Survival Rate Estimation from Fdc10 Red Fox Populations

# Introduction on data structure

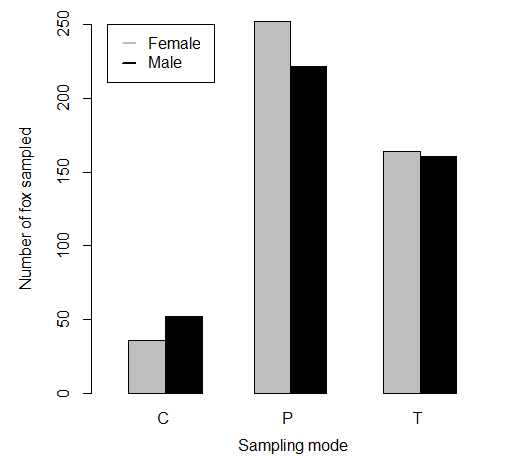


**C:** Chasse (**Hunting**); **D:** Déterrage (**Digging out**); **P:** Piégeage (**Trapping**); R: Route ; **T:** Tir de nuit (**Shoot**)

The data collection of FDC10 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], especially concerning the juvenile proportion. As a consequence, our survival estimates based on this age structure should be highly biased. For our analysis, we will use only Hunting, Trapping and Shooting, the three modes that removed an important number of foxes with a good-looking age structure. We also removed the poor life table of 2005 to avoid bias in the analysis.

The resulting data set shows a more fairly age structures even if trapping samples are five times larger than hunting samples. Moreover, yearling proportion is smaller with hunting (43%) than others (65%).

The sex ratio of samples depends on the sampling mode, but is equilibrated in average. The age structure of the sampling is fairly constant between sites [χ²=3.69, df=4, p=0.45].





# Survival

The age-at-harvest data are sampled from hunting and intensive trapping and shooting effort during 2006 and 2011. This effort is not constant between years and the average proportion of yearlings varies from 40 to 60%. Thus, the age structure is not fairly stable between years [χ²=54.4, df=20, p=5.10e-5]. This is a violation of the assumption of stable age structure needed for the usual life table method to estimate survival. However, the method of Udevitz and Gogan 2012 release the assumptions of a stable age structure by using lambda estimation from independent data (Distance sampling between 2006 and 2011).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Age** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
| *1* | 88 | 65 | 74 | 95 | 97 | 73 |
| *2* | 40 | 42 | 27 | 22 | 23 | 29 |
| *3* | 30 | 37 | 9 | 22 | 17 | 8 |
| *4* | 22 | 13 | 16 | 20 | 9 | 4 |
| *5* | 9 | 7 | 10 | 11 | 9 | 5 |
| *6* | 6 | 4 | 5 | 0 | 3 | 0 |
| *7* | 4 | 4 | 2 | 4 | 2 | 3 |
| *8* | 2 | 3 | 1 | 2 | 0 | 2 |
| *9* | 1 | 1 | 1 | 2 | 0 | 1 |
| *10* | 2 | 0 | 0 | 0 | 2 | 0 |
| *11* | 0 | 0 | 1 | 0 | 0 | 0 |
| *Total* | 204 | 176 | 146 | 178 | 162 | 125 |
| *% yearlings* | 0,43 | 0,37 | 0,51 | 0,53 | 0,60 | 0,58 |

## 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* | 105 | -61,19 | 332,39 |
| *6-10;* | 95 | -90,90 | 351,79 |
| *3-5; 6-10* | 75 | -100,34 | 350,69 |
| *2-5; 6-10* | 70 | -106,58 | 353,16 |
| ***2-10;*** | **65** | **-107,61** | **345,22** |
| *1-10;* | 60 | -114,80 | 349,61 |
| *all; time inv* | 20 | -121,45 | 282,90 |
| *3-5; 6-10; time inv* | 14 | -127,31 | 280,63 |
| *2-5; 6-10; time inv* | 13 | -125,47 | 278,93 |
| ***2-10; time inv*** | **12** | **-125,60** | **275,20** |
| *1-10; time inv* | 11 | -152,39 | 326,78 |

A two-age class model for is selected from the overall data. The time invariant model is more parsimonious because the age structure of the data is nearly stable. However, because yearlings cannot be differentiate from adults; a potential management model should only propose a single age class for all sexual matured foxes. We should present the selected model for publishing the survival rate.

At the level of the Site, the sampling mode influences the survival estimates but differences remain almost in the Confidence interval of the global estimate. The average and trend of the survival probabilities are imposed by the trapping data, which represents the main part of the data set.



## GIC by GIC estimation

The age structure is stable between populations. 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 two parameters for all adult ages. However, we will estimate a S0 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

### GIC Barrois

We test again model selection between two age class (juvenile vs adult) and three age classes (juveniles, yearlings and adults). The three age class model remains the most parsimonious for annual variation. However, we keep also two age class because removals do not distinguish yearlings and adults.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** |
| *Age* | **Age-at-harvest data** | | | | | |
| *X0F* | 270 | 260 | 275 | 82 | 87 | 88 |
| *X0T* | 259 | 265 | 227 | 72 | 91 | 96 |
| *1* | 88 | 65 | 74 | 95 | 97 | 73 |
| *2* | 40 | 42 | 27 | 22 | 23 | 29 |
| *3* | 30 | 37 | 9 | 22 | 17 | 8 |
| *4* | 22 | 13 | 16 | 20 | 9 | 4 |
| *5* | 9 | 7 | 10 | 11 | 9 | 5 |
| *6* | 6 | 4 | 5 | 0 | 3 | 0 |
| *7* | 4 | 4 | 2 | 4 | 2 | 3 |
| *8* | 2 | 3 | 1 | 2 | 0 | 2 |
| *9* | 1 | 1 | 1 | 2 | 0 | 1 |
| *10* | 2 | 0 | 0 | 0 | 2 | 0 |
| *% juvenile* | 0,56 | 0,60 | 0,61 | 0,29 | 0,36 | 0,43 |
|  | **Population Dynamic** | | | | | |
| *Density* | 0,69 | 0,44 | *0,34* | 0,34 | 0,38 | 0,50 |
| *CV Density* | 0,09 | 0,09 | 0,09 | 0,09 | 0,09 | 0,09 |
| *Lambda* | 0,64 | 0,76 | 1,00 | 1,14 | 1,31 | 0,99 |
| *VarLam* | 0,01 | 0,01 | 0,02 | 0,02 | 0,03 | 0,01 |
| *Age class* | **Litter Size** | | | | | |
| *(0,1]* | 3,83 | 4,42 | 4,65 | 3,39 | 4,52 | 4,00 |
| *(1,2]* | 4,23 | 4,83 | 5,06 | 3,80 | 4,93 | 4,40 |
| *(2,5]* | 4,35 | 4,94 | 5,17 | 3,91 | 5,04 | 4,52 |
| *(5,10]* | 2,89 | 3,48 | 3,71 | 2,45 | 3,58 | 3,06 |
| *Age class* | **Probability of breeding** | | | | | |
| *(0,1]* | 0,64 | 0,93 | 0,76 | 0,67 | 0,97 | 0,80 |
| *(1,5]* | 0,88 | 0,98 | 0,93 | 0,89 | 0,99 | 0,95 |
| *(5,10]* | 1,00 | 1,00 | 1,00 | 1,00 | 1,00 | 1,00 |
| *Age class* | **Survival rate with X0F** | | | | | Average |
| *Juveniles* | 0,11 | 0,17 | 0,33 | 0,40 | 0,41 | 0,24 |
| *Adults* | 0,35 | 0,33 | 0,54 | 0,30 | 0,70 | 0,51 |
| *SD\_S0* | 0,02 | 0,03 | 0,07 | 0,09 | 0,09 | 0,04 |
| *SD\_SA* | 0,06 | 0,07 | 0,14 | 0,09 | 0,18 | 0,09 |
| *Age class* | **Survival rate with X0T** | | | | | Average |
| *Juveniles* | 0,12 | 0,19 | 0,38 | 0,41 | 0,38 | 0,25 |
| *Adults* | 0,33 | 0,38 | 0,51 | 0,27 | 0,69 | 0,51 |
| *SD\_S0* | 0,02 | 0,03 | 0,08 | 0,09 | 0,08 | 0,04 |
| *SD\_SA* | 0,07 | 0,12 | 0,15 | 0,11 | 0,19 | 0,09 |

There are no real differences between the two kind of juvenile survival estimates !



Two age classes:



Three age classes:

### Sarce

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** |
| *Age* | **Age-at-harvest data** | | | | | |
| *X0F* | 61 | 112 | 68 | 193 | 295 | 105 |
| *X0T* | 66 | 128 | 72 | 188 | 279 | 132 |
| *1* | 19 | 23 | 15 | 63 | 70 | 43 |
| *2* | 7 | 16 | 6 | 13 | 15 | 16 |
| *3* | 7 | 9 | 5 | 19 | 15 | 4 |
| *4* | 3 | 2 | 5 | 15 | 8 | 3 |
| *5* | 1 | 4 | 1 | 9 | 7 | 3 |
| *6* | 0 | 1 | 0 | 0 | 3 | 0 |
| *7* | 2 | 1 | 0 | 2 | 2 | 2 |
| *8* | 0 | 1 | 0 | 2 | 0 | 0 |
| *9* | 0 | 0 | 1 | 2 | 0 | 0 |
| *10* | 1 | 0 | 0 | 0 | 2 | 0 |
| *% juvenile* | 0,62 | 0,69 | 0,69 | 0,60 | 0,70 | 0,65 |
|  | **Population Dynamic** | | | | | |
| *Density* | 0,80 | 0,90 | 0,67 | 0,74 | 0,49 | 0,30 |
| *CV Density* | 0,08 | 0,08 | 0,09 | 0,08 | 0,08 | 0,11 |
| *Lambda* | 1,12 | 0,75 | 1,10 | 0,66 | 0,61 | 0,82 |
| *VarLam* | 0,02 | 0,01 | 0,02 | 0,01 | 0,01 | 0,02 |
| *Age class* | **Litter Size** | | | | | |
| *(0,1]* | 3,83 | 4,42 | 4,65 | 3,39 | 4,52 | 4,00 |
| *(1,2]* | 4,23 | 4,83 | 5,06 | 3,80 | 4,93 | 4,40 |
| *(2,5]* | 4,35 | 4,94 | 5,17 | 3,91 | 5,04 | 4,52 |
| *(5,10]* | 2,89 | 3,48 | 3,71 | 2,45 | 3,58 | 3,06 |
| *Age class* | **Probability of breeding** | | | | | |
| *(0,1]* | 0,73 | 0,95 | 0,83 | 0,76 | 0,98 | 0,86 |
| *(1,5]* | 0,91 | 0,99 | 0,94 | 0,92 | 0,99 | 0,96 |
| *(5,10]* | 1,00 | 1,00 | 1,00 | 1,00 | 1,00 | 1,00 |
| *Age class* | **Survival rate with X0F** | | | | | Average |
| *Juveniles* | 0,25 | 0,17 | 0,33 | 0,18 | 0,21 | 0,24 |
| *Adults* | 0,57 | 0,41 | 0,66 | 0,21 | 0,33 | 0,41 |
| *SD\_S0* | 0,06 | 0,05 | 0,06 | 0,03 | 0,04 | 0,06 |
| *SD\_SA* | 0,13 | 0,11 | 0,15 | 0,04 | 0,08 | 0,11 |
| *Age class* | **Survival rate with X0T** | | | | | Average |
| *Juveniles* | 0,22 | 0,15 | 0,32 | 0,19 | 0,19 | 0,23 |
| *Adults* | 0,55 | 0,43 | 0,70 | 0,22 | 0,28 | 0,41 |
| *SD\_S0* | 0,05 | 0,04 | 0,06 | 0,03 | 0,04 | 0,06 |
| *SD\_SA* | 0,13 | 0,11 | 0,16 | 0,04 | 0,07 | 0,11 |

There are no real differences between the two kind of juvenile survival estimates!



Two age classes:

