SHOULD CLIMATE CHANGE BE TAKEN INTO ACCOUNT IN RECLAMATION PLANNING?[1]

by

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Abstract. When planning for reclamation, climate is often taken for granted as being fixed, or at least variable within a known range. This range, coupled with the soils and final landforms, sets the limits for land use and revegetation species. It has been suggested that our climate is going to vary, or shift, outside of these expected ranges. If this occurs, there could be a change in the ecological region where a particular mine site is located. This change could, in turn, render current reclamation plans for the site obsolete. Since mines are often operating within the time frame suggested by some for climate change, there is ample opportunity to plan for change. The paper will challenge the reader to answer the question "should reclamationists plan for climate change?"

Additional Key Words: models, CO_2, greenhouse effect, global warming

Introduction

Mining generally involves the use and alteration of a given block of land over a long period of time (10 to 30 years or more). In strip mines, reclamation of any given mine cut may take place shortly after the resource is extracted (e.g., within two years); however reclamation of open pit mines may not take place until the entire pit has been exhausted. In the latter case, reclamation planners are looking at completing their jobs in 20+ years.

Planning for final reclamation involves a number of factors, including land use (both present and future), materials balances, replacement soil depths, materials handling sequences, landscape design, surface manipuila-tion, soil amendments, and revegetation species selection. Climate, both regional and local, is very important for reclamation planning (e.g., Ashby and Kolar 1984), especially for harsh sites (e.g., Brown and Chambers 1989; Macyk et al. 1989). However, climate is often taken for granted as being fixed, or at least variable within a known range. This range, coupled with the site's location (latitude, altitude, aspect), soils, and final landforms, sets the environmental limits for land use and plant species. Further limits on land use, and therefore reclamation methods, may be set by legislation and public input.

Recent research and media speculation have suggested that our climate is going to vary, or shift, outside of these expected ranges. If this occurs, there could be a change in the ecological region where a particular mine site is located. This change could, in turn, render reclamation plans based on current climate obsolete.

Climate Change

Climate is created by the interaction of the atmosphere, hydrosphere (oceans, lakes, rivers, ice, and snow), lithosphere (land and soil), and the biosphere (animals, plants, and man) (Bach 1984). Climate is affected by the balance between short wave radiation received from the sun and the long wave radiation emitted by the earth. The composition of the atmosphere and the reflectivity of the earth's surface and clouds determine how much of the incoming energy from the sun is retained.

Some atmospheric gases allow the sun's energy to pass through, but absorb and retain the earth's emitted

[1] Paper presented at the 1991 American Society for Surface Mining and Reclamation 8th Annual Meeting, Durango, Colorado, May 14-17, 1991.

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Proceedings America Society of Mining and Reclamation, 1991 pp 447-454

DOI: 10.21000/JASMR91020447

https://doi.org/10.21000/JASMR91010447

energy. The gases which absorb this infrared energy are water vapour (which is less than 4% by volume), carbon dioxide (approximately 0.03% by volume), nitrous oxides, ozone, and methane. The "natural" greenhouse effect produced by these gases raises the earth's surface temperature to a global average of 15°C, which is about 35°C warmer than would be the case if they were not present (Hare 1989).

It is the increase in these gases due to man's activities, particularly water vapour, carbon dioxide (CO_2) and methane, but also the introduction of chlorofluorocarbons (CFCs), which is thought to be responsible for global warming, and thus, in theory anyway, climate change (Hare 1989). Most discussions and predictions of climate change effects revolve around a doubling of CO_2 from pre-industrial levels (Douglas 1990). There is general consensus, though not universal agreement, that this additional CO_2 will result in a warming of the planet, although the amount of warming is in debate. Current predictions range from 1.5°C to 4.5°C (Hare 1989; Titus 1990); however, higher and lower numbers may be found.

The time frame for this warming effect to take place is also in debate. Most authors suggest 50 years as a target (Brundtland 1989; Douglas 1990). Maini (1989) suggested 40 years for a "business as usual scenario", but 25 years in a "high emission scenario" and 85 years in a "modest policies scenario". The shorter time frames may well be within those for large mines being planned, or indeed for very large mines currently in operation.

Models

Models used to evaluate future climatic conditions and effects of these conditions range from very simple to very complex, and from conceptual to numerical. The three common types of numerical models used, in order of complexity, are energy balance models, radiative-convective models, and general circulation models (GCMs) (Goos 1989).

GCMs are most often referenced in the literature and are sophisticated approximations of climate components and interactions. However, they have a number of assumptions and limitations which means their predictions must be recognized as having a large potential for error. The Goddard Institute for Space Studies (GISS), Geophysical Fluid Dynamics Laboratory (GFDL), National Center for Atmospheric Research (NCAR), United Kingdom Meteorological Office (UKMO), and Oregon State University (OSU) GCMs are most often referenced (Cushman and Spring 1989; Schlesinger 1988).

A number of studies compared various models (e.g., Cushman and Spring 1989; Douglas 1990; Smith and Tirpak 1988; Wheaton and Singh 1988) with most authors noting large variations in predictions between the models. This variability makes it very difficult for managers to plan for future site reclamation requirements, or even to accept the causes of concern and the need to plan for change.

For a detailed review of GCMs and other models see Liss and Crane (1983) and Schlesinger (1988).

Potential Effects

Most of the consequences of global warming would result from three physical changes - sea level rise, higher local temperatures, or changes in precipitation patterns (Titus 1990). The potential effects of climate change may be drastic - deserts may expand, crop production in today's marginal lands may be seriously reduced, annual global rainfall may increase up to 11% with the tropics becoming wetter and the sub-tropics becoming drier, extremes of weather may become more common, available soil moisture may decrease, winters may be shorter and summers longer, forest fire intensity and frequency may increase, insects and diseases may spread further north, and wildlife migration patterns may change, among other effects (Brundtland 1990; Hare 1989; Maini 1989; Rizzo 1990; UNEP 1987).

Or, none of these may occur. There is great debate among scientists in this area, both about whether any effects will be seen and the magnitude of these effects. For example, Jaeger (1988) stated that sea level may rise between 30 cm and 150 cm, while Titus (1990) reported 30 to 200 cm.

CO_2 acts as a fertilizer, therefore the additional CO_2 creating climate change will also have a direct effect on vegetation (UNEP 1987). Indeed some commercial greenhouse producers use CO_2 to increase yields (Liss and Crane 1983). This growth-inducing effect will occur for both crop plants and weed species, thus it is difficult to determine if this will result in a net benefit to man. Krupa and Kickert (1989) have reviewed the literature regarding the effects of CO_2 on individual plant species; they note that much less is known about the effects on whole ecosystems.

The effects are generally expected to be greater at higher latitudes than in the tropics. This development could prolong the growing season for crops in the northern Great Plains; however these benefits may be offset by drier summers and more frequent heat waves (Douglas 1990). The same is true for the boreal forest (Maini 1989).

As climate is one of the most important factors governing ecosystem distribution and composition, the most radical change for reclamationists will be the major shifts in ecological regions. Using 600 and 1300 growing-degree-day isolines as the southern and northern limits of the boreal forest in Canada, and the GISS and GFDL models, Wheaton and Singh (1988) estimated potential northward shifts in the northern boundary of 100 km to 700 km, and 250 km to 900 km for the southern boundary.

Thus any Prairie Province sites in the southern portions of this region that were planned for revegetation to boreal forest species could gradually develop towards grassland or transitional grassland ecosystems (Rizzo 1990), which may require completely different revegetation species to be successful. Furthermore, even though these new areas would have the climate of a grassland ecosystem, they would not have grassland soils (Rizzo 1990), thus revegetation may be further hampered until the soils develop grassland characteristics (a very long time).

This potential shift in the ecological region will pose a particular problem for those advocating the use of native species. Where should the revegetation species be native to? Many reclamationists have been moving towards use of genetic material from on site or as close to it as possible in order to ensure "native" species are being used. Will this be suitable in the future, or is it perhaps fortuitous that in Alberta most of our "native" seed happens to come from Montana, Colorado or California?

The effects of climate change will be felt in other reclamation areas besides revegetation. In particular, water resources are immediately sensitive to climate change (Jacobs and Riebsame 1989). For example, if precipitation increases in a given location, will water control structures, sediment basins, reconstructed streams and lakes, or tailings ponds that are designed to withstand current storms and water inputs be suitable for, and safe in, the changed climate? Will wetlands be flooded or will they dry up? Will a rise in sea level flood expensively reclaimed sites in Australia's coastal mineral sands mines or Florida's phosphate mines?

Other water related questions also arise. Will salts in spoils buried at currently "safe" depths move up or down under changed precipitation and evaporation rates thus limiting future sustainability of the reclaimed soils? Will acid mine drainage increase as a result of more precipitation?

Planning for Change

What can reclamationists do to prepare for climate change? First, we must decide if there really is any change to plan for. Many authors caution against jumping the gun (e.g., "...water resource managers must now seriously consider the potential for future climate change. However, the evidence does not currently recommend drastic changes in the planning and operating of water systems..." - Jacobs and Riebsame 1989), or note that there are other pressing problems which are much more certain (e.g., "...temperature trends become academic if we are all dead from poisoned water." - Ball 1989, 1990). Others are more certain that action must be taken (e.g., "...the potential risks are so high that we cannot sit back hoping that problems will go away. We are the ones who must take initiative." - Brundtland 1989).

If planning for change is needed, there are three possible strategies (Schneider 1988): prevention or limitation, mitigation, and adaptation. Prevention, the most active approach, would involve reductions or abandonment of the use of greenhouse gases such as CFCs, and a reduction in the use of fossil fuels.

Mitigation is the purposeful intervention in the environment to minimize the potential effects of change by affecting climate processes (e.g., deliberately spreading dust in the stratosphere to reflect sunlight and cool the earth). Planting species with high CO_2 fixation rates and large belowground and aboveground biomass storage systems in current and future reclamation efforts will help reduce the CO_2 available to induce climate change, and thus is, in itself, a prevention strategy (Bach 1984; Revelle 1989).

Most people associate this strategy with planting trees (Liss and Crane 1983; Sedjo and Solomon 1989), however there are many non-woody species which may fit these criteria as well. Furthermore, stable organic matter is a good carbon sink, thus any ecosystem which produces a lot of stable organic matter will also fit these criteria.

Adaptation strategies adjust the environment or our ways of using it to reduce the consequences of climate change (Jaeger 1988), and appear to be the main strategy open to reclamationists.

Since climate change is, itself, in question, and since predictions of the effects of change on a given site are speculative at best, Douglas (1990) recommends "a contingent decision-making framework ... meaning one in which we make a set of decisions now, based on what we know, and then plan to improve on these decisions once more knowledge has been gained." Titus (1990) indicates that "...there are many anticipatory (adaptive) responses that would substantially reduce adverse impacts of global warming with relatively little risk of the response proving to be ill advised should the expected effects of global warming fail to unfold."

The simplest way to prepare is to learn as much as possible about the predicted changes for your region, and the range of conditions that your soils, landscapes, and especially your revegetation species can tolerate. If your site is located at the border of a climatic or ecological zone, or at the limit of an important plant species, you may need to give more thought to potential change than if you are in the centre of a large region. Similarly, the further north, or the higher up, you are the more you may need to plan for change.

Plant a diversity of species and lifeforms (which is a good idea for reclaimed sites at any time) as a hedge against change by providing a range of tolerances in your revegetation mix. Select species which will grow in your current ecological zone, but which will also be viable in the zone predicted for your site. Plant carbon-storing vegetation now so that you can contribute to CO_2 reduction (this may also be good public relations for industries associated with CO_2 production), but make sure they are species that are likely to be suitable for the new climatic zone.

Design permanent water bodies and structures with a bit more room to handle the additional water that may be present in the future. Evaluate the role and importance of soil water in your reclamation plans, particularly in relation to release rates for contaminants (e.g., acid mine drainage) using both current and predicted precipitation rates. Determine if current materials handling practices need to be, or could be, changed to deal with the effects of these new precipitation rates.

Remember that climate change is not just a problem for future reclamationists to worry about. If you are currently planning or undertaking revegetation using long-lived species such as trees then you should be giving some consideration to the environment they may experience in the future. Revegetation schemes using more rapidly adaptable species such as grasses and forbs may pose less of a problem.

Or do nothing - it is up to you.

Acknowledgements

The authors are indebted to the following people for providing review comments and reference material: Anne Naeth (University of Alberta), Arnold Janz and Stuart Loomis (Alberta Environment), and Terry Macyk (Alberta Research Council).

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