN and FOU only from 2003

## Model selection of Age Classification

The Udevitz’s method has been used to estimate age-specific survival between different age classifications. They were designed relative to biological reasons (yearlings vs. adults, senescence) and the data age structure. Likelihood estimate and AIC calculation enable to compare models:

|  |  |  |  |
| --- | --- | --- | --- |
| **Model** | **Parameters** | **logL** | **AIC** |
| *all* | 76 | -50,43 | 252,86 |
| *3-5;6-10* | 56 | -72,47 | 256,94 |
| *2-5;6-10* | 52 | -73,57 | 251,14 |
| *2-10;* | 48 | -75,83 | 247,67 |
| ***1-10;*** | **44** | **-77,08** | **242,16** |
| *all; time inv* | 18 | -67,43 | 170,86 |
| 3-5;6-10; time inv | 13 | -70,45 | 166,90 |
| 2-5;6-10; time inv | 12 | -70,80 | 165,61 |
| ***2-10; time inv*** | **11** | **-70,59** | **163,19** |
| *1-10 ; time inv* | 10 | -76,88 | 173,77 |

A single-age class model for is selected from the overall data. Survival probability of all sexual mature individuals is estimated. However, the time invariant model is more parsimonious because the age structure of the data is nearly stable. A two age class model is more parsimonious because the number of parameters decreased.



At the level of the Site, the sampling mode does not highly influence the survival estimate: estimates for trapping and hunting only remain in the confidence interval of the global data set. The average and trend of the survival probabilities are imposed by the trapping data, which represents the main part of the data set. Moreover, at the same level, annual variation is quite slight: it explains why time invariant estimate are more parsimonious.

## GIC by GIC estimation

The age structure is stable between populations. Domagné presents an important number of samples than the two others. We will evaluate in this part population difference in red fox vital rate as we previously showed a different population dynamic. Even if time invariant model of survival are more parsimonious, time dependent information should be required to investigate population dynamics under changing hunting pressure. For each population, we will estimate a single survival rate for adult red foxes. However, we will estimate a juvenile survival rate, corresponding to the 10th first month of life between fox birth to sexual maturity. We use previously estimated reproductive rate to calculated expected number of newborn removed. There are three possibilities to estimate it:

Use the number of female caught per year

Use the total removals per year assuming a 1:1 sex ratio

**In general, we are only interested by a two age class model (juvenile vs. adult) for management applications. So, I will estimate such parameters even if they are not the most parsimonious.**

### GIC Domagne

We test again model selection between two age class (juvenile vs adult) and three age classes (juveniles, yearlings and adults). The two age class model remains the most parsimonious for annual variation. But, as for the global test, the three age class model is better for time invariant estimates.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** |
| *Age* | **Age-at-harvest data** | | | | | |
| *X0F* | 325 | 220 | 314 | 278 | 272 | 105 |
| *X0T* | 342 | 260 | 323 | 297 | 271 | 120 |
| *1* | 72 | 87 | 81 | 73 | 69 | 25 |
| *2* | 29 | 24 | 43 | 27 | 34 | 10 |
| *3* | 23 | 16 | 10 | 21 | 13 | 5 |
| *4* | 12 | 4 | 9 | 9 | 9 | 3 |
| *5* | 11 | 5 | 1 | 3 | 3 | 4 |
| *6* | 5 | 1 | 3 | 1 | 3 | 1 |
| *7* | 1 | 1 | 2 | 2 | 1 | 0 |
| *8* | 0 | 0 | 0 | 0 | 1 | 0 |
| *9* | 0 | 0 | 0 | 0 | 1 | 0 |
| *10* | 0 | 0 | 1 | 0 | 0 | 0 |
| *% juvenile* | 0,69 | 0,65 | 0,68 | 0,69 | 0,67 | 0,71 |
|  | **Population Dynamic** | | | | | |
| *Density* | 0,85 | 0,96 | 1,00 | 1,00 | 1,09 | 1,33 |
| *CV Density* | 0,10 | 0,11 | 0,13 | 0,13 | 0,10 | 0,13 |
| *Lambda* | 1,14 | 1,04 | 1,00 | 1,08 | 1,23 | 0,79 |
| *VarLam* | 0,03 | 0,03 | 0,03 | 0,03 | 0,04 | 0,02 |
| *Age class* | **Litter Size** | | | | | |
| *(0,1]* | 4,65 | 4,48 | 4,84 | 4,63 | 4,31 | 4,90 |
| *(1,2]* | 5,06 | 4,89 | 5,25 | 5,03 | 4,71 | 5,31 |
| *(2,5]* | 5,17 | 5,00 | 5,36 | 5,15 | 4,83 | 5,42 |
| *(5,10]* | 3,71 | 3,54 | 3,90 | 3,69 | 3,37 | 3,96 |
| *Age class* | **Probability of breeding** | | | | | |
| *(0,1]* | 0,89 | 0,77 | 0,82 | 0,88 | 0,87 | 0,98 |
| *(1,5]* | 0,95 | 0,88 | 0,91 | 0,94 | 0,94 | 0,99 |
| *(5,10]* | 1,00 | 1,00 | 1,00 | 1,00 | 1,00 | 1,00 |
| *Age class* | **Survival rate with X0F** | | | | | Average |
| *Juveniles* | 0,38 | 0,29 | 0,26 | 0,28 | 0,30 | 0,29 |
| *Adults* | 0,48 | 0,44 | 0,47 | 0,53 | 0,55 | 0,51 |
| *SD\_S0* | 0,07 | 0,06 | 0,06 | 0,05 | 0,07 | 0,06 |
| *SD\_SA* | 0,10 | 0,09 | 0,11 | 0,11 | 0,14 | 0,10 |
| *Age class* | **Survival rate with X0T** | | | | | Average |
| *Juveniles* | 0,36 | 0,27 | 0,25 | 0,27 | 0,27 | 0,28 |
| *Adults* | 0,47 | 0,44 | 0,46 | 0,55 | 0,51 | 0,51 |
| *SD\_S0* | 0,06 | 0,05 | 0,05 | 0,05 | 0,07 | 0,05 |
| *SD\_SA* | 0,10 | 0,09 | 0,10 | 0,12 | 0,13 | 0,10 |

The two possible estimation of juvenile survival are very close, without significant differences.



Two age classes :

**There is an important difference between juvenile and adult survival but there are weak annual variations.**

### Vendelais

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **2003** | **2004** | **2005** | **2006** | **2007** |
| *Age* | **Age-at-harvest data** | | | | |
| *X0F* | 93 | 51 | 27 | 88 | 44 |
| *X0T* | 87 | 44 | 41 | 88 | 57 |
| *1* | 28 | 14 | 8 | 24 | 14 |
| *2* | 9 | 4 | 8 | 16 | 7 |
| *3* | 4 | 0 | 1 | 2 | 0 |
| *4* | 3 | 2 | 1 | 1 | 2 |
| *5* | 1 | 1 | 0 | 1 | 0 |
| *6* | 0 | 0 | 1 | 0 | 0 |
| *7* | 1 | 0 | 0 | 0 | 0 |
| *8* | 1 | 0 | 0 | 0 | 0 |
| *9* | 0 | 0 | 0 | 0 | 0 |
| *10* | 0 | 0 | 0 | 0 | 0 |
| *% juvenile* | 0,65 | 0,68 | 0,68 | 0,67 | 0,71 |
|  | **Population Dynamic** | | | | |
| *Density* | 0,94 | 0,94 | 0,85 | 1,07 | 0,81 |
| *CV Density* | 0,10 | 0,11 | 0,13 | 0,10 | 0,14 |
| *Lambda* | 1,01 | 0,90 | 1,26 | 0,75 | 1,19 |
| *VarLam* | 0,02 | 0,02 | 0,04 | 0,02 | 0,05 |
| *Age class* | **Litter Size** | | | | |
| *(0,1]* | 4,48 | 4,84 | 4,63 | 4,31 | 4,90 |
| *(1,2]* | 4,89 | 5,25 | 5,03 | 4,71 | 5,31 |
| *(2,5]* | 5,00 | 5,36 | 5,15 | 4,83 | 5,42 |
| *(5,10]* | 3,54 | 3,90 | 3,69 | 3,37 | 3,96 |
| *Age class* | **Probability of breeding** | | | | |
| *(0,1]* | 0,74 | 0,79 | 0,86 | 0,85 | 0,98 |
| *(1,5]* | 0,87 | 0,90 | 0,93 | 0,93 | 0,99 |
| *(5,10]* | 1,00 | 1,00 | 1,00 | 1,00 | 1,00 |
| *Age class* | **Survival rate with X0F** | | | | Average |
| *Juvenile* | 0,30 | 0,22 | 0,39 | 0,24 | 0,28 |
| *Adults* | 0,29 | 0,74 | 0,46 | 0,30 | 0,42 |
| *SD\_S0* | 0,09 | 0,08 | 0,11 | 0,07 | 0,07 |
| *SD\_SA* | 0,12 | 0,27 | 0,15 | 0,11 | 0,12 |
| *Age class* | **Survival rate with X0T** | | | | Average |
| *Juvenile* | 0,33 | 0,18 | 0,33 | 0,20 | 0,27 |
| *Adults* | 0,31 | 0,51 | 0,60 | 0,25 | 0,42 |
| *SD\_S0* | 0,10 | 0,07 | 0,09 | 0,06 | 0,07 |
| *SD\_SA* | 0,13 | 0,19 | 0,20 | 0,10 | 0,12 |

The two possible estimations of juvenile survival are very close, without significant differences.





### Fougères

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **2003** | **2004** | **2005** | **2006** | **2007** |
| *Age* | **Age-at-harvest data** | | | | |
| *X0F* | 326 | 239 | 161 | 93 | 210 |
| *X0T* | 200 | 197 | 146 | 199 | 164 |
| *1* | 52 | 43 | 37 | 61 | 39 |
| *2* | 15 | 19 | 12 | 21 | 14 |
| *3* | 8 | 10 | 10 | 5 | 8 |
| *4* | 12 | 9 | 3 | 3 | 2 |
| *5* | 4 | 1 | 2 | 3 | 2 |
| *6* | 3 | 3 | 0 | 1 | 0 |
| *7* | 2 | 1 | 0 | 1 | 0 |
| *8* | 0 | 0 | 0 | 0 | 0 |
| *9* | 0 | 0 | 0 | 0 | 0 |
| *10* | 1 | 0 | 0 | 0 | 0 |
| *% juvenile* | 0,67 | 0,70 | 0,70 | 0,68 | 0,72 |
|  | **Population Dynamic** | | | | |
| *Density* | 1,95 | 1,92 | 2,27 | 2,32 | 2,62 |
| *CV Density* | 0,11 | 0,11 | 0,11 | 0,13 | 0,11 |
| *Lambda* | 0,98 | 1,18 | 1,02 | 1,13 | 1,07 |
| *VarLam* | 0,02 | 0,03 | 0,03 | 0,04 | 0,03 |
| *Age class* | **Litter Size** | | | | |
| *(0,1]* | 4,48 | 4,84 | 4,63 | 4,31 | 4,90 |
| *(1,2]* | 4,89 | 5,25 | 5,03 | 4,71 | 5,31 |
| *(2,5]* | 5,00 | 5,36 | 5,15 | 4,83 | 5,42 |
| *(5,10]* | 3,54 | 3,90 | 3,69 | 3,37 | 3,96 |
| *Age class* | **Probability of breeding** | | | | |
| *(0,1]* | 0,92 | 0,94 | 0,96 | 0,96 | 0,99 |
| *(1,5]* | 0,85 | 0,88 | 0,92 | 0,92 | 0,99 |
| *(5,10]* | 1,00 | 1,00 | 1,00 | 1,00 | 1,00 |
| *Age class* | **Survival rate with X0F** | | | | Average |
| *Juveniles* | 0,17 | 0,26 | 0,46 | 0,32 | 0,24 |
| *Adults* | 0,57 | 0,54 | 0,65 | 0,21 | 0,47 |
| *SD\_S0* | 0,04 | 0,06 | 0,09 | 0,08 | 0,05 |
| *SD\_S1* | 0,13 | 0,14 | 0,16 | 0,06 | 0,11 |
| *Age class* | **Survival rate with X0T** | | | | Average |
| *Juveniles* | 0,22 | 0,30 | 0,30 | 0,28 | 0,28 |
| *Adults* | 0,46 | 0,50 | 0,39 | 0,40 | 0,47 |
| *SD\_S0* | 0,05 | 0,07 | 0,06 | 0,06 | 0,06 |
| *SD\_S1* | 0,10 | 0,13 | 0,10 | 0,11 | 0,11 |

The two possible estimations of juvenile survival are more different than before.



