Siberian Brown and Arctic Lemming dynamics in the Russian tundra: an overview of published data.

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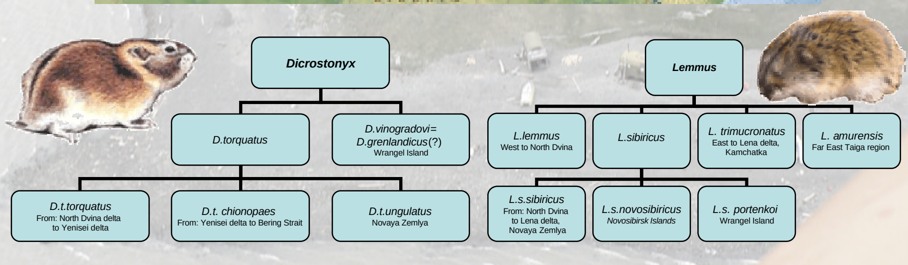
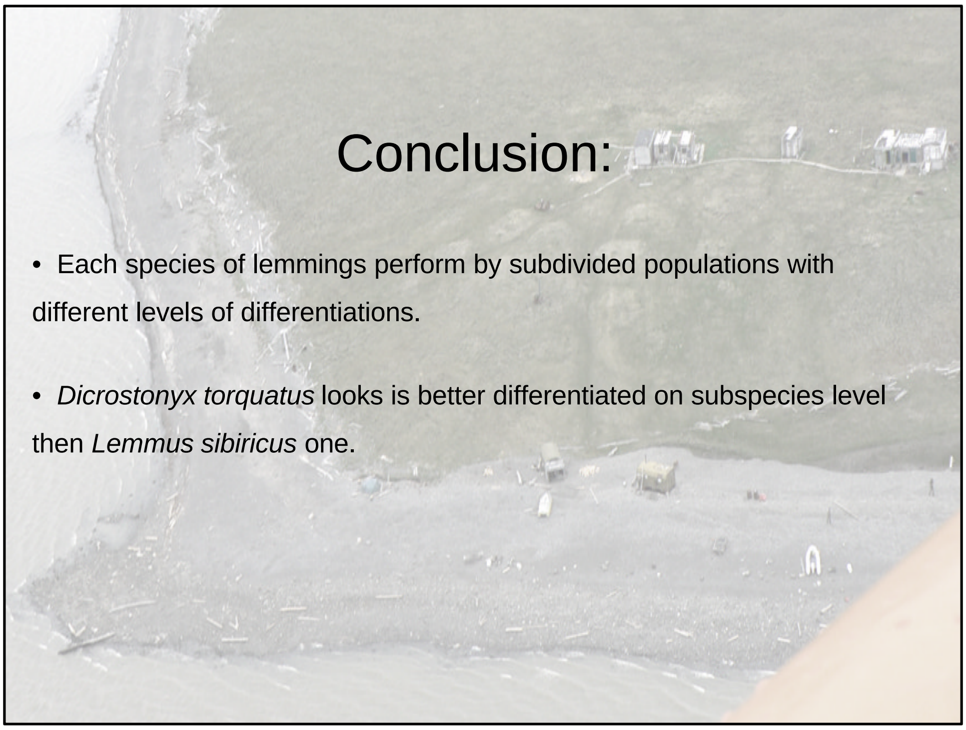
What about this report?

1. First, short overview of systematic and distribution of these lemmings
2. Direct and indirect indicators for years of lemmings peak and peak history reconstruction
3. How to explain lemmings dynamic? Internal and external causes of dynamics

Systematic of Russian Lemmings





Conclusion:

- Each species of lemmings perform by subdivided populations with different levels of differentiations.

- *Dicrostonyx torquatus* looks is better differentiated on subspecies level then *Lemmus sibiricus* one.

Distribution of *L.sibiricus.*

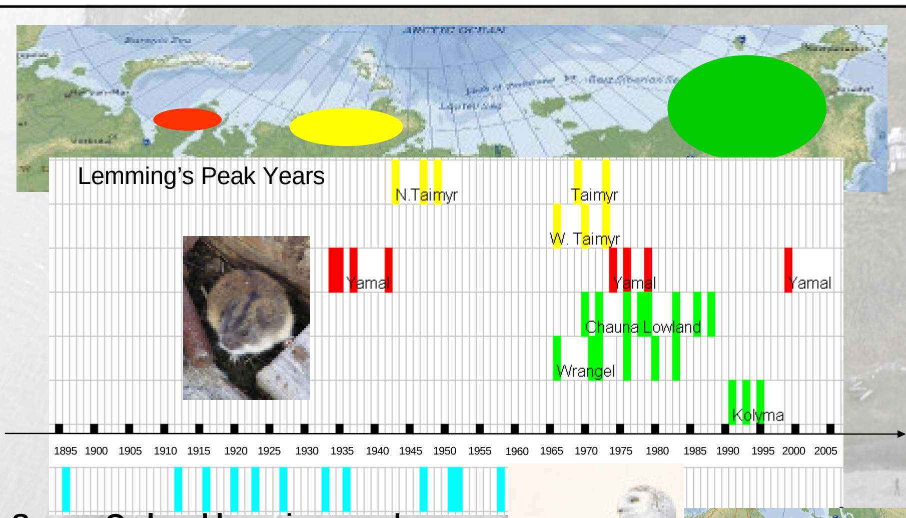
There are only Arctic Lemmings on the north island of Novaya Zemlya and on the Severnaya Zemlya Islands,
BUT
Some of the small Taimyr islands are occupied by only Siberian Brown Lemmings

There is no Lemmings on the Kolguev Island at all

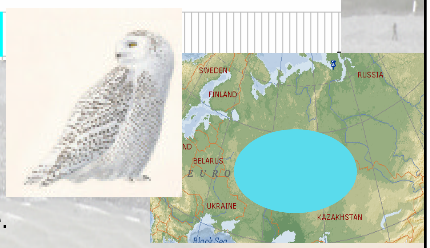
The reconstruction of "lemmings" years

1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975

The years with abundant Snowy Owl migration in Wisconsin are correlate with the lemmings peaks in Alaska. So, Snowy Owls can be indicator of lemming peak year.

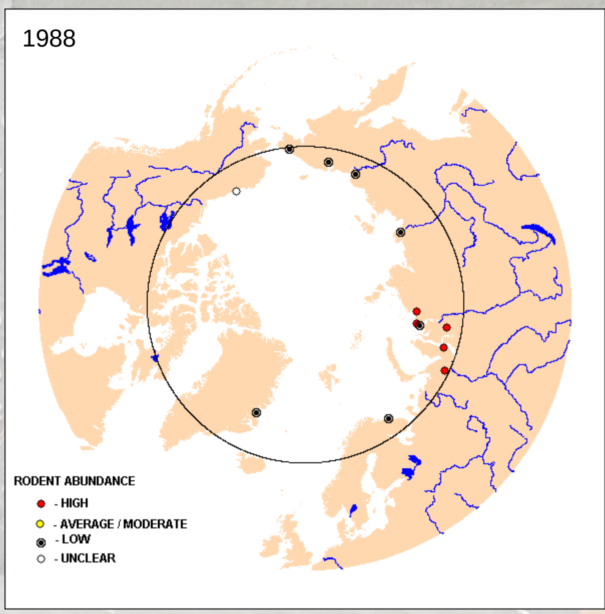


Snowy Owl and lemmings peak years in Palearctic region.



1. There is no synchronization between the regions (green, yellow, red).
2. There is no fixed period of population cycle.

Web site: arcticbirds.ru



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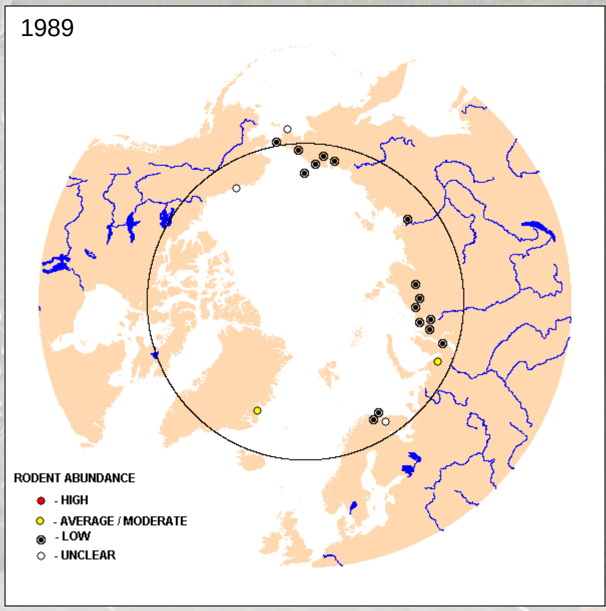

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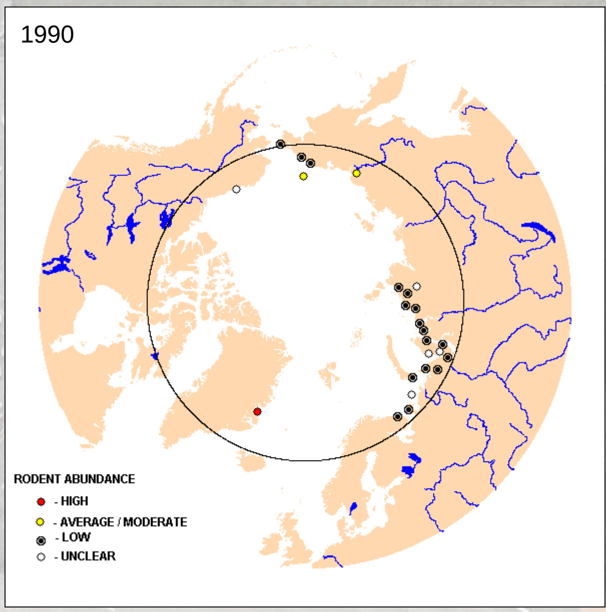

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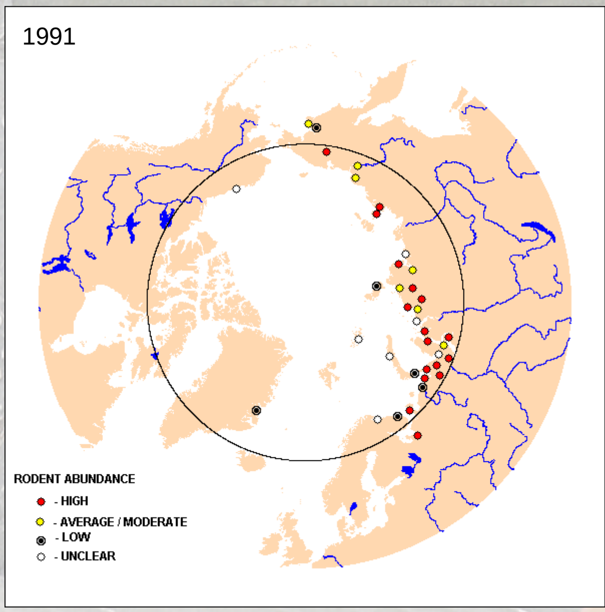

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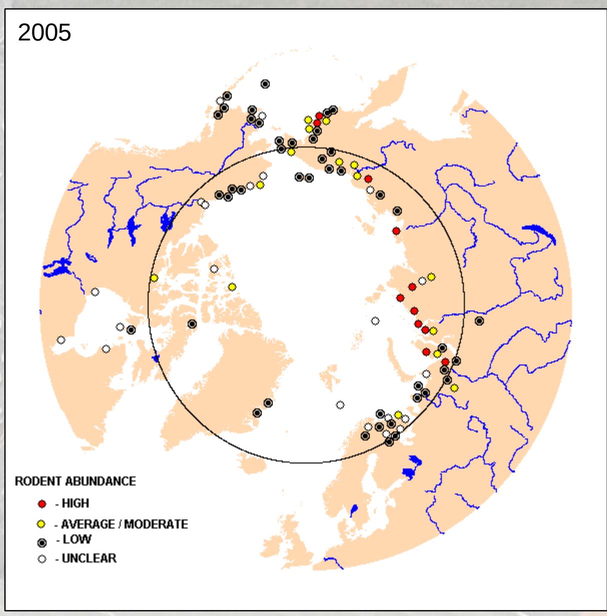
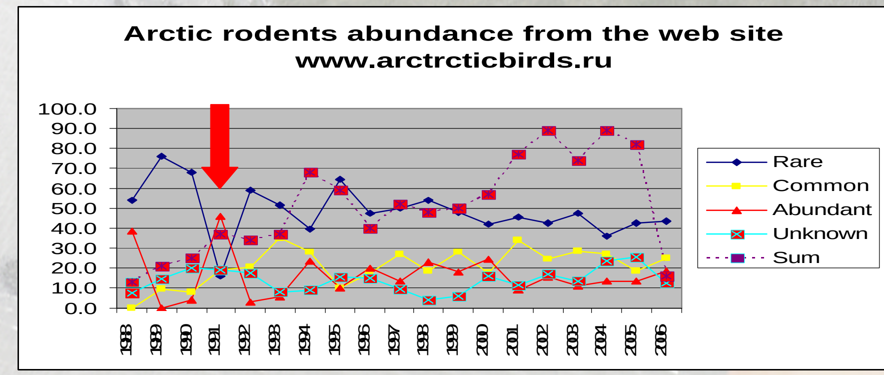


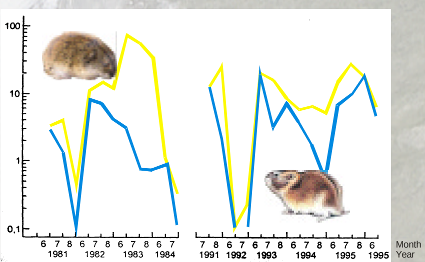
Population dynamics

- There is no synchronization between the regions except the 1991

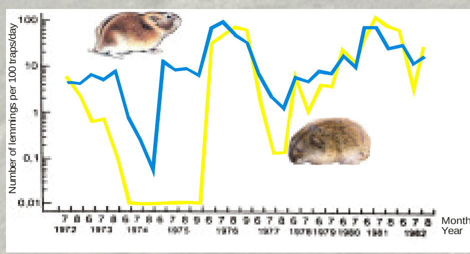
The red arrow shows the last hall Arctic lemming's peak (1991)



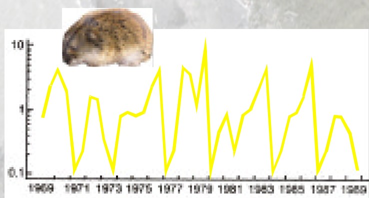
Population dynamics



Population dynamics of *Dicrostonyx torquatus* (blue) and *Lemmus sibiricus* (yellow) on the Kolyma lowland in 1981 - 1995.



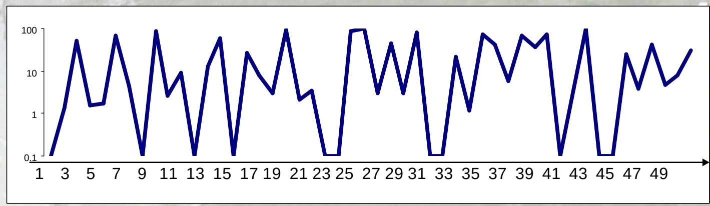
Population dynamics of *Dicrostonyx torquatus* (blue) and *Lemmus sibiricus* (yellow) on the Wrangel Island in 1972 - 1982.

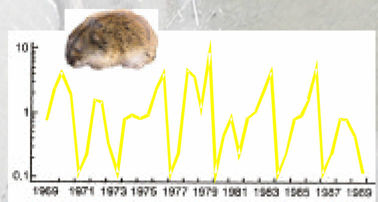


Population dynamics *Lemmus sibiricus = L. trimucronatus* on the Chauna lowland in 1969 - 1989.

- The maximal amplitude is 600 times for *L.sibiricus* and 200 times for *D.torquatus* in Arctic tundra and 30 and 5 times for south tundra correspondingly
- The maximal density is 1500 lemmings per ha in arctic and 90 (12) in south tundra for *Lemus (Dicrostonix)*
- There are 3 to 4 years between the peaks
- Peaks of both species usually are coincide

Population dynamics





Population dynamics *Lemmus sibiricus = L. trimucronatus* on the Chauna lowland in 1969 - 1989.

The upper figure is constructed as follows. On each time step (year) the random number from 0 up to 100 was generated. Then, with probability 0.5 it turned in 1 (there was a catastrophe caused by external circumstances, "weather", for example). Have received «population size dynamics» with the average period of 4.27 years …

Is there clean differences?

Conclusion

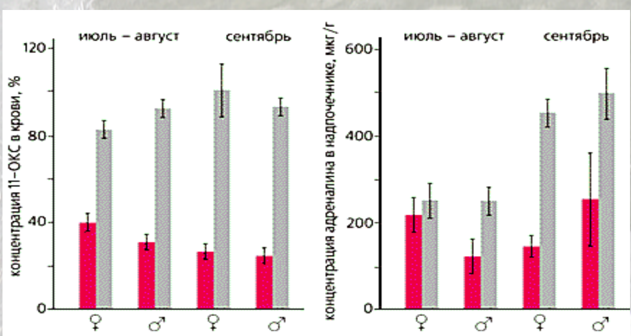
1. There are different amplitude and period of fluctuation from region to region in lemmings populations
2. There is tendency to have higher amplitude in north population then in south ones
3. The amplitude of population dynamic is higher in *L. sibiricus* then in *D. torquatus*
4. Period of fluctuation is bigger in *D. torquatus* then in *L. sibiricus* ones
5. There is no clear period in population cycle.
   The realistic average 4 years cycle can be generated by random sequences

Demography

- Winter under snow breeding (1-2 generations in January – April) is the cause of population grows. Another words balance of breeding-death rate is positive
- The balance in summer time – always negative. Population during the summer – decreasing in spite of 2-3 summer generations
- Brood size and number of generations are correlate with population phase: maximal during population grows and minimal during population decreasing
- Death-rate is minimal during population grows and maximal during population decreasing

Physiology

- Hormones concentration and morphology of endocrine glands indicate a strong stress development in peak phase.



Oxi-corticosteroid (in blood) and adrenalin (in Adrenals) concentration in *D.torquatus* of Wrangel Island in 1975 (red columns, depression year) and 1976 (gray columns, peak year)

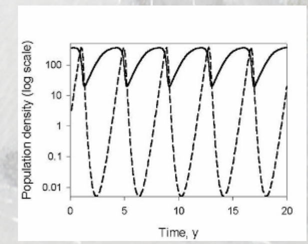
Mechanisms of population dynamics

Lemmings are "predators"

For: Lemming destroyed up to 70% of phytomass in some places during the peak years (????? ????, 1955; ??? ???, 1977; ???? ? ????, 1979 ? ??.)

Against:

- next year after peak vegetation regenerate very quickly (? ????????? ? ??., 1981);
- there are many places without visible depletion of phytomass in the peak year
- The shape of dynamics curve also not look like predators are (dotted line) (Turchin, 2004)



Conclusion:

It seems that at least in some cases our lemming cycles are not driven by predator type interaction

Mechanisms of population dynamics

Lemmings are prey

For:

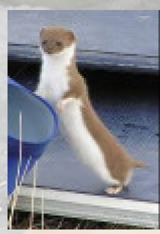
• There are many lemmings are killed by predator in the peak year. See picture

• There are some predators (mustelids), which can theoretically drive the lemming cycle.

Against:

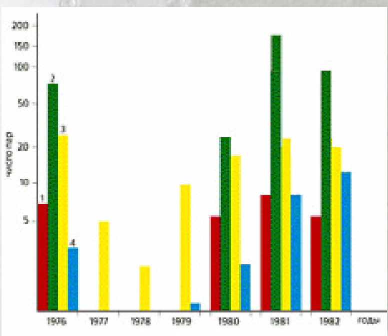
Normally the part of population eaten by predators in snow-free period are not exceed the 20% of population.

There are some territory (for instance, Wrangel Island) where no mustelids at all, but lemmings still cycling.

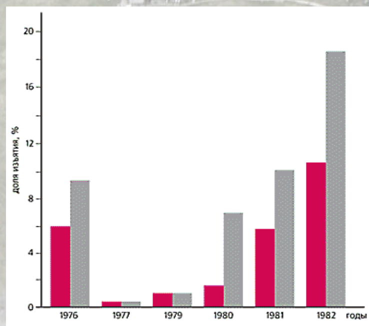


Mechanisms of population dynamics

Lemmings are prey



Number of predators breeding pairs on 60 sq.km testing plot in Wrangel Island
1 – Snowy Owl (red)
2 – Pomarine Skua (green)
3 – Longtail Skua (yellow)
4 – Polar Fox (blue)



Percents of lemmings killed by predators on the Wrangel Island. Red – *L.sibiricus*, grey – *D. torquatus* (??????????, 2002)

Conclusion:

It seems that predators play not the key role in lemming cycles

Mechanisms of population dynamics

Conclusions

✍ There is no evidence on external factors priority in lemming cycle driving

That is prey-predator systems and impact disturbances as a causes of population crash

✍ Demography and physiology data give us suggestions about importance role of intrinsic mechanisms for population cycle driving

The models of lemming dynamics

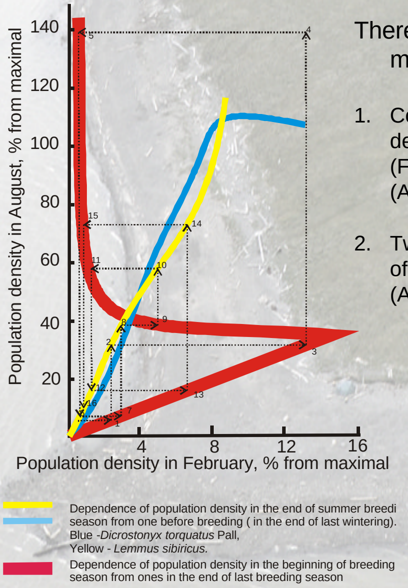
All the next models use idea about density dependence of populations parameters such as

- •pubescence time,
- •brood size,
- •mating delay,
- •death rate

Model 2 explore spacing behavior as important side of population dynamic
All 3 models produce the 2-5 year cycles more or less similar with the natural ones.

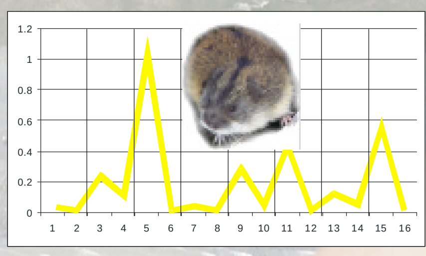
1. Orlov V.A., Sarancha D.A., Shelepova O.A. Mathematic model of lemmings population size (Lemmus, Dicrostonyx) and its using for West Taimyr population description // "Ecology", 1986. No.2. pp 43-51
2. Sorokin P.A. Individual based biological population modeling // Electronic journal "Researched in Russia", 2002. http://zhurnal.ape.relarn.ru/articles/2002/103.pdf
3. Orlov V.A., Benenson I.E., Zav'alova S.V., Obrydko I.V., Shelepova O.A., Sarancha D.A. About the lemmings population modeling // Dokl. MOIP, MGU, 1985 pp 63-65

DISCRETE MAPS MODEL as a perspective approach to predict of impact free population dynamics



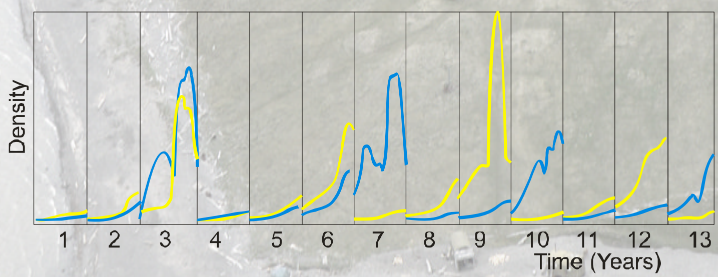
There are 3 function of population density (from the model 1):

1. Common for both species dependence population density in the beginning of current breeding season (February) from density in the end of previous one (August)
2. Two curves for individual species indicate dependence of population density in the end of breeding season (August) from one in the beginning (February)



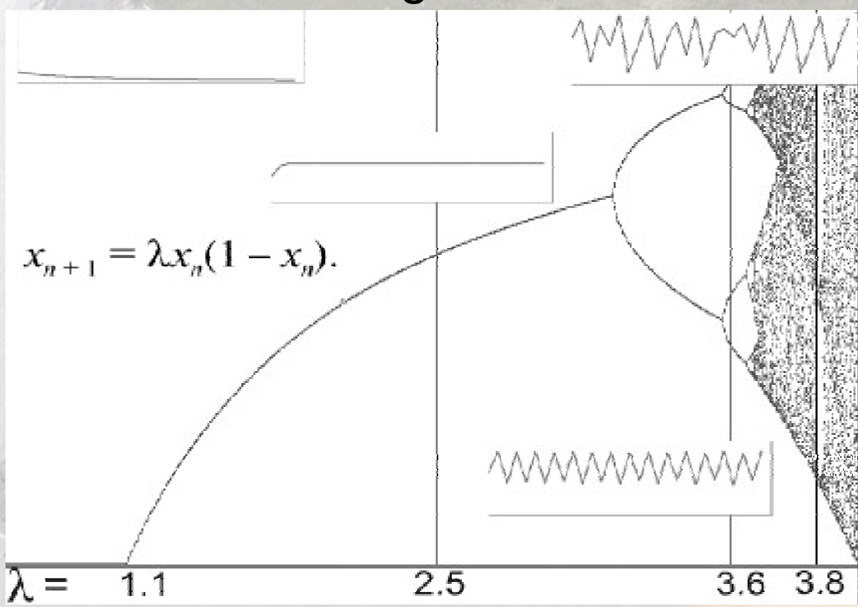
Example of *Lemmus sibiricus* dynamics according to first return functions

Result of lemmings cycle modeling



Artificial dynamic of *Dicrostonix torquatus* (blue) and *Lemmus sybiricus* as a result of modeling

The discrete logistic function



General Conclusions

- Logistic function shows a different type of population dynamics: fix point, periodic oscillations and chaos. So, population dynamics can be simply result of this.
- We should assume, that default condition (H0-hypotesis) for the fast breeders like small mammalian is population cycle or chaotic fluctuation of population size.
- The only way to predict population size for the short perspective is to construct a discrete maps on the empirical basis. So, WE NEED MORE GOOD EMPIRICAL DATA.
- Long term prediction (4-and more years forward) is a vain time