SL Mathematical Studies Project

An investigation into the growth of Red Kite populations in Wales.

Introduction:

The Red Kite (Milvus Milvus) is a species of raptor native to the British Isles. It was saved from national extinction by one of the world's longest running protection programmes, and there are now 430 breeding pairs in Britain. The Kite is unmistakeable, with its reddish- brown body, angled wings and deeply forked wings, and is becoming a more common sight in parts of England, Scotland and Wales. Its favoured habitats tend to be deciduous woodland with farmland or grassland nearby; this habitat suits its feeding patterns as it feeds mostly on carrion, worms and small mammals.

Red kite adult:

Photo removed for copyright reasons

In this project I will be looking at the population of Red Kites in Wales over the last forty years, I will then attempt to construct a mathematical model for future population growth. I feel that as a project it will be constructive, as I believe that the need to create awareness for conservation is becoming more important in the world.

A1

Hypothesis:

Once I have my mathematical model, I will predict the populations from 1994 – 99, the model should be able to predict the expected population for those years, which I can then compare to the observed populations. If this is successful, I will predict future populations of Red Kites in Wales from 2000- 2010. I hypothesise that the population will grow exponentially, and that there will be over a thousand adults in Wales alone by 2010.

Data Collection:

In order to analyse the population patterns of the Kites, I must first gather the necessary data. I need the to collect the observed populations over the last four decades. Useful information sources would be the RSPB (Royal Society for the Protection of Birds) and the Hawk Conservancy Trust.

The data I have collected for the years 1951- 93 has come from a university assignment[1] which deals with the Kites' breeding productivity, but the data that is

[1] http://www.ma.hw.ac.uk/~roger/f73sj2/CDA_Project2_2003.pdf

B2

provided is ideal for this project also. The population data for the years 1989- 99 came from the Welsh Kite Society's revised population figures for those years.[2]

Population data for red kites in Wales, 1951-93

year	adults	chicks
1951	31	9
1952	31	7
1953	29	11
1954	31	13
1955	28	1
1956	25	7
1957	26	8
1958	32	5
1959	28	8
1960	25	10
1961	33	6
1962	37	7
1963	38	4
1964	41	7
1965	44	11
1966	45	11
1967	48	11
1968	55	12
1969	58	16
1970	60	17
1971	59	16
1972	67	19

year	adults	chicks
1973	76	14
1974	78	13
1975	75	24
1976	80	18
1977	89	17
1978	94	22
1979	105	19
1980	106	27
1981	118	21
1982	117	23
1983	108	24
1984	131	24
1985	139	25
1986	140	29
1987	158	39
1988	178	39
1989	202	50
1990	227	74
1991	260	62
1992	294	96
1993	314	80

This table gives the population data for the years 1951- 93, and gives data for both the total number of adults, and the number of chicks (i.e. chicks that were reared and survived) for a particular year.

RED KITES IN WALES: revised population table.

Year	Breeding pairs	Other pairs	Total pairs	Unmated birds	Successful pairs	Young reared	Total April	Total August
1989	54	18	72	58	33	50	202	242
1990	65	20	85	57	47	74	227	296
1991	76	16	92	76	41	62	260	318
1992	84	17	101	92	60	96	294	386
1993	104	11	115	88	61	82	318	397
1994	111	27	138	94	70	99	370	469
1995	127	19	146	106	79	117	398	514
1996	130	31	161	122	90	119	444	556
1997	152	28	180	135	99	129	495	618
1998	167	33	200	132	112	174	536	700
1999	181	47	228	155	118	165	610	766

[2] http://www.gigrin.co.uk/latestkitenos.htm

F2

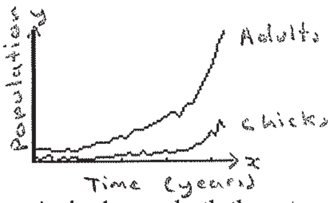
This table gives the population data for the years 1989- 99. As is clear, there is common data between the two tables; this proves that the data is accurate and reliable as the results are identical for the overlapping years.

C1

Data processing:

To observe the trend in the kite populations, a graph must be constructed from the data. This will show whether the growth is linear or exponential. I would expect the graph to show an exponential increase in the kite population, because as the kites spread out and find new habitat, there are more breeding adults available.

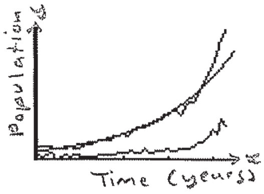
Graph for Red Kite population and number of chicks per year (1951-93):



As is shown, both the rates of population growth and number of chicks are exponential. This suggests that the conservation program was indeed successful in boosting populations in Wales. The population appears to vary from the years 1951-82 with sharp but small climbs and declines; the same is true for chick numbers. From 1984 onwards, the population seems to stabilise as adults become more productive.

The adult population graph can be compared to an exponential curve, a good method to see this is to perform an exponential regression on the graphical calculator.

Exponential regression on the adult population graph:



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The curve fits the graph very well up to a point, with a strong correlation coefficient of .959. The value of b = 1.0596 which suggests an annual population growth rate of approximately 6%. The equation of the curve is:

G1

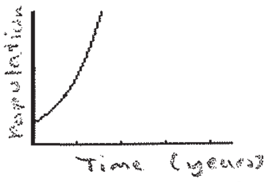
y = 1.077481024 x 1.05963188 ^ x

If we analyse the exponential growth, we see that Δ y does not change at a very high rate as the x value increases. For example, between x = 57, x = 68 the Δy = 24.

G1

However, the line of regression does not fit the graph after the x value of 32 (1982), therefore I must isolate that section of the graph and perform a separate exponential regression for that portion of data.

Exponential regression for x values 36- 43:



This line of regression again fits very well with a correlation coefficient of .995. Therefore it will be the curve I will use to prove my hypothesis. The equation for this graph is:

y = 0.0170546811 x 1.111351958 ∧ x

G1

The values for Δy are far higher here, which shows the sudden increase in population growth.

D2

Data Analysis:

Now that I have graphs to represent the data, I can interpret the population behaviour of the Kites by analysing the graphs and using information regarding the conservation program and natural events that influenced population growth.

As the graph tells us, there is a steady exponential growth in Kite population up until 1982, whereby we see a small yet sharp decline, and then a massive increase in the rate of population growth. This is explainable, as there are many events that influenced the welfare of Kites during this period. Certain toxic pesticides were widely used up to the early 1980's; these toxins were ingested by the kite's prey, which resulted in the deaths of many adults. Also, the adult kites were not breeding productively. Adults showed unwillingness to move far away from their own rearing site. This meant that kites did not spread the way that conservationists had predicted. The number of adults for a year may have been high, but the number of breeding adults remained low due to the kites not spreading. This obviously resulted in fewer chicks. However, once the harmful pesticides were outlawed, greater numbers of adults survived. This started a cycle of breeding productivity that rapidly boosted the population growth rate.

The graph of chicks per year follows a similar pattern as that of the graph of adults. It is somewhat more erratic, but it shows a similar trend. At first there are relatively few young reared, and after around 1984 the rate of chicks per year also increases. The reason that the change takes place in 1984 and not 1982 is that kites take around two winters to reach breeding maturity. So the chicks reared in 1984 were born to adults born in 1982. So it is less to due the number of adults in 1982, rather it is due to the increased breeding productivity of adults born in that year.

Predictions:

Now that I have the curve with which I will make my predictions, I can begin the process of judging its accuracy. A good way to do this would be to compare the expected values for populations between 1994– 99 with the observed populations for those years. This will be given by the *r* value in the exponential regression.

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Expected and observed population values, 1994- 99:

Year	94	95	96	97	98	99
Adults (Exp)	364.39	410.21	461.8	519.86	585.23	658.82
Adults (Obs April)	370	398	444	495	536	610

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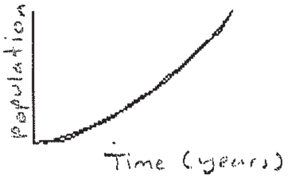
An effective approach would be to take a larger sample of the data, say from 1984- 99 and predict future population growth from this instead, having obtained a line of exponential regression.

Exponential regression for graph of populations 1984- 99:



Again the fit is good with a correlation coefficient of .995. The equation of the curve is:

G1

y = 0.0136006669 x 1.11425474 ^ x

D2

This curve seems to be sufficiently representative of the population growth as to enable me to use it to predict future population growth. A sample prediction of ten years would be appropriate. Also, the values for Δy are regular at defined intervals of 5 of the x axis, this indicates stable and steady growth.

Prediction of Red Kite populations in Wales for the years 2000- 2010 (rounded to nearest whole number):

Year	Expected adult population
2000	679
2001	757
2002	843
2003	940
2004	1047
2005	1167
2006	1300
2007	1448
2008	1614
2009	1798
2010	2004

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The final prediction for the kite population in 2010 is 2004 adult Red Kites, more than double the population ten years previously.

Conclusion:

Through my investigation of Red Kite populations in Wales, I have been able to predict future populations of adults. Hopefully, my predictions will prove correct, as this means that the Red Kite is well on the way to becoming firmly established across Wales and other parts of the United Kingdom. Without serious environmental change or disaster, the kite population should follow a similar pattern to that which I have predicted, which would prove the conservation effort to be a complete success story.

My hypothesis was proved correct; the population has grown exponentially, and the will be over a thousand adults in Wales by 2010.

I feel that this project was thoroughly worthwhile, as the welfare of Welsh Wildlife and conservation are matters that are particularly important to me. This would be an interesting project to apply to other rare species in the UK, as I would seem that many rare species have a good chance of success with the ever-increasing awareness of the need for conservation.