Ecoregional Climate Change and Biodiversity Decline

Altai-Sayan Ecoregion

Climate Passport of the Ecoregion

issue 1
A great system of mountain ranges and valleys are situated in the very center of Eurasia, where two of the largest rivers in the world, the Ob’ and the Yenisei, originate. It is the natural “inner core” of Eurasia and the motherland of many peoples.

Altai-Sayan mountain country is included in WWF’s “Global 200”-a list of virgin or little changed ecoregions in the world, where more than 90% of the planet’s biodiversity is concentrated. The floral and faunal diversity of Altai-Sayan is especially unique for temperate latitudes. Large mammals the Snow Leopard (Irbis) and the Altai Mountain Sheep, Argali, are endangered species of the region.

The Altai-Sayan ecoregion occupies nearly 1065,000 sq. km., 2,000 km from east to west, and 1,500 km from north to south. About 62% is located in Russia, 29% in Mongolia, 5% in Kazakhstan, and 4% in China. The region includes the mountain systems of Altai, Sayan and vast intermountain basins, and its highest peak is Belukha Mount (4506 m) in Altai.

The Altai-Sayan mountain country expects climate changes almost as strong as in the Arctic zone and much stronger than in the average in the temperate latitudes of the Northern Hemisphere. Catastrophic floods caused by the sudden melting of snow, serve as a vivid illustration of such changes, such as occurred in Tyva in 2001.

Since 1998, WWF is implementing a project for long-term conservation of biodiversity in the ecoregion, and starting in 2001, it includes climatic component. The creation of an “ecological network” of protected areas was one of the main tasks. A basic framework for the system has been developed by WWF experts, including 86 existing and 119 new areas with total area of 19.5 million hectares. Four protected areas of 850 thousand hectares have already established under WWF support. A Russian national strategy and action plan for Mongolia in the conservation of Irbis and Argali have been developed.
WWF has established a very timely, ambitious, but very difficult target to prepare and begin implementation of climate adaptation strategies and action plans for 50 countries and ecoregions in the world by the year 2010. Unfortunately it is clear that the Altai-Sayan ecoregion will be included in the 50 most vulnerable regions demanding assistance. Development and implementation of the “action plans on climate change” demand thorough developmental work. The preparation of the given climate brochure is the first step in this way. The preparation of similar brochures for all ecoregions is suggested. Their role is to attract the attention of authorities, ecologists, and general public to climate changes in the region, danger to ecosystems, and point out the first recommendations aimed at prevention or, at least, reduce a damage.

Two years ago the WWF “Altai-Sayan Millennium Initiative” was drawn up and adopted, proclaiming new solution principles for global ecological problems. The heads of all Russian, Mongolian, and Kazakhstan regions signed the Initiative and confirmed willingness to prioritise natural resource conservation among economic development. Such an approach should also be used for the solution of climate change problems in regions responsible for Earth’s biodiversity conservation.

Igor Chestin
Director, WWF Russia
Climate, weather and seasonal changes are principle determinants of life in any ecosystem. Although weather can be thought of as a manifestation of the climate at any given moment, the term “climate” is understood to be a combination of many parameters for an extended period of time: average, maximum and minimum temperatures; air humidity; wind speed; precipitation; hydrological phenomena, etc. The World Meteorological Organisation (WMO) recommends using the 30-year period from 1961 to 1990 to characterise the modern climate, by calculating climate changes from the average values observed during these years. The absolute values of the currently observed changes have been registered more than once in the past. However, it is the very fast rate at which these changes are taking place that is unique, and it is this rate which poses the gravest danger. The problem is that biological communities will not have enough time to adapt or to migrate, and thus, unfortunately, will suffer the most dramatic of consequences.

The climate of the Altai-Sayan region is determined by its location in the very center of the Asian continent, and the peculiarities of atmospheric circulation and relief. Due to the remoteness from oceans, the climate can be considered sharply continental, especially in the southern part. The characteristic feature of the region is the western “transfer” – the wind that dominates the entire year at a height of 1000-2000 meters. A relief

### Average climate parameters of the region in 1961–1990

<table>
<thead>
<tr>
<th>Station</th>
<th>Month/Year</th>
<th>Air Temperature, °C</th>
<th>Mean</th>
<th>Average maximum</th>
<th>Average minimum</th>
<th>Absolute maximum</th>
<th>Absolute minimum</th>
<th>Relative humidity (%)</th>
<th>Precipitation amount, mm</th>
<th>Mean wind speed, m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiselyovsk</td>
<td>I</td>
<td>−17.2</td>
<td>−12.6</td>
<td>−21.1</td>
<td>4</td>
<td>−50</td>
<td>77</td>
<td>17</td>
<td>3.4</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>18.8</td>
<td>24.9</td>
<td>13.0</td>
<td>38</td>
<td>2</td>
<td>70</td>
<td>15</td>
<td>2.7</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>6.9</td>
<td>6.4</td>
<td>−3.9</td>
<td>38</td>
<td>−50</td>
<td>71</td>
<td>436</td>
<td>3.5</td>
<td>7.9</td>
</tr>
<tr>
<td>Nenadnaya</td>
<td>I</td>
<td>−15.6</td>
<td>−12.2</td>
<td>−19.0</td>
<td>6</td>
<td>−39</td>
<td>74</td>
<td>118</td>
<td>2.7</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>13.3</td>
<td>18.3</td>
<td>9.8</td>
<td>30</td>
<td>−1</td>
<td>77</td>
<td>133</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>−2.6</td>
<td>1.6</td>
<td>−6.0</td>
<td>30</td>
<td>−42</td>
<td>74</td>
<td>1507</td>
<td>5.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Chemal</td>
<td>I</td>
<td>−12.4</td>
<td>−7.4</td>
<td>−17.0</td>
<td>15</td>
<td>−42</td>
<td>63</td>
<td>9</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>18.1</td>
<td>25.8</td>
<td>12.1</td>
<td>39</td>
<td>3</td>
<td>72</td>
<td>105</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>−3.3</td>
<td>10.4</td>
<td>−2.4</td>
<td>39</td>
<td>−42</td>
<td>65</td>
<td>529</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Olenya Rechka</td>
<td>I</td>
<td>−19.2</td>
<td>−16.1</td>
<td>−21.4</td>
<td>−2</td>
<td>−41</td>
<td>74</td>
<td>53</td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>12.3</td>
<td>17.6</td>
<td>7.8</td>
<td>29</td>
<td>−3</td>
<td>76</td>
<td>191</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>−3.6</td>
<td>0.9</td>
<td>−7.2</td>
<td>38</td>
<td>−41</td>
<td>74</td>
<td>1227</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Kyzyl</td>
<td>I</td>
<td>−32.1</td>
<td>−26.1</td>
<td>−37.0</td>
<td>−6</td>
<td>−53</td>
<td>74</td>
<td>10</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>19.6</td>
<td>26.9</td>
<td>13.2</td>
<td>38</td>
<td>3</td>
<td>57</td>
<td>92</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>−3.4</td>
<td>3.5</td>
<td>−9.6</td>
<td>38</td>
<td>−54</td>
<td>64</td>
<td>228</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Orlik</td>
<td>I</td>
<td>−24.4</td>
<td>−16.9</td>
<td>−30.2</td>
<td>0</td>
<td>−46</td>
<td>73</td>
<td>2</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>13.1</td>
<td>21.5</td>
<td>5.8</td>
<td>33</td>
<td>−4</td>
<td>73</td>
<td>92</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>−5.1</td>
<td>3.2</td>
<td>−12.1</td>
<td>33</td>
<td>−48</td>
<td>67</td>
<td>325</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Iriutsk</td>
<td>I</td>
<td>−20.6</td>
<td>−15.0</td>
<td>−25.5</td>
<td>2</td>
<td>−50</td>
<td>84</td>
<td>14</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>17.6</td>
<td>24.7</td>
<td>11.3</td>
<td>36</td>
<td>0</td>
<td>74</td>
<td>101</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>−0.9</td>
<td>5.8</td>
<td>−6.9</td>
<td>36</td>
<td>−50</td>
<td>72</td>
<td>466</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Ulaangom</td>
<td>I</td>
<td>−32.3</td>
<td>−26.9</td>
<td>−37</td>
<td>−12</td>
<td>−49.6</td>
<td>75</td>
<td>1.9</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>19.5</td>
<td>25.4</td>
<td>12.2</td>
<td>33.7</td>
<td>0.4</td>
<td>56</td>
<td>37.7</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>−3.6</td>
<td>2.9</td>
<td>−9.7</td>
<td>36.4</td>
<td>−49.6</td>
<td>64</td>
<td>138.4</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Bayan Ulgii</td>
<td>I</td>
<td>−17.2</td>
<td>−10.7</td>
<td>−22.6</td>
<td>4.2</td>
<td>−37.9</td>
<td>71</td>
<td>0.8</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>16.3</td>
<td>22.6</td>
<td>10.7</td>
<td>32.3</td>
<td>0.6</td>
<td>63</td>
<td>34.2</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>0.2</td>
<td>7</td>
<td>−5.7</td>
<td>32</td>
<td>−40.2</td>
<td>61</td>
<td>115.5</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Khovd</td>
<td>I</td>
<td>−24.4</td>
<td>−16.3</td>
<td>−30.2</td>
<td>8.7</td>
<td>−46.6</td>
<td>65</td>
<td>1.5</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>18.5</td>
<td>24.7</td>
<td>12.1</td>
<td>33.4</td>
<td>1.5</td>
<td>58</td>
<td>37.9</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>−0.2</td>
<td>7.1</td>
<td>−6.7</td>
<td>35.6</td>
<td>−46.6</td>
<td>65</td>
<td>127.4</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Renchikilhembe</td>
<td>I</td>
<td>−32.4</td>
<td>−27.7</td>
<td>−37</td>
<td>−6.8</td>
<td>−50.1</td>
<td>80</td>
<td>2.5</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VII</td>
<td>12.6</td>
<td>19.6</td>
<td>5.8</td>
<td>29.3</td>
<td>−2.5</td>
<td>67</td>
<td>78.5</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>−7.8</td>
<td>−0.7</td>
<td>−14.4</td>
<td>30.8</td>
<td>−56.1</td>
<td>71</td>
<td>263.1</td>
<td>1.3</td>
<td></td>
</tr>
</tbody>
</table>
similar to that of the alpine region determines the wide diversity of local climate conditions.

In winter the center of a powerful Asian anticyclone is situated just to the south of the region, which results in cold and particularly prolonged winters with extreme temperature inversions. Thus, the surface air temperature in intermontane depressions is considerably lower than on the mountain slopes. Because of seeping into the southern, Mongolian part of the region. This condition allows for keeping cattle out in the open, and also provide an opportunity for wild ungulates, including the mountain sheep argali, to graze without the exhausting long seasonal migrations. Heavy snowfalls and thaws, which are unfavourable for animals, are also very rare in this area. In winter the average temperature varies from -15 °C to -35 °C, while day and night temperature fluctuations of 20 °C and even 30 °C are common. And due to inversions the temperature in the enclosed mountain depressions can even drop as low as -50 °C. Such heavy cold causes the spread of permafrost in northern Mongolia that is found nowhere else in the world at these latitudes.

As a rule, the winter weather in the northern, Russian part is also cold. And due to inversions, the temperature may even fall to -30 °C in the intermontane depressions. A record low of -60 °C was once registered in the Chuisk steppe. However when the influence of the Asian winter anticyclone and its western “branch” is weakened, the cyclone “bursts” with sudden thaws, and strong winds and intensive snowfalls become more frequent. Accumulation of snow on the leeward slopes of peaks and watersheds along with heavy snow cover (up to 3-5 meters, and in some gorges up
to 10-15 meters) force ungulates and other predatory mammals to migrate. Snowy winters are the most unfavourable climate factor for animals.

In spring as the continent warms up, the Asian anticyclone dwindles. The period beginning in the end of March to the beginning of May is characterized by rather unstable weather, especially in the central and southern parts of the region. It is during this period that a thicker snow cover and ice-crusted ground are most often formed, which tend to severely impede the animals in their acquisition of food. Large temperature fluctuations and storms that bring sand and snow are typical here, especially in the Gobi region, where wind speeds can reach up to 15-25 m/sec. Even in May and sometimes June night frosts are common.

In summer the Front-Asian thermal depression is formed to the south of the region, and more vividly expressed cyclone activity begins. Summer in the mountains is short and cool; in July the average temperature at a height of 1,000 meters usually does not exceed +15 °C. In Mongolia up to 70-80% of annual precipitation falls during the formation of the depression. Autumn is short but is truly the best time of the year, as it is characterized by sunny, dry weather and a gentle breeze. Night frosts start again in September but sometimes occur even in August.

Precipitation levels depend on both the altitude and the direction of the mountain ranges. The east-west direction of the Altai ranges allows the westerly winds to carry the humid air masses deep into the region, and up to the Western Sayan. Moisture condensation on the high ranges has a tendency to cause heavy rain. The largest amount of precipitation (up to 800-1,200 mm, and in some places up to 2,000 mm per year) falls on the western and north-eastern slopes, which face the humid air masses. In summer the north-eastern winds formed over Siberia reinforce the rains on the north-eastern ranges of the Western and Eastern Sayan. However, behind these high ranges an area called the “rain shadow” develops, where precipitation is two or more times less. The annual precipitation amount decreases to 200-300 mm towards the south-eastern part of the ecoregion, especially on the leeward eastern slopes and in the inter-montane flat steppe hollows that are protected by ranges. It is particularly dry in the Chuisk steppe, where precipitation reaches only up to 100 mm per year.

The high mountain areas of the Altai-Sayan region have characteristics typical of high mountain climates: temperature inversions; a greater quantity of precipitation on the mountain peaks than in canyons; high recurrence of strong winds (10-15 m/s and more); and the development of mountain-valley circulation. The winds of this circulation have been termed fans, and refer to the winds that have a relatively high temperature and low humidity, and blow from the mountains to the valleys. Winter fans reduce the effects of harsh conditions, and in enclosed basins in summer, fans can raise air temperatures considerably. In several places in Sayan, temperatures can reach as much as +40 °C, due to summer fans.

However, strong winter winds are also correlated with the accumulation of snow on the leeward slopes of mountain ranges. It is interesting to note that, under the influence of these winds, the trees on the uppermost edge of the forest often have peculiar “skirt” crowns.

Temperature inversions occur on the high mountains even in summer. In particular, in August this can result in the frequency of frosts in the valleys being greater than the number occurring in the mountains. In the mountains, the annual figure of relative humidity is opposite the behaviour that is observed in the valleys. In the high mountain areas, the relative humidity in summer is greater than in winter, and thus the formation of fog and mists is a common occurrence.

Average total solar radiation increases from the north to the south from 20 to 70 W/m² in winter and from 180 to 250-260 W/m² in summer. Typically, in the northern part, more than half of the sky is covered with clouds, while in the southern part, a cloudless sky is more typical. In the Mongolian part of the region the number of sunny days reaches up to 250 per year.
Ten thousand years ago the climate of the Altai-Sayan region was approximately 10 °C colder, though the following five thousand years saw a gradual warming to 1-2 °C warmer than modern-day temperatures. Steppe and forest-steppe landscapes dominated the middle mountain zone, and coniferous taiga dominated the high mountain zone. The forest borderline was 300-400 meters higher than at present. About 4-4.5 thousand years ago the climate became a little colder. And the silver fir that dominated the topmost border of the forest in the warming period gave place to the cedar.

In the medieval optimum (800-1300 years ago) the highest border of the forest on the North-Chuisk range, for example, was 50-60 meters higher than it is today. The average annual temperatures were higher than the modern ones, though precipitation levels were actually much closer to present levels. In the small glacial period (17th-18th centuries) the temperature was 2 °C colder than at present, and the topmost forest border was 100-120 meters lower, as the glacial area was widening. However, its reduction then began, and by the middle of the 20th century glaciers constituted 15-35% of former area.

On the whole, an analysis of paleoclimatic data indicates that we live in an interglacial period. Natural cooling is taking place at a rate of approximately 0.02 °C every 100 years, which, by comparison, is 10-100 times slower than the warming that results from anthropogenic causes. It is evident that the speed of natural changes is so much lower that this nature impact can only be considered significant on a scale of several thousand years.

In the 20th century the average surface air temperature on a global scale has increased by approximately 0.6 °C. At first glance this change seems to be relatively insignificant, especially considering that the uncertainty is 0.2 °C. However, these changes are very heterogeneous in time and space and carry with them a number of indirect local impacts, such as floods, droughts, rapid thaws, etc. Therefore an analysis of regional changes is both extremely important and very timely. The amount of warming that has taken place in the 20th century has proven to be greater than at any other time in the recent millenium. It was determined that the 1990s were the warmest years, and the year of 1998 was marked as the warmest year of the entire millennium.

During the 20th century the length of the ice cover period on rivers and lakes of the middle and high latitudes in the Northern Hemisphere decreased by approximately two weeks. In the second half of the 20th century the recurrence of extremely low temperatures decreased, while on the contrary the extremely high temperatures
were observed more frequently. Starting in the 1950s, in many regions of middle and high latitudes, warming has already led to a lengthening of the frost-free period. Satellite data demonstrates that since the end of the 1960s the total snow covered area on the Earth has decreased by nearly 10%. An overall retreat of mountain glaciers has also been registered, in particular, in the Altai-Sayan mountain region.

In most regions of the high and middle latitudes in the Northern Hemisphere the amount of atmospheric precipitation has increased by 0.5-1% per decade. Also, in the second half of the century heavy precipitation occurred much more frequently, causing considerable damage. Though there may not have been an overall tendency for heavy droughts or periods of extreme humidity on a broad scale from 1900 to 1995, nevertheless in some regions of Asia and Africa in the 1990s there was a significant increase in the periodicity and intensity of droughts.

There were particular changes in the climate that occurred in the Altai-Sayan region. In general, they can be judged by the average indices of the entire region. During the last century the change in surface air temperature for January in the ecoregion amounted to approximately 3-4 °C. This means that the warming that occurred in winter was 6 times higher as compared with the warming that occurred on a global basis, while summer temperatures increased insignificantly. On the other hand, the number of days with frosts in summer decreased, particularly in the second half of the century.

In the Mongolian portion of the ecoregion the average air temperature increased in the last 60 years by approximately 1.5 °C. During the same time the mountains of western and northern Mongolia saw winter warming that was much stronger than the warming in the steppe and the Gobi Desert. The maximum increase registered for winter temperature amounted to 3.6 °C, while for summer months no warming was registered at all.

Yet another noteworthy change is the decrease in amplitude of day and night air temperature in the ecoregion. To a certain extent this fact can be considered an indicator of the softening of the continental characteristics of the climate.

The amount of total annual precipitation has remained practically the same. It should be noted that the time series of precipitation contains some sort of disturbance in uniformity, which can be explained by changes in observational instruments and methods in Russia. In Mongolia from the 1940s to the 1980s the annual precipitation decreased, though an opposite tendency was observed following that decrease, excepting the Gobi Desert region. Changes in cloud cover and wind speed in winter and summer were not registered. Winters with increased air humidity dominated in the recent decades, and since the 1970s a certain increase in humidity has also been observed in summer.

On many rivers, changes in the start times of ice drifting have been especially obvious. In particular, on the Yenisei River and its tributaries (Abakan, Tuba) the average shift has been 1-2 days per decade since the 1920s. This phenomenon is a direct consequence of warming during the spring months. However, the time of the autumn freezing-over of rivers also demonstrates a similar tendency, representing a general shift toward the earlier freezing-over of rivers, and the earlier melting of the ice in spring. Thus, the period between freezing-over and ice drifting remains practically unchanged. Observations of glaciers also indicate an overall reduction of their total area. Visual observations indicate a strengthening in thermokarst processes.
As clearly seen from the above data, the climate has, undeniably, been changing. However, in order to configure a prognosis, it is first necessary to determine the reasons for the changes, which has proven to be a very difficult task that is far from being solved. The best global prognostic and mathematical models take into account the growth in the concentration of carbon dioxide and other greenhouse gases caused by the burning of fossil fuels and other industrial activities. The change in content of aerosol particles in the atmosphere and a number of other impacts have also been taken into consideration. These models indicate a significant influence of anthropogenic activity on the temperature trends both on the Earth’s surface and in the troposphere, especially during the four last decades. This influence is also combined with a number of other fundamentally important impacts. One of which is the intrinsic instability of the climate system itself. It is understood that the ocean, upon interaction with the atmosphere, could cause long-term fluctuations in the climate system. And thus, on a temporal scale of decades, such fluctuations may well take place without any external influence.

There may also exist other natural reasons for such changes as well, such as the fluctuations in solar radiation intensity or volcanic eruptions.

Model runs have shown that modern models in general are capable of describing the climate structure and its changes during the 20th century. In this, a small amount of warming was determined to be caused by the change of atmospheric transparency, which is a natural external factor, in the first half of the century. While the rapid warming which is being observed nowadays, is mainly connected with an increase in the concentration of carbon dioxide and other greenhouse gases in the atmosphere.

A method of drawing up scenarios for greenhouse gas emissions and their accumulation in the atmosphere is used for assessment of future climatic changes. Several dozens of scenarios have been composed using different variables in population growth and industrial development. Calculations of the expected changes in air temperature in the 21st century are then made for each scenario. Such assessments reveal that the global temperature near the surface of the Earth will likely increase by as much as 1.5-5.8 °C. Such warming has had no precedent in the past ten thousand years. It is necessary to remember that assessments of changes cannot be considered exact prognoses, as it is unknown which of the scenarios of greenhouse gas emissions will really occur. This will be determined by human activity. However it is most likely that something in between the maximum and minimum prognostications will take place.

Our task is to try to assess how these changes may influence the climate of the Altai-Sayan region. It should be mentioned that regional assessments of expected climate changes are far less
defined than the world average. According to one of the best models which was developed at the Hadly Centre for Climate Analysis (UK), rather detailed assessments for an average likely scenario of greenhouse gas emissions into the atmosphere were made.

According to calculations, within the next 50 years the January temperature in most parts of the Altai-Sayan region will increase by 2-3°C, though warming may even be much more pronounced in the western parts. At the western part of West Sayan the temperature increase will be as much as 3-4°C, moreover around the Belukha Mount and on the western spurs of the Altai Range the temperature will likely increase by 4-5°C. According to the Hadly model, the Uvs Nuur Lake region may be a separate area of greater winter warming (by 3-4°C), though it requires more specific research. In the Mongolian part of the ecoregion the increase in average annual temperature may constitute as much as 1.8-2.8°C in just the first quarter of the 21st century. It is, however, possible that winter temperatures will increase by 3°C, while summer temperatures, on the contrary, will change very little. In any case, the warming that is expected in this ecoregion is much larger than what is forecasted for the neighbouring northern, eastern and southern regions.

On the whole, the second quarter of the century may see warming that is twice as fast as the warming in the first quarter. At the same time, increased precipitation by 20-40% is also very possible, especially during winters in the western part of the region. However, according to some global models this increase will also be replaced by a corresponding decrease in another part of the territory.

All prognoses predict an intense glacial melt and subsequent retreat up into the mountains. Within the next 50 years it is predicted that the total area covered by glaciers in the temperate latitudes of the Asian continent will decrease by 25%. It is not yet clear how intensive the melting in the Altai-Sayan ecoregion will be, but all the data indicate that the process will be very rapid and that the high mountain nature zone may, for example, shrink in half. Considerable melting of the permafrost layer is also expected, and in some remote areas it may even disappear completely. However, there are still no reliable numeric assessments for these predictions.

It should be once more emphasised that the prognoses given above are only considered future indicators rather than prognoses. Of course, they will be further specified and worked out in greater detail as our knowledge accumulates and more accurate climate “signals” appear. However, there are some regional impacts that can be singled out even now and that should be watched especially closely. These impacts are those that will be key in anticipating the imminent, powerful and unfavourable climate changes.

Assessment of expected changes in air temperature, °C (left) and precipitation, mm/day (right) in July (down) and January (up) by 2050 in comparison with the 1961-1990 period
It is clear that scientists and politicians now face a plethora of complicated problems. Therefore, the World Meteorological Organisation and the UN Environment Program (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988. Thousands of scientists from all over the world participate in its efforts. Three Work Groups were created, and every five years each group prepares a report of about 1,000 pages. The first Group deals with the identification of climate changes and their prognoses. The second Group assesses current and potential impacts of those changes on ecosystems. And the third Group considers the impact on socio-economic systems and assesses possible ways to reduce greenhouse gas emissions.

Very recently in 2001 the IPCC published the Third Assessment Report, consisting of three large volumes. Naturally, all these materials were used in the preparation of the given brochure. However, even the united efforts of scientists world-wide still do not make it easy to get answers to problems in specific regions, such as the region currently in question.

Along with the activity of the IPCC, deeper and more specific research is also being conducted, directed towards a prognosis of the impact of climate change on certain ecosystems. Thus, in September 2000 the WWF published the report on the impact of global warming on terrestrial ecosystems “Global Warming and Terrestrial Biodiversity Decline”. As in the IPCC reports, it includes model calculations of the status of the ecosystem at $\text{CO}_2$ concentration in the atmosphere 2 times more than level of 1960-1990. However, the report also gives a more detailed analysis of the consequences of animal and plant migration. In particular, the report indicates that the “required speed of migration” may be higher than is physically possible for species, and that migratory routes can meet both natural and anthropogenic barriers.

These effects are very acute for the Altai-Sayan ecoregion. This remote mountain country is separated from the sub-arctic regions by hundreds of kilometres of taiga, which will prove impossible for the inhabitants of the mountain ecosystems to pass over. Research has shown that in order to save themselves these species would need a migration, which would force them into arid, high and rocky mountain landscapes and lead to habitat fragmentation. In particular, the 3 °C warming that was predicted by the IPCC may lead to a loss of 10-60% of mammal species in boreal mountain ecosystems like the Altai-Sayan.

Hence it is not surprising that the ecoregion has been identified as a high risk zone. The prognosis for the long-term perspective is very unfavourable. Up to a certain extent the adaptive abilities of the ecosystems may safely sustain them, but sudden irreversible changes may also take place. This is a very serious warning that should be heeded and considered with utmost responsibility.
Mountain steppe, mountain taiga and high mountain zones represent the Altai and the majority of mountain massifs of the northern part of the region. Cereals dominate the vegetation cover of the steppe foothills. Larch forests up to a height of 2,000-2,200 meters are the most typical of the mountain taiga zone. More humid regions are represented mainly by dark coniferous taiga consisting of cedar, silver fir and fir trees. In many places due to long-term exploitation, massifs of second birch-aspen forests replaced dark coniferous forests.

Low bushes and sub-alpine meadows dominate in the lower part of mountain zone, while higher in the mountains they are replaced by magnificent alpine meadows with an abundance of grass species with large and bright flowers. In the eastern area of the region alpine vegetation in the high mountain belt is replaced by mountain tundra, in particular, bush tundra and moss-lichen ecosystems.

Patches of vegetation are typical of the Kuznetsk Alatau, North-West part of the region, and such patchiness is the combined result of impacts such as slope layout, snow cover thickness, etc. Such species as linden, asarum and woodruff, which are typical of broad-leaf forests of the Russian Plain and the Far East but not typical of Siberian taiga, are found among the plants of the unique dark taiga of the Kuznetsk Alatau. This is a peculiar taiga formation with a predominance of silver fir and aspen, with underbrush consisting of the bird cherry tree, Siberian rowan tree and snowball-tree, and high grasses up to 2.5 meters. Much precipitation and thick snow cover also create favourable conditions for the development of marshes.

Intermontane depressions are represented by steppes and meadows, and in the south by semi-deserts. In the northern
along the southern slopes of the Tannu-Ola Range (South Tyva) forests generally can be absent in natural zone structure at all. And there grassy meadows and semi-deserts at a height of 2,100–2,300 meters are directly contiguous with steppes.

The fauna of the region is extremely diverse and includes a broad spectrum of communities from desert to mountain tundra types. In general, the region is located at the intersection of the Central Asian and Siberian faunal provinces. The foothill steppe in the northern part of the region differs little from the steppes of Western Siberia and Kazakhstan. Among the dominant animals are small rodents such as ground squirrels, hamsters and field voles. Hares and badgers are also encountered. Typical taiga inhabitants, such as the brown bear, wolverine, lynx, sable, and chipmunk are widely represented in the mountain forests. There are also typical Eastern Siberian species such as musk deer, Siberian maral deer, and big forest mouse. Almost 300 bird species have been observed in this region, the most common of which are the wood grouse, hazel grouse, black cock, hawk owl, Tengmalm owl, three-toed woodpecker, crossbill, and thrush.

In the southern, Mongolian part of the ecoregion, steppe and semi-desert species dominate, such as dzeren, Mongolian marmot, and predatory birds. Drought-resistant and salt-resistant plants such as onions and absinthes represent steppe and desert-steppe communities of the Basin of Great Lakes. Small rodents are also abundant in this area, such as jerboas and chipmunks. However, dzeren is rare here and is instead replaced by goiter gazelle, kulan, and saiga antelope.

In a very peculiar Uvs Nuur Depression, both the Central Asian and Siberian species can be observed. For example, sable, squirrel and elk inhabit the mountain taiga. Dzeren antelope, tolai hare, and the long-eared hedgehog inhabit the steppe zone representing the species of the Mongolian semi-deserts. The rivers of the depression are inhabited by Central Asian fish species such as osman and thick-lipped mullet.

Mountain goat, argali mountain sheep and the snow leopard (irbis) represent the alpine fauna. The two latter species can be considered special symbols of the ecoregion, as the World Community has regarded them as the most valuable species for global biodiversity conservation.

part of the region most of them are plowed and serve agricultural purposes, while in the south they are mainly used as pastures. Sagebrush-grass plant communities, which are common to the steppes, also dominate here. The high mountain belt is broadly represented with alpine steppes and uncultivated plots, and it is here that the small sedge, kobresia, which serves as rich “fat-providing” summer fodder for the ungulates, is the dominant plant. The mountain taiga belt consists of larch and cedar-larch taiga, which is the source of timber for all of Mongolia.

It should be noted that in dry central and southern parts of the ecoregion, in the Gobi Altai, in the south-eastern Altai and
Ecosystem Response to Climate Changes

Observations have indicated obvious correlation between the climate changes and dates of phenological events in plants, such as blossoming, unfolding of the first leaves, leaf shedding, etc., though specific responses vary among species. Thus the dates of blossoming of the bird-cherry tree coincide with temperature alterations recorded in the Russian part of the region, such as slight cold in 1915-1925 and 1945-1960, and substantial warming from the mid-1960s until present.

There are also regional differences that have been observed. For example, in Altai and in the north-western part of the ecoregion, the blossoming time of the bird-cherry tree shifted ahead about one day every ten years, though in the Minusinsk area no shift was detected at all. On the other hand, there are no clear change in dates of meteorological events, which are close to the date of bird-cherry tree blossoming (the last observation of the negative air temperature and sustainable transfer of daily temperature over the 10 °C).

It is important to note that there has been a shift in the phenological events of plants in spring, and that herbaceous (grass) species react more sensitively to climate changes.

The arrival dates of summer events either did not change at all, or began to occur even later. Also noticed was a slight tendency for autumn events, such as the end of the leaf fall date for birch trees, to shift to a later time of year.

Dendrochronological analysis based on tree-ring patterns established over long periods of time, has been a traditional method for determining the impact of climate factors on forests. Research has shown that, starting in the mid-1950s and especially since the end of the 1970s, an increase in annual tree-ring increment and the shifting of forest vegetation upwards were observed in the Altai-Sayan. A large number of young trees and undergrowth creeping up the slopes can be observed.

An improvement in climate conditions for forests can also be judged indirectly by...
changes in the growth of the Siberian silver fir, as this tree is very particular in its requirements for humidity and warmth. One hundred and fifty-year-old silver firs were found at the topmost edge of the forest, and were found to have a peculiar knee-shaped bend at a particular height. The presence of this bend indicates that the growing conditions for these trees changed dramatically from good, to bad, and back to favourable again. In fact 100-200 years ago the highest border of the forest in the Western Sayan was 100-150 meters higher than it is at present. During that time it lowered, but is currently once again rising. Thus only after the “creeping up” of the forest growth in the region by at least 100-150 meters can it be considered principally “new.”

The observed date changes of bird migration in spring are not always unidirectional. For example, wild duck migration and first cuckooing in the Sayano-Shushensky Nature Reserve began to occur much earlier (by 13-16 days), while at the same time starling arrival over the entire region was delayed by several days. It should be noted that a similar tendency is typical of the starling arrival on the eastern european plain.

An analysis of bird migration in the Barguzin Nature Reserve showed that, though about 40% of the species started to arrive in spring four or more days earlier, another 20-25% of species demonstrated a reverse effect. Although the reserve is not part of the ecoregion, the same bird species that inhabit the reserve also inhabit the Altai-Sayan region. In autumn the number of species with earlier and later migration periods is divided into approximately equal parts. Earlier arrivals and later departures were registered for 12 species, while the period between the first arrival and the departure for another 5 species decreased. Synanthropic species (those closely connected with man), and species which actively settle within the boundaries of the region, are the main representatives of the first group. The increase of their stay is most likely connected both with climate changes and with their increase in number, which prolongs the length of their flight migration period. On the contrary, the changes in the second group of species can be connected both with climate factors and with their decrease in number.

Sometimes expansion to the north is simultaneously noted in widely separated territories for different populations or subspecies of one species. For example, the paddy-field warbler is presently expanding its habitat in the latitude zone from the north-western part of Russia to the Far East. This observation clearly indicates the presence of an impact common to the entire nature zone. The cause is, presumably, a climatic one.

Among the birds, whose habitats change, there are no information about mountain birds. However, the reasons for this remain unclear. This, first of all, is most likely due to the fact that mountain areas are studied less often. In connection with this, the “discovery” of several new species penetrating from the west to the Western Sayan, such as the Alpine (yellow billed) chough and others, probably reflects more a rise in deeper ornithological research in the area rather than actual changes in species expansion.

A decrease in precipitation also plays an important role for the steppe zone species. For example, the huge steppe fires in the Trans-Baikal Lake area in 1995-1997 coincided with an active penetration of the Japanese quail and the upland buzzard into the Front-Baikal Lake area. Before this, the appearance of Japanese quail was registered in the Irkutsk Region at the end of the 1970s, while it appeared at the delta of the Selenga River in the 1950s and at the beginning of the 1980s. And it was specifically during these periods in Northern Mongolia when the precipitation amount was decreasing and summer temperatures were increasing.

Thus, it is apparent that there exists a definite phenological connection between the behaviour of birds and natural conditions, though specifics will demand thorough research. However, it still proves extremely difficult to distinguish between external and internal population factors when determining expansion changes, species number, and the population structure. The reason is clear: profound research that fundamentally examines external factors is available only for a very small number of species, and there is a few long-term research in this area.
Altai Mountain Sheep, or Argali (Ovis ammon ammon), can undoubtedly be distinguished as an animal unique from all other wild sheep species. It is one of the largest and most beautiful mountain sheep. The weight of an adult male Argali can reach up to 200 kilograms. They have massive horns, which when well developed can weigh up to 27 kilograms. Two subspecies of the Argali have been identified: the western Altai, which is larger and more numerous, and the Gobi subspecies, to which less study has been devoted.

Argali can feed on rough high mountain vegetation that has low nutritional value. The animal is extremely adapted to low temperatures, but is very sensitive to high temperatures. Thus temperatures of +23-24 °C have a negative impact on the animal’s health, particularly on large males. It is likely this important biological peculiarity of the species that is the reason for its exclusive habitation of high mountain areas.

Argali appendages are thin and slender, giving the animal the ability to run at speeds of up to 60 km/h, which is 15 km/h higher than the speed of chasing wolves. This is why the habitat of the sheep is most often located in open areas with relatively flat relief. The climate of the ecoregion is also ideal for the animals: the mountain ranges shade the middle and the southern parts of the region, there is little precipitation in winter, and the thickness of snow cover rarely exceeds 10 cm.

The majority of the Argali population inhabits Mongolia, where the total protected area within its habitat constitutes 1.1 million hectares (as of the year 2000). According to the UN Food and Agriculture Organisation (FAO), the number of sheep in 1976 was between 10-12 thousand on the territory stretching from the western border of the country to the one hundredth meridian. However, according to the estimation of the Mongolian Association of Hunters, there were about 40 thousand individuals, and according to other estimates – about 52 thousand in the middle of the 1970s. The latest available estimate is about 18-20 thousand animals as of 1986. Yet, now under the initiative of the Mongolian government and the support of WWF it has been planned to undertake a count of Argali sheep to finally obtain exact data.

In Mongolia the Argali sheep population “shifts” from south to north, which is partly a result of the climate change, as the last 60 years has seen an increase in winter temperatures of about 3.6 °C.

In Russia the number of Argali is estimated as 600-650 mainly on the Sailugem Ridge along boarder of Altai and Mongolia (120-300) and the Chikhachov Ridge (from the Mongolian border to the Altai Nature Reserve along Altai-Tyva boarder) – 150-300. Sheep migrations of about 100-200 animals per year are observed crossing the Russian border, mainly in the south-western Tyva. In summer the Argali habitats are used for livestock pastures, and the wild animals are forced to migrate.
In the Kazakhstan part of the Altai, the number of Argali does not exceed 100 individuals, though there are probably several hundred more sheep in the Chinese territory.

The number of Argali has, unfortunately, decreased in recent years. Moreover, separation into distinct groups has been a clear sign of fragmentation of the population. This is connected both with illegal hunting and competition with livestock, both of which increased in the 1990s as the result of economic difficulties and the privatisation of livestock. Extremely severe winters with particularly heavy snowfall also present a serious danger for the sheep. For example, about 160 years ago after the catastrophically snowy winters, Argali disappeared from the vast territory of the Orhon Valley of the central-east part of the ecoregion. In the last two years, less severe yet still deleterious conditions were observed in Mongolia, with severe winters and dry summers, which led to the death of a large number of sheep.

Thus, under the initiative of the WWF, a strategy for the conservation of Argali sheep was recently prepared. The stabilisation of population can be expected in the Russian part of the ecoregion only if a series of restoration activities are undertaken, and a hunting ban achieves strict compliance. Unfortunately, it is possibly only on relatively small territories along Altai boarder with Mongolia and China: the ranges surrounding the Chuisk steppe, the north of the Chikhachev Ridge and the south of the Ukok Plateau. An increase in Argali habitat, however, is rather doubtful due to the forthcoming climate changes, with which come a larger probability of heavy snowfalls and winter thaws, and a gradual widening of the forest zone.

Even larger changes are possible in Mongolia, which provides the primary part of the habitat. However, it is too early to make an exact prognosis for this area. And the highest of priorities should be finding solutions to the most acute of problems, which are overgrazing and illegal hunting.
The Snow Leopard, or Irbis (Uncia uncia), is the only large wildcat in the world that lives in high mountain regions. Occupying the highest trophic level in the high mountain ecosystem, Irbis represents the most significant species in the entire ecoregion. However, at the same time, the snow leopard is also one of the rarest and most vulnerable species of the Altai-Sayan mountainous country. Irbis is not particularly sensitive to temperature changes, but heavy disturbance and the degradation of the mountain ecosystem have made the survival of this rare cat practically impossible. And it is because of this that conservation of the species is inseparably connected to conservation of the entire high mountain zone. The species is listed in Appendix I of CITES (Convention on International Trade in Endangered Species of Flora and Fauna), and in the endangered species category of the Red List for the International Union for Conservation of Nature (IUCN).

Irbis inhabits the mountain zone at a height of 2-4 thousand meters, though in a few particular areas, such as the Gobi Altai and the eastern part of the Western Sayan, it can descend lower into the forest zone in winter. To the south, in particular, in Kazakhstan, it can go as high as 5 thousand meters. Although Irbis is called the snow leopard, it tries to avoid deep snow. Winters with heavy snowfall can be dangerous for the species, as indicated by an increased death rate. In particular, it is the heavy snow cover that prevents the cats from spreading into the western part of the Katun Ridge of the South Altai.

In Russia, the northern part of the Irbis habitat is exposed most of all to extreme external impacts. The total territory of potential habitat for the snow leopard constitutes approximately 60 thousand square kilometres. Two main habitat centres – the western and the eastern – have been determined. The western one includes West Tyva, south of Khakassia and two Altai groups (Shapshal and Argut, which is the largest part of the population). The East Sayan (Kitoi, Tunkin, and Sengilen) populations constitute the eastern habitat center. The small groups of Irbis in West Sayan and West Tannu-Ola (South-West Tyva) occupy an intermediate but very important position, as they are the ecological “corridors,” sustaining the integrity of the entire population. Including even small populations, the total number of Irbis in Russia is estimated to be between 150-200 cats. Unfortunately, it is the small habitat centres that have a tendency toward extinction.

In Mongolia, data on the total number of snow leopards varies from several hundred to as many as 4,000. It is probable that the most reliable assessments were done by Schaller in 1994, which stated that there are about one thousand cats on a territory comprising 90 thousand square kilometres, equalling 1.1 anymal per 100 square kilometres. Such a low density is typical of the species, but its further decline and subsequent fragmen-
tation of the population not only present a grave genetic danger, but may also lead to the eventual extinction of the species.

Though the network of protected areas is well developed in the Altai-Sayan ecoregion, only a small portion of the Irbis habitat is covered. In Russia only 6-7% of potential Irbis habitat is located on the territory of nature reserves, and in Altai around 11%. In reality, the largest and the most valuable snow leopard populations are located outside the borders of the protected areas. The one exception to this is the Sayano-Shushensky Nature Reserve, which includes a significant part of the Irbis population of West Sayan.

The situation is the same in Mongolia, where the 19 protected areas cover no more than 20% of the snow leopard habitat. The worsening of the social and economic situation in the 1990s forced many people in Russia and Mongolia to use any possible means of sustaining and supporting themselves. And thus, the poaching of Irbis and ungulates, its main sustenance, increased. This, in turn, forced the wildcats to attack livestock grazing in the mountains, of course resulting in conflict with humans, which often ended in the death of this rare species. In Mongolia the problem is even more aggravated by the illegal export of leopard bones to China, where they are used in traditional medicine.

The long-term preservation of a healthy and sustainable population of Irbis is simply not possible without clearly defined goals and priorities for ecological and economic policy of the entire ecoregion. A conservation strategy for the Irbis has been developed with the help of WWF support expeditions and research work. In the Altai republic, a separate cluster of the biosphere Katunsky Reserve is required, which will provide for protection of the Argut population of Irbis. In the Republic of Tyva, the organisation of additional clusters of the state Uvs Nuur Depression Nature Reserve (Big Mongun-Taiga, Uvs Nuur, Oruku-Shynaa, and Kara-Khol) is in progress to protect both Irbis and Argali.

However, in WWF’s development of this Irbis conservation strategy, the direct impact of climate changes was not considered. And thus, this factor should most definitely be taken into account when the strategy is reworked and improved. If in the next few years the leopards were forced to endure several snowfall severe winters in a row, the situation could turn especially critical and may even result in the undermining of the population. Another potential threat is the epizootic (or broad spread of diseases) of the Siberian goat, which is the main feed base for the Irbis. The future melting of mountain glaciers could potentially increase Irbis habitat, however this possibility is negated due to the effects of forest expansion in the high mountains, which will, on the contrary, considerably reduce Irbis habitat.

Currently Irbis poaching in Russia results in the loss of 15-20 per year, while in Mongolia it is approximately 100 animals per year. The impact of poaching on the leopard population is much more critical than the impact suffered from climate change, and it follows that the solving of this problem should take top priority. The restoration and stabilisation of the snow leopard population can only be expected if anti-poaching is strictly enforced.

Habitat expansion, unfortunately, is especially unlikely due to the expansion of forests and an increase in winter precipitation. Thus special attention should be paid particularly to high mountain populations on snowless slopes. The conservation of these areas is crucial to the salvation of the species under future increasing climate changes.
Changes Expected in the Nature of the Ecoregion

In a short-term perspective, the most unfavourable events of the next 15-20 years will be caused by the significant warming of spring and winter months. As a result, the frequency of winters with heavy snow and heavy floods similar to those that occurred in 2001 could become even greater. The possibility of winter thaws is also likely to increase, which are not yet typical of the region, and thus may become a new critically important factor in the survival of the animals.

The northern part of the region will likely see more unfavourable winter conditions for ungulates and predatory mammals, and force upon them large seasonal migrations. A few years of particularly heavy snowfalls may then be followed by the massive death of animals, including Argali and Irbis. The thaws will likely then see the compression of snow cover, and the formation of especially dense layers which may lead to the death of birds of prey, and of small mammals that winter under snow.

Winter conditions in the south, especially in the south-eastern part of the region, have become a bit less harsh for the mammals of the area. However, due to the intensification of the summer dry period, the ungulates will be forced to spend more time on high mountain pastures, thus increasing competition with cattle.

The reduction of certain nature zones and habitat fragmentation into “islands” will have an increasing effect, as viewed with a long-term perspective. The territory of the high mountain ecosystems will decrease considerably. This is inevitable because the movement of the forests up the slopes, while formation of a soil cover on rocky surfaces of glaciers melt demands a longer period of time than the moving of forests towards a “prepared” area. Potentially, within 30-50 years the upper edge of the forest could rise significantly (from 15 to 150 m, according to various assessments and in different places). The length of the vegetation period for most plants will also increase by 1-2 weeks, particularly in the spring months.

However, the most serious deleterious effects from the decrease of natural zone area are expected in Mongolia. Assessments of to the Holdridge Life Zone Classification Model indicate a considerable shift of deserts towards the north. Thus, by the middle of the 21st century the territory of steppes could potentially decrease by 7% in the area of the Great Lakes Basin and its surrounding territories, while total desert area, on the contrary, could increase by 13%. On the whole, the total area of tundra and forest ecosystems in the Mongolian part of the ecoregion is likely to decrease by 4-14%.

The total exhaustion of migration possibilities in the mountain ecosystems is very possible within the next couple decades. Unfortunately, in all cases, the saving of the most valuable species, for example the Irbis and Argali, will demand large-scale and costly efforts, such as a more thorough account and greater protection of the animals. It will also require the capturing and relocating of animals found in enclosed areas where their survival has become impossible. It will be necessary to have nature reserves, or at least long-term “shelters,” covering all high mountain areas or at least areas with the smallest frequency of heavy snowfalls.

At the same time it is apparent that along with climate changes, direct anthropogenic factors will inflect an even more significant impact on the ecosystems. Depending on specific choices made regarding economic development in the region, anthropogenic factors can be even more influential than the effects of climate changes.
Most of the territory of the Altai-Sayan ecoregion is included in the number of least-economically developed regions of Russia and Mongolia. Nevertheless, biodiversity conservation in the conditions of the changing climate depends both on the chosen path of economic development, and to no less extent, the ability of the indigenous people to uphold a traditional way of life. The poverty of the local people is a serious socio-economic problem that is inflicting a negative impact on the natural resources and biodiversity.

The ancient history of the region is so unique that many historians and archaeologists call it “the cradle of civilisation.” In the course of many thousands of years, the cultures of ancient Turks, Ugro-Finns, Chinese, and Iranian peoples gathered here and “merged” together. The region can be considered multinational, as Russians, Mongolians, Chinese, Kazakhs, Uigurs, Altainians, Tyvinians, Buryats, Shors, Khakasians, Soyots and other nationalities occupy its lands. They speak a myriad of different languages from the Slavic, Mongolian, Turk and Altai language groups. A combination of both modern and ancient attitudes, as well as closeness to nature is common to all of the groups.

At present, there is a tendency for the revival of old traditions of pagan customs and shamanism. National holidays, traditional occupations and the unique musical art of throat singing are undergoing a rebirth. The culture of the indigenous people is based on the traditions of cattle-graing tribes with a nomadic lifestyle. Mutton, horseflesh, milk and sour milk products are the basis of the national cuisine. Part of the population still lives in chums, yurtas and other traditional constructs.

Many nationalities even until now have kept up a traditional style of life and use of natural resources. For example, in the dry areas of Tyva, shepherds are returning more and more often to the traditional nomadic way of life. They are undertaking four seasonal migrations just as their ancestors did, in order to avoid pasture desolation by the overgrazing of cattle. This method has proven to be an effectively sustainable use of pasture resources.

Large number of people of the ecoregion still earn a sufficient part of means for living and support their families by hunting. This fact was revealed to the greatest extent in the last decade, when the economic recession resulted in a decrease in the number of jobs in the industrial sector, transportation, and the service sphere, especially in distant areas.

The development of a market economy inflicted a serious crisis on collective and soviet farms, and has resulted in a considerable decrease in the number of livestock on collective farms. On the other hand, both in Russia and in Mongolia the number of private cattle-graing farms saw a sudden increase, which led to an increased burden on surrounding pastures and thus to a feed shortage for livestock.
In the Mongolian part of the ecoregion the majority of the population works in the cattle breeding, as their economic activity is based almost strictly on pasture and livestock. Because of this, overgrazing has become one of the most serious problems in the conservation. Especially in the last decade following the legalisation of livestock privatisation, the number of livestock has increased considerably. Other factors that have contributed to the overgrazing problem and the exhausting of pastures were provoked by the economic crisis which resulted in widespread unemployment. Moreover, this problem in Western Mongolia is also connected with a change in species composition, and the increase in number of Kashmir goats.

So what can be said of the expected change in light of the approaching climate problems? At present the three most significant concerns are those factors that will affect: 1) the infrastructure of transportation and habitation, 2) opportunities for hunting and 3) the livestock-overgrazing problem.

The first impact is, of course, the ever-increasing likelihood of catastrophic flooding in the spring. The unpredictable and strong intrusion of warm air masses, particularly in the northern and central parts of the ecoregion, will lead to a sudden uplift of water, which results in the flooding of settlements, and the destruction of bridges and roads. These threats must be taken into account in the construction or reconstruction of buildings, and detailed and practically tested emergency plans must be prepared. It is also highly likely that sudden and unpredictable avalanches, rock falls and permafrost melting in some areas will only add to the flooding problem.

The increasing frequency of severe snowfall winters and sudden spring-winter thaws, which are most likely in the western and northern parts of the ecoregion, will create adverse conditions for ungulates, birds of prey, small mammals, and even for the snow leopard. So in order to further protect threatened populations, the introduction of additional hunting restrictions for certain years, and stricter anti-poaching regulations is necessary.

Though the major climate changes are expected in the winter-spring season, in the Mongolian part of the ecoregion an extension of the summer dry period is also a likely possibility, which will potentially cause an adverse effect on livestock grazing. However, at the same time, the grazing conditions in other seasons may even improve. These factors will pose an important question about the stricter regulation of the use of mountain pastures in summer months.

The overall economic well being of the population in the ecoregion depends to a great extent on local natural resources. Developments in transportation and external economic influences are making once isolated areas now accessible for resource exploitation. Roads that were once built for gold mining have recently opened the northern parts of the ecoregion to settlers and loggers. There are also plans to construct a direct road from Russia to China across the protected areas of the mountain Altai and others.

The question then arises, “where and how can the economic development of the ecoregion be directed sustainable, so as to minimise detriment to the environment or the traditional way of life of the indigenous people, while still considering climate changes to a proper extent?”

Even the immediate aspects of the economic development of the region are not yet clear, however, in general there exist two tendencies. The first one includes the development of “new territories” in the style of the 1930-1970s, which would mean the maximum exploitation of mineral resources, i.e. gold mining, etc. Such choices obviously subscribe to the attitude “first it is
necessary to achieve economic well-being, and only afterwards can we worry about nature conservation."

As world experience has clearly indicated, this path will by all means lead to the rapid "improvement" of statistical data of the regional economy (e.g. Gross Industrial Product of a region), and the enrichment of large Russian, Chinese and transnational companies. However the life of the common people, indigenous people and other nationalities that currently live on the territory will most likely not see any significant change for the better.

For example, the construction of a new road to China will create many job opportunities, but based on similar world experience, only the least paying jobs will be left for the local people. Even more, the environment will suffer serious detriment, which will practically deplete the indigenous population of possibilities for traditional ways of life and hunting. In the course of such events, means may be found to diminish the consequences of floods, and for road and bridge reconstruction. However, biodiversity conservation will most likely lose its priority, and in many cases there may not be anything left to protect anyway.

Another way for development, which is receiving more and more support on a world-wide basis, is founded upon an international "distribution of labour" and an overall account of long-term ecological losses. One particular situation is when about 200 ecoregions located on the territories of a relatively small number of countries are providing all humankind with ecological services. However, under the pressure of a non-regulated market, the populations of these countries are often forced to destroy unique ecosystems for the sake of immediate benefits. The way to conserve these regions, and the Altai-Sayan region in particular is to recognise that the conservation of nature is a major global effort, – "global ecosystem service", and then to develop and implement a system for receiving means for the conservation of biological systems.

Of course, all of these ideas still look rather far off from the reality of today. However certain improvements have already occurred. For example, the approach is recommended in the third volume of the IPCC Third Assessment Report (2001), which highlights full accounting of environment costs and benefits. There are already examples of positive measures that provide the special privilege for goods with "environmentally friendly" labels. The leaders of all areas in the Altai-Sayan ecoregion have already made the first step towards by signing the Altai-Sayan Initiative proposed by WWF. This document is based on the aforementioned basic regulations, and confirms the intention to develop strategies of sustainable development in the ecoregion.

This way of development do not in any way hinder the development of social, educational, medical or other infrastructures of the ecoregion, including transportation and communication. However, decisions about industrial projects should be made only after comprehensive analysis. Large projects for the development of mineral resource should be implemented only in exceptional cases under the condition that they will not undermine the ecological basis of the region's economy.

Another important question is the region's participation in the global climatic "distribution of labour" and efforts to decrease greenhouse gas emissions, as outlined in the UN Framework Convention on Climate Change, and, in particular, in international economic mechanisms of the Kyoto Protocol. The Convention divided participants into the countries of Annex 1 (developed countries and the majority of countries with economy in transition, including Russia), and the remaining countries (including Mongolia, China and Kazakhstan). The countries of Annex 1 should follow qualitative obligations to decrease or limit emissions, and through special funds help other countries to adapt to climate changes and prepare to decrease emissions.

However, even though Russia is included in Annex 1, the development of the Altai-Sayan area is so weak that in order to adapt the entire ecoregion to climate changes, the region unquestionably should receive external assistance.

It is, of course, too early to speak about a decrease of greenhouse gas emissions in the ecoregion. However, there could be projects proposed for the modernisation of boiler-houses, residences and energy efficient heating systems, as well as projects for the development of alternative energy sources which do not emit CO₂ (small hydroelectric power stations, wind stations, etc.). Other potential projects include forest restoration that would lead to the absorption of CO₂ from the atmosphere, and ecologically sound forest management. These measures will make significant contributions to the decrease in the specific regional emission (per unit of Gross Regional Product), and in future to the decrease in greenhouse gas emissions.
The most critical, deleterious consequences of climate change in the near future will be winters with much snow and heavier snowfall, sudden thaws and heavy floods. Such extreme conditions will allow the safe sustainable populations of Argali only on the ridges surrounding the Chuisk steppe and on the Ukok Plateau. Because of these circumstances, relevant measures for the establishment of protected areas should be undertaken. The idea road construction across the Ukok Plateau will inflict the most serious of detrimental effects on efforts to save Argali in the Republic.

The Snow Leopard will experience heightening stress from heavy snowfalls, whose impact will be felt stronger in the western portion of the population. Thus, the establishment and enlargement of protected areas for the Argut population of Irbis becomes critically important. However, the implementation of effective anti-poaching measures has become an even more urgent task, as it is poaching that is inflicting the most damage to the Irbis population. The effects of poaching can be more pronounced than the impact of climate change in the next 20-30 years.

Sudden spring-winter thaws will create unfavourable conditions for ungulates, birds of prey, and small mammals. This will demand the specific hunting restrictions and stricter anti-poaching regulations.

There is a continually increasing possibility of heavy floods in spring. These floods could potentially lead to the flooding of homes and buildings, and the destruction of bridges and roads. These threats must be taken into account in the construction or reconstruction of buildings, and detailed emergency plans and supplies must be prepared.

Snowy winters and heavy snowfalls will become even more frequent and are having serious deleterious effects on the safety of animals, up to massive death of Argali and a sharp decrease in the number of Irbis in the Republic. The danger of avalanches will grow in some areas, which will also create additional transport problems.

The habitat conditions of the Argali and Irbis will only grow worse, and without undertaking special measures within the next 20-30 years, their presence in the Republic may be as separate comings of the animals from Mongolia and Altai. In a short-term perspective, anti-poaching measures are especially critical there for the protection of both the main populations of animals and for migrating individuals. In a mid-term perspective, the creation of vast protected territories is crucial for the areas with the least possibility of unfavourable climatic conditions, more specifically, in areas such as the Sengilen mountain range and the Uvs Nuur Depression.
Mongolia

Because of the strengthening of the dry period in summer, ungulates will be forced to spend more time in mountain pastures. Their competition with livestock will subsequently increase, and in accordance with this, problems with the protection of wild animals will also arise. Questions regarding the stricter regulation of mountain pasture use and the problem of regulation of specific breeds of livestock, especially the Kashmir goats, must also be solved.

In contrast with the Russian part of the ecoregion, the Mongolian Argali and Irbis have not yet been threatened with extinction. However, it is essential to obtain complete and accurate data on their numbers, habitats, and migrations. In a long-term perspective, this data should be used as a basis to organise vast protected territories, and create long-term and strategic “refuges” for these specially protected species.

The implementation of effective anti-poaching measures for the protection of the Irbis and Argali has become particularly urgent, because poaching now is inflicting major detriment that is more effectual than the climate changes that will take place in the next 50 years.

In a more distant perspective, the changes of the nature zones will have more and more often adversely affect, particularly on a shift of the deserts in a northern direction. By the middle of the century in the Great Lakes Basin and the surrounding regions, the steppe area may be reduced by 7%, and the desert area will likely increase by 13%.
List of web-sites


www.ipcc.ch – IPCC (Intergovernmental Panel on Climate Change) different issues of climate change, forecasts, estimation of impact on environment.

http://ipcc-ddc.cru.uea.ac.uk – IPCC, the IPCC Center for climate change data dissemination.

www.unfccc.int – Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), the library of documents, information on greenhouse gase emissions.

www.pacinst.org/wildlife.html – site with wide library concerning climate change impact on flora, fauna and ecosystems.

www.lib.noaa.gov – USA Agency Library on Atmosphere and Ocean research, wide spectrum of materials and data on climate change.


www.wmo.ch – site of WMO, Country Office, information, events, and activities.


Recent publications


Batima P., Davadajor D. Climate Change and Its Impact in Mongolia, Ulaanbaatar, 2000, 223 p.


Global Warming and Terrestrial Biodiversity Decline. Eds.: J. Malcolm and A. Markham. WWF, Gland, Switzerland, 2000, 40 p. climate.campaign@wwfus.org; www.panda.org/climate


Climate PASSPORT
of the Altai-Sayan Ecoregion

Editors:
Kokorin A.O., Ph.D.
Kozharinov A.V., Prof.
Minin A.A., Prof.

Contributors:
Amgalanbaatar S., Batsukh N., Bondarev A.I.,
Dagvadorj D., Dostoevskaya L.P.,
Fedotova V.G., Fefelov I.V., Gruza G.V.,
Istomov S.V., Kisiltsin I.P., Klimanov V.A.,
Kokorin A.O., Kozharinov A.V., Minin A.A.,
Munkhtsog B., Nemolyaeva L.A.,
Rankova E.Y., Shapkhaev C.G., Tuluev K.D.,
Zakharchenko U.V.,

Contacts:

WWF International
Avenue du Mont-Blanc
1196 Gland
Switzerland
Phone: +41 22 364 91 11
Fax: +41 22 364 32 39
user@wwfint.org ; www.panda.org

WWF Climate Target Driven Program
1250 24-th St., NW
Washington, D.C. 20037-1175, USA
Tel.: +1 202 822 3455
Fax: +1 202 331 2391
jmorgan@wwfus.org
www.panda.org/climate

WWF Russia
109240, Nikolko-Yamskaya 19-3,
Moscow, Russia
Tel.: (095) 727-09-39
Fax: (095) 727-09-38
russia@wwf.ru ; www.wwf.ru

WWF Mongolia Country Office
C/o Hydrometeorological & Environmental
Monitoring Agency
Khudaldanu Street 5
Ulaanbaatar 46
Tel.: +976 11 31 16 59
Tel./fax: +976 11 31 0237
wwfmon@magicnet.mn; www.wwf.mn

WWF Altai-Sayan Ecoregion Project Office
41 of, 38, Lenin St.
660049, Krasnoyarsk
Russia, P.O.box 25254
Tel.: (+7 3912) 27 94 91
Tel./fax: (+7 3912) 27 86 40
abondarev@wwf.ru

Art and design:
O.Vajnik, S.Trukhanov,
design studio “ORBIS PICTUS”

Brochure is prepared under the WWF
project RU0078.01 and RU0074.03
funded by the WWF Netherlands.

Published in November, 2001 by WWF, Moscow,
Russia
Any full or partial reproduction of this publication
must include the title and give credit to the
above-mentioned publisher as the copyright
holder.
No photographs from this publication may be
reproduced without prior authorization from
WWF Russia.
© 2001 WWF Russia

ISBN 5-89932-025-7

Ecoregional Climate Change and Biodiversity Decline,
Issue 1, Altai-Sayan Ecoregion

Editors:
Kokorin A.O., Ph.D.
Kozharinov A.V., Prof.
Minin A.A., Prof.

Contributors:
Amgalanbaatar S., Batsukh N., Bondarev A.I.,
Dagvadorj D., Dostoevskaya L.P.,
Fedotova V.G., Fefelov I.V., Gruza G.V.,
Istomov S.V., Kisiltsin I.P., Klimanov V.A.,
Kokorin A.O., Kozharinov A.V., Minin A.A.,
Munkhtsog B., Nemolyaeva L.A.,
Rankova E.Y., Shapkhaev C.G., Tuluev K.D.,
Zakharchenko U.V.,

Editorial stuff:
Banner J., Kalinicheva U.V.,
Nemolyaeva L.A., Sargsyan A.H.

Art and design:
O.Vajnik, S.Trukhanov,
design studio “ORBIS PICTUS”

WWF Climate Programm
With several million supporters and a network of offices in more than 90 countries on five continents, WWF is one of the world’s largest independent conservation organisations.

WWF’s mission is to stop the degradation of the planet’s natural environment and to build a future in which humans live in a harmony with nature, by:
- conserving the world’s biological diversity
- ensuring that the use of renewable natural resources is sustainable
- promoting the reduction of pollution and wasteful consumption.

Let’s leave our children a living planet