

DAS BILD DER LANDSCHAFT ÄNDERT SICH

Dagmar Haase und Matthias Rosenberg

Zu den Faktoren, welche den Zustand und die Funktionsfähigkeit der Landschaft am nachhaltigsten beeinflussen, zählt die Landnutzung. Vielerorts wurde und wird sie intensiv betrieben und gerät so leider allzu oft in Konflikt mit dem für die Zukunft der Menschheit so immanent wichtigen Schutz der biotischen und abiotischen Ressourcen. Betrachtet man die enormen Landschaftseingriffe durch Braunkohleförderung und die sich anschließende völlige Neugestaltung der betroffenen Gebiete, so ist Mitteldeutschland sicher ein Extremfall. Doch die Frage stellt sich weltweit: Wie weit kann der Mensch gehen, ohne dass natürliche Regulationsmechanismen in der Natur versagen? Landschaftsökologen arbeiten auf internationaler Ebene und mit modernster Technik an deren Beantwortung. Dabei haben sie erkannt, von welcher enormen Bedeutung es ist, auch die Vorgeschichte einer Landschaft in ihre Betrachtungen einzubeziehen ...

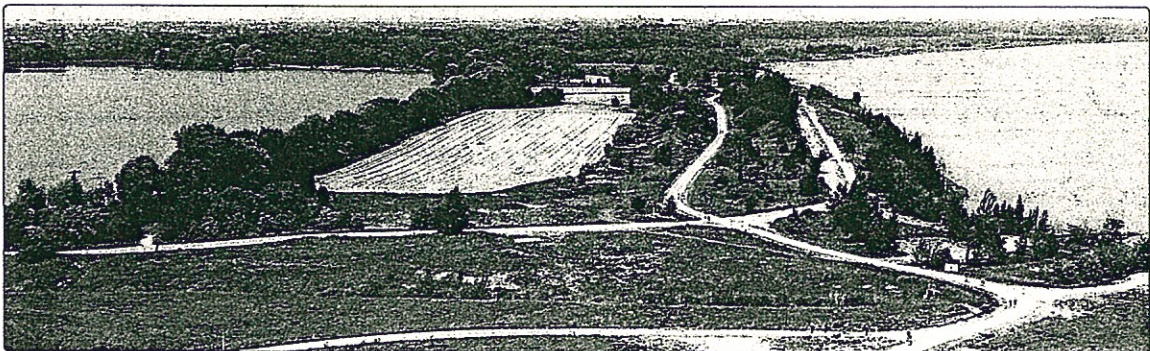
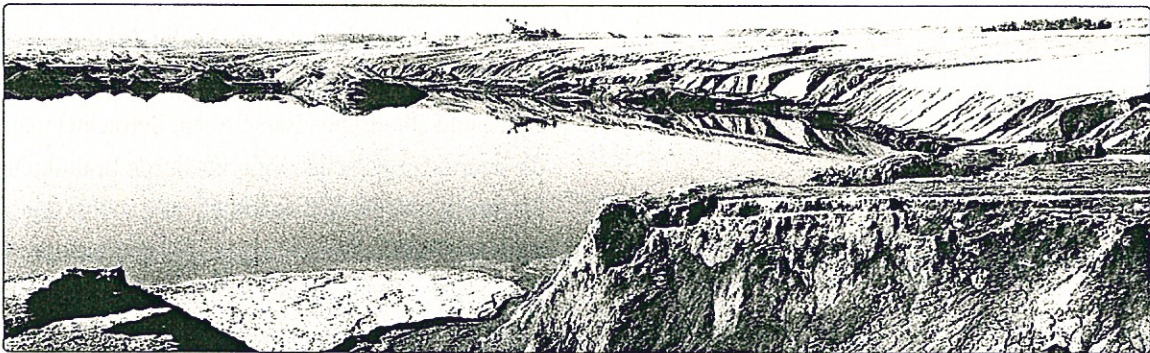
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Bilder 1; 2; 3: Drei Bilder ein und desselben Landschaftsausschnittes. Die Elsteraue am Südrand von Leipzig, nahe des Tagebaus Cospuden. 1880: Auenlandschaft; 1998: die Re-kultivierung des Tagebaus Cospuden ist in vollem Gange; 2002: Das Tagebauresifloch ist zum Badesee und Erholungsgebiet für die Bewohner Leipzigs geworden.

1880: Ein waldgesäumter Flusslauf windet sich durch die Grundmoränen des Leipziger Landes und überflutet seine wenig eingetieft Talebene. Ackerland und vor allem kleine Dörfer liegen wenige Meter über der Aue am Rande der Grundmoränenplatten. Feuchtwiesen in den waldfreien Auenbereichen formen das Landschaftsbild. Es sind noch viele Kilometer bis zur Stadtgrenze Leipzigs ...

1980: Der Braunkohlebergbau hat sich bis an die Stadtgrenze Leipzigs herangefressen. Schon hat man auch unter der Stadt großflächige Kohlevorkommen gefunden. Weite Auenbereiche und das Ackerland sind verschwunden, genauso wie die dörfli-

chen Siedlungen. Industrie und Bergbau bestimmen das Landschaftsbild bis zum Horizont ...

2002: 4,3 Quadratkilometer Wasserfläche – mit dem Cospudener See hat sich im Süden der Großstadt Leipzig ein erster ehemaliger Tagebau in ein Erholungsgebiet verwandelt, mit Sandstrand und Yachthafen – und alles innerhalb von zehn Jahren. Eine so große Wasserfläche gibt es natürlicherweise im Altmoränenland der Leipziger Tieflandsbucht nicht. Und es sollen noch weitere Seen entstehen, deren Ufer von neuen Wäldern und Stränden begrenzt sein werden.



Bild 4: Faktoren, die den Wandel von Landschaften bestimmen.

Der Konflikt

Seit es den Menschen gibt, nutzt er bewusst die ihn umgebende Landschaft – die Böden, die Rohstoffe, die Gewässer und biologischen Ressourcen – und verändert sie damit. Auch natürliche, vom Menschen kaum beeinflussbare Prozesse verändern die Landschaft. In Mitteleuropa geschah das zuletzt am gravierendsten mit der Eiszeit vor rund 22.000 Jahren. Als die Eispanzer etwa 10.000 Jahre später das Land freigaben, hatte es keinerlei Ähnlichkeit mit dem vorher da gewesenen. Die Geschichte der Veränderung der Landschaft von Menschenhand begann damit wieder von Null an, jedoch zunehmend häufiger, intensiver sowie in immer kürzeren Zeiträumen. Der Konflikt zwischen Nutzung und Erhalt war irgendwann vorprogrammiert. Doch was heißt Erhalt von Natur und Landschaft aus heutiger Sicht? Im Bundesnaturschutzgesetz steht: dass Natur und Landschaft »...für die künftigen Generationen im besiedelten und unbesiedelten Bereich so zu schützen, zu pflegen, zu entwickeln und, soweit erforderlich, wieder herzustellen ist, dass

1. die Leistungs- und Funktionsfähigkeit des Naturhaushalts,
2. die Regenerationsfähigkeit und nachhaltige Nutzungsfähigkeit der Naturgüter,
3. die Tier- und Pflanzenwelt einschließlich ihrer Lebensstätten und Lebensräume sowie

4. die Vielfalt, Eigenart und Schönheit sowie der Erholungswert von Natur und Landschaft auf Dauer gesichert sind.« (BNatGes § 1, Abs.1, 2002).

Wissenschaftler von nahezu allen Kontinenten beschäftigen sich seit zirka 30 Jahren intensiv mit diesem Konflikt. Ein wichtiges Forum ist beispielsweise die Internationale Gesellschaft für Landschaftsökologie (International Association of Landscape Ecology, IALE), innerhalb der über 1.000 Landschaftsökologen, Geografen, Biologen und Agrarwissenschaftler in den verschiedensten Projekten zusammen arbeiten. Sie suchen Antworten auf solche Fragen wie: Ist man heute an einer Schwelle angekommen, wo natürliche Retentions- und Regulationsmechanismen der Natur zunehmend versagen und eine Übernutzung der Landschaft nicht mehr aufzuhalten ist? Befinden wir uns vielleicht nur am Ende einer Epoche intensivster landwirtschaftlicher Nutzung, Siedlungsausdehnung und Biotopzerschneidung, welche schon in den nächsten Jahrzehnten abklingen wird? In welchen Zeiträumen und in welcher Intensität geschehen überhaupt gravierende Landschaftsveränderungen?

Auch die Landschaftsökologen des UFZ bringen sich in diese Diskussion ein. Konkretes Forschungsobjekt für sie ist in vielen Fällen der mitteldeutsche Raum, geradezu prädestiniert für Untersuchungen des Landnutzungswandels, der Landschaftsstruktur



beziehungsweise deren Einfluss auf die »Leistungsfähigkeit« des Naturhaushaltes und der Biodiversität. Sie schenken dabei den historischen Landschaftszuständen ebenso Aufmerksamkeit, wie der Analyse der Triebkräfte dieser Entwicklungen in Vergangenheit und Zukunft sowie den Trends der Landschaftsentwicklung in den kommenden Jahrzehnten.

Ausgehend von Trendanalysen zur künftigen Landnutzung, die auf ökonomischen, sozialen und naturwissenschaftlichen Indikatoren beruhen und unter Berücksichtigung der europäischen Förderpolitik sowie der räumlichen Gesamtplanung in Deutschland, werden Szenarien zur Art und Intensität der Veränderungen von Landschaften erarbeitet. So zeigte sich bei den Analysen, dass sich in Mitteleuropa die Landwirtschaft immer mehr auf wenige fruchtbare Gebiete beschränken und viele bisher genutzte Flächen aufgegeben wird.

Vorstellungen zum historischen und zukünftigen Landnutzungswandel sind die Grundlage für eine modellbasierte Abschätzung der Nutzungsveränderungen, zum Beispiel auf den Wasser- und Stoffhaushalt. Auf Basis derer sollen dann, so wie es unter anderem die Europäische Wasserrahmenrichtlinie fordert, Bewirtschaftungspläne erarbeitet werden, die der Sicherung eines guten ökologischen und chemischen Zustandes der Oberflächengewässer und der Verfügbarkeit an Grundwasser dienen (Bild 4).

Zwei Beispiele sollen die allgemeinen Betrachtungen illustrieren.

Städte dehnen sich aus . . .

Prognostiziert wird für den Zeitraum 1997 bis 2010 ein Anstieg der Siedlungs- und Verkehrsflächen in Deutschland von 530.000 Hektar. Das bedeutet einen täglichen Zuwachs von 112 Hektar – eine Größe von mehr als 100 Fußballfeldern. Doch wie sieht es diesbezüglich in Mitteldeutschland aus?

Wie man das Wachstum von Städten und anderer Landnutzungsänderungen über große Zeiträume und vor allem auch historische Landschaftszustände bestimmen und dabei auch die ökologische Funktionsfähigkeit betrachten kann, erprobten die Wissenschaftler am Beispiel der Region um Taucha, einer Kleinstadt im Nordosten Leipzigs.

Das historische Kartenmaterial digitalisierten sie mithilfe Geografischer Informationssysteme (GIS). Dabei gehört viel Erfahrung im Umgang mit kartografischen Darstellungen dazu, alte Karten zu »lesen« und zu interpretieren, eine wesentliche, wenn auch nicht alltägliche Aufgabe für Landschaftsökologen. Diese histori-

Bild 5: Anhand der drei Zeitschnitte ist die zunehmende Zersiedelung der Landschaft um Taucha und vor allem der Auen sehr gut sichtbar. (Inhalt, Kartografie und GIS: D. Thormann; Datenquelle: Landesvermessungsamt Sachsen)



schen – nun computertauglich aufbereiteten Daten – werden mittels der Koordinaten in einem Geografischen Informationssystem mit aktuellen Karten, Luft- und Satellitenbildern überlagert und verglichen. So sind genaue statistische Analysen von Flächennutzungs- und beispielsweise Versiegelungsentwicklung möglich. Außerdem gestatten die Datenbanken des GIS, den Einfluss von Nutzungsänderungen auf bestimmte Landschaftsfunktionen zu bestimmen, zum Beispiel den Einfluss der Suburbanisierung auf das Abflussverhalten und die Grundwasserneubildung. Beides sind wichtige Faktoren einer intakten Landschaft, was nicht zuletzt die katastrophale Elbe- und Muldeflut im August 2002 gezeigt hat. Das Abflussverhalten kennzeichnet das Vermögen der Landschaft, insbesondere der Böden, in Abhängigkeit von der Art der Nutzung, den Oberflächenabfluss des Niederschlagswassers so aufzunehmen und zu regulieren, dass auch die Gefahr von Überschwemmungen gemindert wird. Die Grundwasserneubildung ist ein Prozess, welcher zur Erneuerung der Wasserressourcen in einer Region beiträgt. Beide Prozesse sind direkt miteinander verbunden – dort, wo der oberflächliche Abfluss hoch ist, findet wenig Grundwasserneubildung statt und umgekehrt.

In Bild 5 sind für die Region Taucha die Veränderungen der Flächennutzung in drei Zeiten – 1879, 1927 und 1997 – dargestellt. Auf deren Basis erfolgten die Modellierungen zur Abflussregulation. Gut erkennbar ist, wie die Siedlungen und somit auch der Anteil bebauter beziehungsweise versiegelter Fläche am nordöstlichen Stadtrand von Leipzig besonders nach der politischen Wende im Jahr 1990 stark zugenommen hat und Auen sowie Freiflächen um die Stadt immer seltener wurden. Das bedeutet insbesondere für die Bewohner der Innenstadt Leipzigs immer weitere Wege ins Grün. Darüber hinaus hat die Parthe ihre Funktion als Retentionsraum für Überschwemmungen verloren, denn das 1879 noch gut erkennbare grüne Band ihrer Auenlandschaft – wichtig als Rückhalte- oder Retentionsraum für Wasser

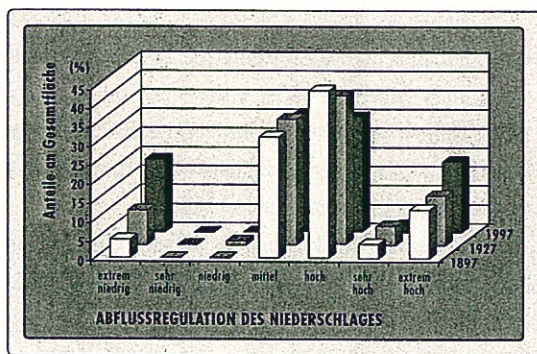
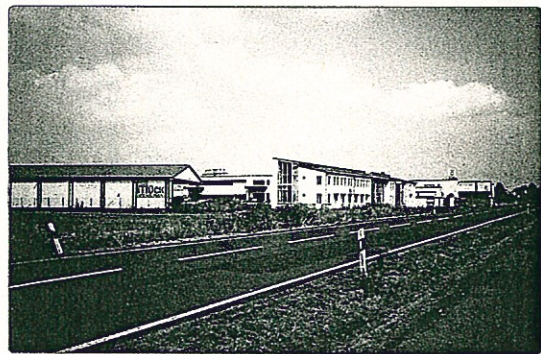
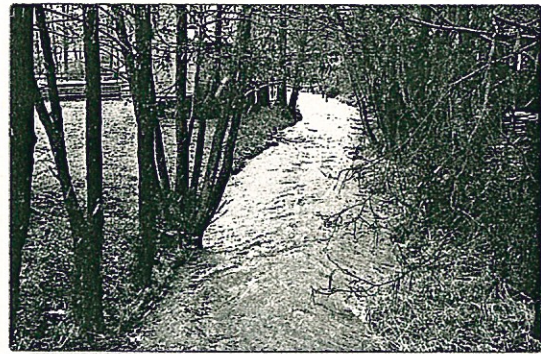


Bild 6: Die Versiegelung der Böden vermindert das Abflussregulationspotenzial der Erdoberfläche in dieser Region drastisch, wie die seit 1897 zunehmenden Anteile mit extrem niedrigem Abflussregulationspotenzial zeigen.



Bilder 7 und 8: Ganz nah beieinander und doch weit entfernt – Eindrücke aus dem Einzugsgebiet der Parthe heute: relativ naturnahe Flussabschnitte liegen direkt neben neu errichteten Gewerbezentren mit hohen Bodenversiegelungsraten.

und Sedimente aus dem Einzugsgebiet der Parthe – ist 1997 an vielen Stellen durch bebaute Flächen und Ackerflächen unterbrochen, so dass kein zusammenhängender funktionierender Auenraum mehr vorhanden ist. Damit ist auch der Wanderungs- und Verbreitungskorridor für viele Tier- und Pflanzenarten weitgehend verloren gegangen. Wasserschwertlilie (*Iris pseudacorus*) oder Ackergoldstern (*Gagea arvensis*) beispielsweise, früher in dieser Gegend weit verbreitet, kommen hier nicht mehr vor. Es besteht aller Grund zu der Annahme, dass sich der Zersiedlungsprozess in der Landschaft rund um Leipzig weiter fortsetzen wird und Freiflächen in wenigen Jahrzehnten zu einem sehr raren Gut werden: denn legt man die ermittelte Dynamik von 1879 bis 1997 von 1181 Hektar Zunahme an versiegelter Fläche im Umland von Taucha zu Grunde und bezieht in den Trendanalysen aktuelle Bauvorhaben wie das BMW-Gelände in der Partenaue und weitere ausgewiesene Bauerweiterungsflächen für Wohnbebauung ein, muss man zu dem Schluss kommen, dass trotz schrumpfender Bevölkerung in Leipzig und anderen Regionen Mitteldeutschlands die natürlichen Retentions- und Regulationsmechanismen der Natur zunehmend versagen. Die Hochwässer 2002 haben es gezeigt.

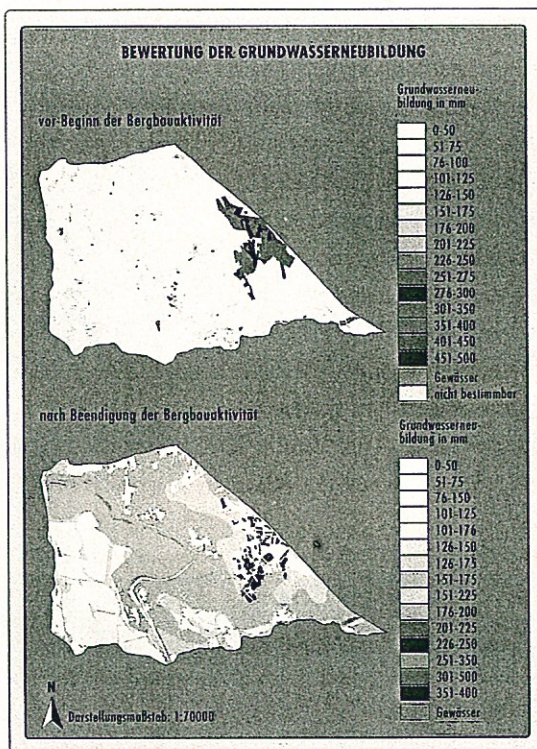


Bild 9: Das Gebiet des ehemaligen Tagebaus Espenhain vor Beginn der Bergbauaktivitäten und heute kurz vor dem Beginn der Restseeflutung: durch Bergbau und Siedlungserweiterung erfolgte eine starke Veränderung der räumlichen Verbreitung der Grundwasserneubildungsrate. (Inhaltliche und kartografische Bearbeitung: Yvonne Voigtmann)

Die Landschaftsökologen des UFZ sind der Auffassung, dass eine Übernutzung der Landschaft trotz der flächenintensiven Landschaftsveränderungen nach 1990 aufzuhalten ist. Um die bestehenden politischen und rechtlichen Instrumente zu schärfen und zu untermauern, werden solche Landschaftsanalysen für viele Regionen Europas unerlässlich ...

Die mitteldeutsche Tagebauregion entwickelt sich zu einer Seenplatte ...

Nach Jahrzehnten der Vernichtung von Ackerland, Wäldern, Siedlungen und Auen sowie der Verlegung von Flussläufen wird sich der Südraum Leipzig etwa im Jahre 2050 zu einer Landschaft mit einer Seenfläche von 70 Quadratkilometern verändert haben, die eine Vielzahl von Nutzungs- und Entwicklungsmöglichkeiten bietet. Heute, wo weniger Bedarf an landwirtschaftlichen Produktionsflächen besteht, werden die Flächen der Bergbaufolgelandschaft zum Teil als Freizeitareale sowie unter ökologischen Gesichtspunkten umgestaltet. Dies kann einerseits die Belassung der Kippenflächen in einem möglichst unsanierten Zustand bedeuten –

so fordert es der Naturschutz – oder es bedeutet Aufforstung, wie beispielsweise zu großen Teilen im recht waldarmen Südraum von Leipzig. Hier förderte der Tagebau Espenhain von 1937 bis 1994 über 570 Millionen Tonnen Braunkohle. Er vernichtete solche Gebiete wie die Göselau, die einen wichtigen Regulationsraum für den Wasser- und Stoffkreislauf im Leipziger Land darstellte. Bis zum Jahr 2020 wird ein Seen-System aus Störmthaler See (6,9 Quadratkilometer) und Markkleeberger See (2,5 Quadratkilometer) große Teile der zwischenzeitlich zum Tagebau gewordenen ehemaligen Göselau und der sie umgebenden Flächen einnehmen.

Die wissenschaftliche Analyse der Landschaftsfunktionalität im Südraum von Leipzig führten Wissenschaftler verschiedener Institutionen im Rahmen eines Testlaufs für ein so genanntes überregionales Landschaftsmonitoring-Programm durch. Solch ein Monitoring versucht, alle Komponenten der Landschaft, beispielsweise Boden, Relief, Klima, Wasserhaushalt, Flora und Fauna sowie die Nutzung gleichermaßen und die Landschaftsveränderungen flächenhaft und ökologisch ganzheitlich in der Zeit zu betrachten. Das im speziellen Fall verwendete und getestete Landschaftsmonitoringkonzept soll gültige Methoden und Parameter für größere Räume herausarbeiten. So wird eine ökologische Analyse und Bewertung verschiedenster Naturräume in Sachsen bzw. darauf aufbauend in ganz Deutschland möglich. Da Bergbau- und Bergbaufolgelandschaften zu den dynamischsten Räumen Mitteldeutschlands hinsichtlich des Landschaftswandels zählen, können auf den Nutzungswandel zurückzuführende Veränderungen des Wasser- und Stoffhaushaltes hier beispielhaft modelliert und eindrucksvoll visualisiert werden (Bild 9). Die Veränderungen, die zwischen 1944 und 1996 in der Ackerbauregion der Göselau erfolgt sind, lassen sich wie folgt charakterisieren:

- großflächige Veränderung des Reliefs und Entstehung von Voll- und Hohlformen (Restlöcher, Kippen, Halden);
- Veränderung der Substratlagerungsverhältnisse, großflächige Durchmischung und Neuschichtung der Böden und Sedimente;
- Zerstörung natürlicher Böden, insbesondere der für den Landschaftshaushalt wichtigen Göselau und Entstehung heterogener Kippböden, welche erst in Jahrzehnten wieder eine initiale Bodenentwicklung zeigen werden und schließlich
- Begradigung und Kanalisierung des Vorfluters Gösel, bis zur völligen Vernichtung seiner natürlichen Retentionsflächen sowie Feuchtbioptopen in der Aue.

Im Rahmen der Planung zur Gestaltung des Tagebaus Espenhain entwickelten UFZ-Wissenschaftler in Zusammenarbeit mit der LMBV (Lausitzer und Mitteldeutschen Bergbau-Verwaltungsge-

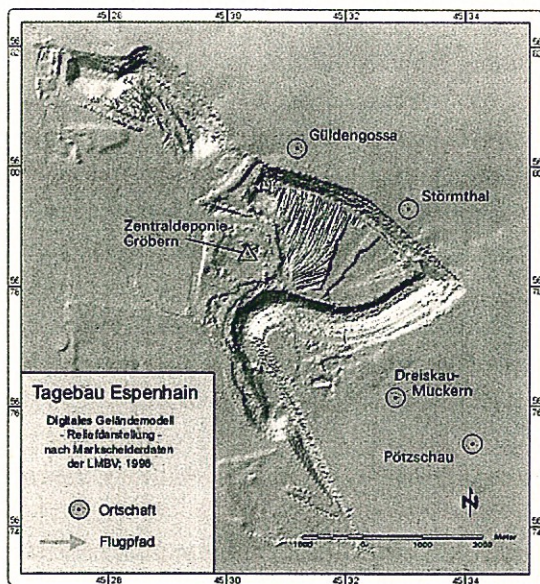


Bild 10: Eine wesentliche Datenquelle für Untersuchungen zum Landschaftswandel sind feinaufgelöste digitale Geländemodelle, hier eines vom Tagebau Espenhain 1998 (nach Markscheiderdaten der LMBV)

sellschaft mbH) eine Methode, die es erlaubt, reale Landschaften und deren Veränderungen unter Anwendung der visuellen GIS-gestützten 3D-Simulation abzubilden. Dieses Verfahren ermöglicht Landschaftsplanern einen räumlichen Eindruck der Landschaftsveränderungen. Des Weiteren stellt es ein wichtiges Hilfsmittel zur visuellen Kommunikation und Entscheidungsfindung im Planungsprozess und zur Entwicklung von Planungsalternativen – auch mit der betroffenen Bevölkerung – dar.

Für den zukünftigen Störmtaler See wurden vier visuelle dynamische Simulationen entwickelt (Bilder 11 und 12). Sie entstanden durch die Überlagerungen von Flächennutzungsdaten (Planungsunterlagen, Luft- und Satellitenbilddaten) und einem aus Vermessungsdaten gewonnenen digitalen Höhenmodell (Bild 10).

Bild 11: »Tagebauegebiet Störmtaler See« – Die 3D-Visualisierung von zwei unterschiedlichen Planungsvarianten (links). Sie unterscheiden sich vor allem im Bereich der Böschungshöhen (rechts).

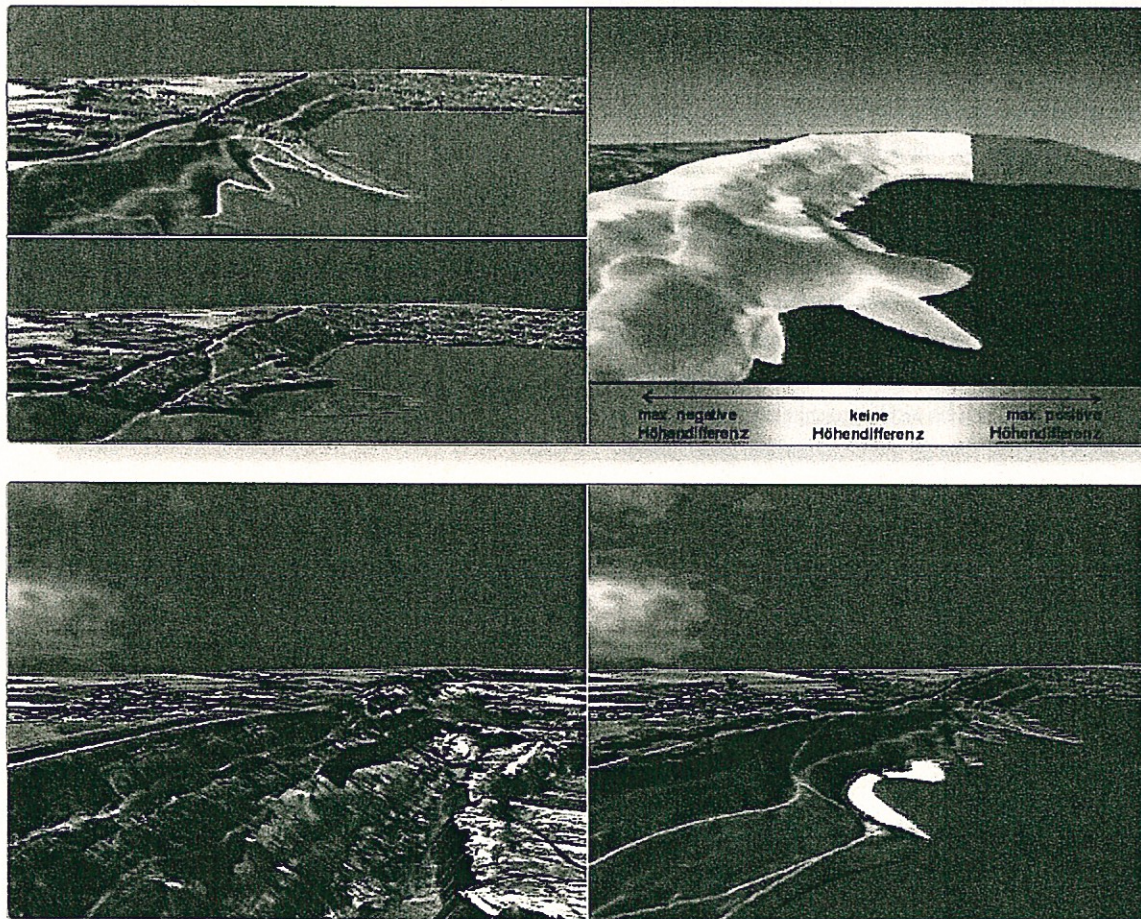


Bild 12: »Tagebauegebiet Störmtaler See« – 3D-Visualisierung der Ausgangssituation 1998 als Tagebaurestloch (links) sowie einer Planungsvariante zur zukünftigen Gestaltung (rechts).



Fazit

Die wissenschaftlichen Arbeiten zum Wandel von Nutzung und zur Struktur einer Landschaft sowie deren Einfluss auf die Leistungsfähigkeit des Naturhaushaltes stellen eine wichtige Grundlage für die Landschafts- und Regionalplanung dar und dienen als Instrumente der Entscheidungsfindung für regionale und lokale Fachbehörden. Im Falle des UFZ sind das unter anderem das Sächsische Landesamt für Umwelt und Geologie, die Staatlichen Umweltfachämter Leipzig und Chemnitz und die Regierungspräsidien der Regierungsbezirke im Saale-Flussgebiet. Ebenso sind sie für einen breiten Interessentenkreis vom Bürger vor Ort bis hin zu Wissenschaftlern vom Bundesamt für Bauwesen und Raumordnung, welche sich mit langfristigen Trends der Raumentwicklung in Deutschland beschäftigen, von großer Bedeutung, zeigen sie doch, wie sich die umgebende Landschaft verändert und wie das, was sich Planer für die Zukunft vorstellen, in der Landschaft später aussehen wird.

Wie weit kann nun der Mensch gehen, ohne dass natürliche Regulationsmechanismen in der Natur versagen? Die bisherigen Untersuchungen der UFZ-Landschaftsökologen untermauern wissenschaftlich, dass eine Reihe natürlicher Regulationsmechanismen der Landschaft, wie zum Beispiel der Abfluss- und Hochwasserrückhalt, aufgrund fortwährender Verbauung von Auen und Freiflächen, nur noch eingeschränkt funktionieren und örtlich tatsächlich versagen.

Die Wissenschaftler werden in Zukunft weitere spezifische Untersuchungen zu den Trends der Flächennutzungsentwicklung und deren Einfluss auf natürliche Landschaftsfunktionen durchführen – ein Baustein, um ein wirklich nachhaltiges »Miteinander« von Mensch und Natur in der multifunktionalen mitteleuropäischen Kulturlandschaft durchzusetzen.

THE CHANGING FACE OF THE LANDSCAPE

Dagmar Haase and Matthias Rosenberg

One of the factors which has the most lasting impact on the condition and function of the landscape is land use. The land around us was and still is intensively used in many places, yet all too often this clashes with the aim of protecting the biotic and abiotic resources mankind needs. Central Germany is doubtless an extreme case given the extensive ravaging of the landscape by lignite mining and the subsequent complete reshaping of the areas concerned. But all over the world, the question of how far mankind can go before nature's regulatory mechanisms finally collapse has become highly relevant. Landscape ecologists are using cutting-edge technology to tackle this issue internationally. One of their key findings is that a landscape's history also needs to be taken into account.

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Figures 1, 2, 3: Three pictures of the same landscape segment. The Elster floodplain on the southern edge of Leipzig near Cospuden opencast mine. 1880: floodplain landscape. 1998: the reclamation of Cospuden mine is in full swing. 2002: the mine pit has been transformed into a lake popular among Leipzig residents for swimming and other recreational activities.

1880: A river winds its way through the base moraine of the Leipzig district, flooding the slight surrounding depression. Farmland and small villages lie a few metres above the floodplain on the edge of the base moraine plates. The sections of the floodplain not containing woodland are marshy. Leipzig's city limits are still several kilometres away.

1980: Lignite mining has eaten its way to the very edge of Leipzig and extensive deposits of lignite have been found beneath the city itself. Large areas of floodplains and farmland have disappeared, as have the villages they once contained, to be replaced by industry and mining as far as the eye can see.

2002: Within the space of just ten years, an old opencast mine has been transformed into Lake Cospuden, complete with a sandy beach and a yachting harbour. Measuring 4.3 sq km, such large areas of water do not occur naturally in the old moraine of the Leipzig lowland indentation. Other lakes are currently emerging with beaches and woodlands on the shore.



Figure 4: Factors which determine the change of landscapes.

The conflict

Mankind has always used – and hence altered – the surrounding landscape and its components such as soil, raw materials, water and biological resources. In addition, the landscape is exposed to natural processes of change which are virtually impossible for mankind to influence. The last major example of this in central Europe was the ice age about 22,000 years ago. By the time the land was finally free of ice about 10,000 years later, the landscape had been drastically reshaped. The history of anthropogenic landscape changes hence started all over again, the difference being that this time they were increasingly more frequent, more intensive and shorter than before. It was inevitable that usage and preservation would eventually clash. But what exactly do we mean nowadays by the preservation of nature and the landscape? According to the German Conservation Act, nature and landscapes:

»... are to be preserved, nurtured, developed and if necessary restored in both populated and non-populated areas in order to lastingly safeguard:

- 1. The function and efficiency of the balance of nature;*
- 2. The regeneration and sustainable exploitability of nature's resources;*
- 3. Fauna and flora along with their habitats;*

4. The variety, particularity and beauty of nature and landscapes.« (Section 1, para.1 German Conservation Act 2002)

This conflict has been studied by scientists from almost all continents of the world for about 30 years. One important forum they use is the IALE (International Association of Landscape Ecology), under whose auspices over 1,000 landscape ecologists, geographers, biologists and agricultural scientists are involved in all sorts of projects. Examples of the questions they are trying to answer include: Have we reached a threshold at which nature's natural retention and regulatory mechanisms are increasingly failing and the overexploitation of the landscape can no longer be stopped? Have we perhaps already reached the end of an era of highly intensive agricultural land use, the expansion of built-up areas and biotope fragmentation which will abate over the next few decades? How long does it take to drastically change the landscape – and how intensive is this process?

UFZ's landscape ecologists are also involved in this discussion. One of their main objects of study is central Germany. This region is ideal for investigating land-use change and landscape structures, and how they affect the »productivity« of the natural balance and biodiversity. As well as studying historical states of the landscape, they also analyse what drives these developments and future trends of landscape development.



Starting from trend analysis of future land use based on economic, social and scientific indicators, and taking into account European Union funding policy and overall spatial planning in Germany, scenarios on the type and intensity of landscape changes are compiled. One of the results to emerge is that in central Europe agriculture is being increasingly restricted to just a few fertile areas and many areas previously used for farming have since been abandoned.

These descriptions of past and future landscape transformation provide a basis for models which are used to estimate how land-use changes will affect the water and substance regime. Management plans can then be drawn up as specified by for instance the EU's Water Framework Directive to ensure that surface water is ecologically and chemically sound and to safeguard the availability of groundwater (Figure 4). These general aspects are illustrated below with two examples.

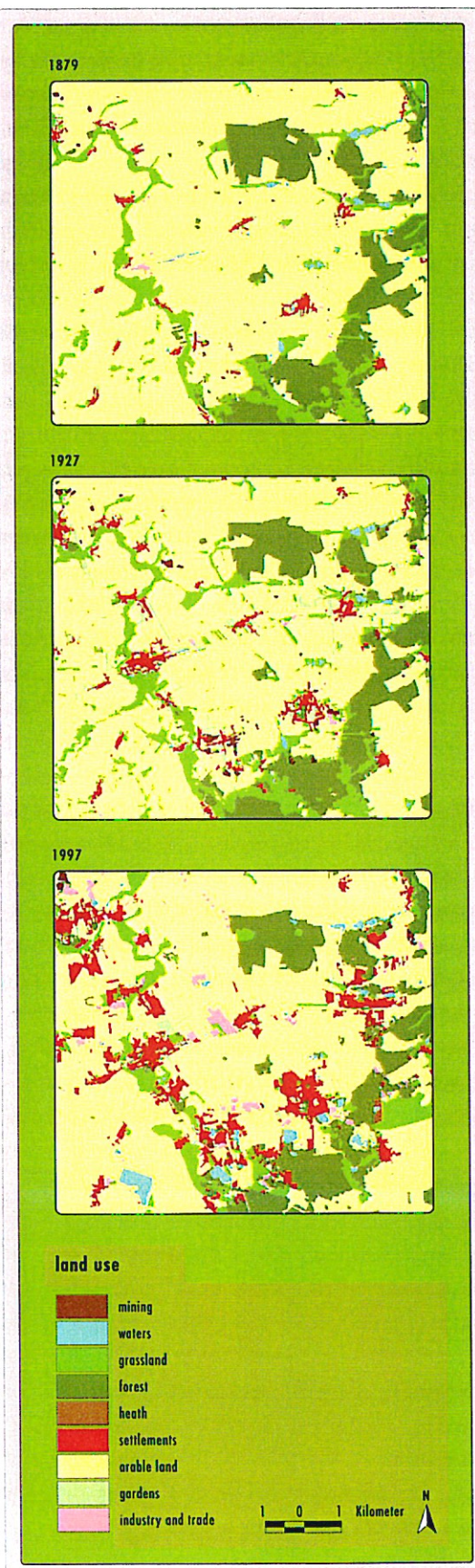
The urban sprawl

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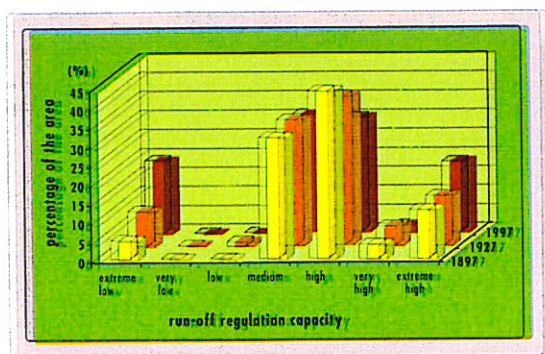


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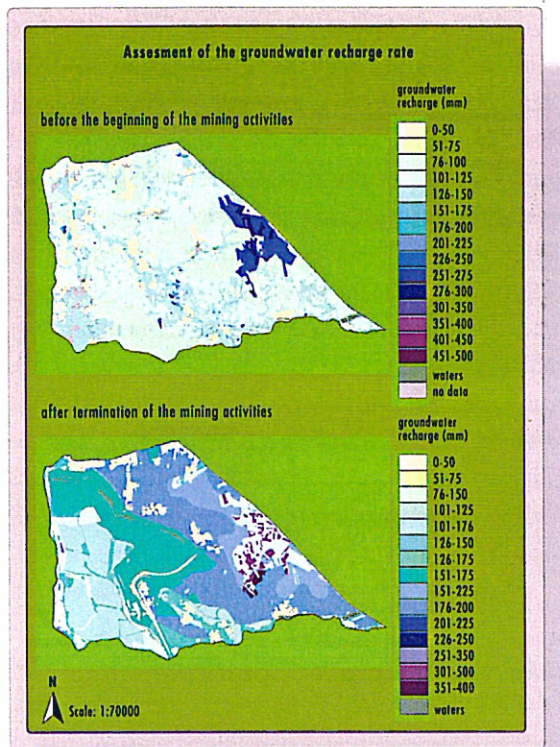


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Mines into lakes

After decades of devastation of arable land, woodlands, villages and floodplains and the diversion of rivers, by around 2050 the region south of Leipzig will have developed into a lake district with a total surface area of some 79 sq km of water with plenty of scope for a variety of usage and development. Nowadays less and less farmland is needed, and so disused mining pits are being ecologically landscaped to provide areas for tourism and recreation. This may mean leaving dumps as they are with as little remediation as possible (as called for by nature conservation), or alternatively afforestation, as is practised for example in large expanses south of Leipzig, an area which is low in woodlands. Over 570 million tonnes of lignite were mined here between 1937 and 1994 at Espenhain mine. The mine destroyed areas like the Gösel floodplain, which was an important regulation area for water and substance cycles in the Leipzig district. By the year 2020, a network of lakes including Lake Störmthal (6.9 sq km) and Lake Markkleeberg (2.5 sq km) will account for large parts of what used to be the Gösel floodplain before

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- Extensive change to the relief and the emergence of hollow and solid structures (mining pits, dumps, slagheaps);
- Changes to the substrate deposition conditions, with extensive mixing and restratification of soil and sediments;
- The destruction of natural soil, especially the Gösel floodplains important for the landscape balance, and the emergence of heterogeneous dump soils which need a few decades to undergo initial soil development;
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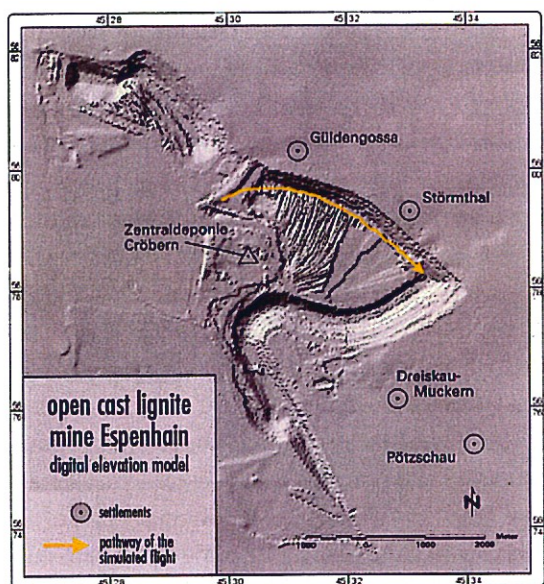


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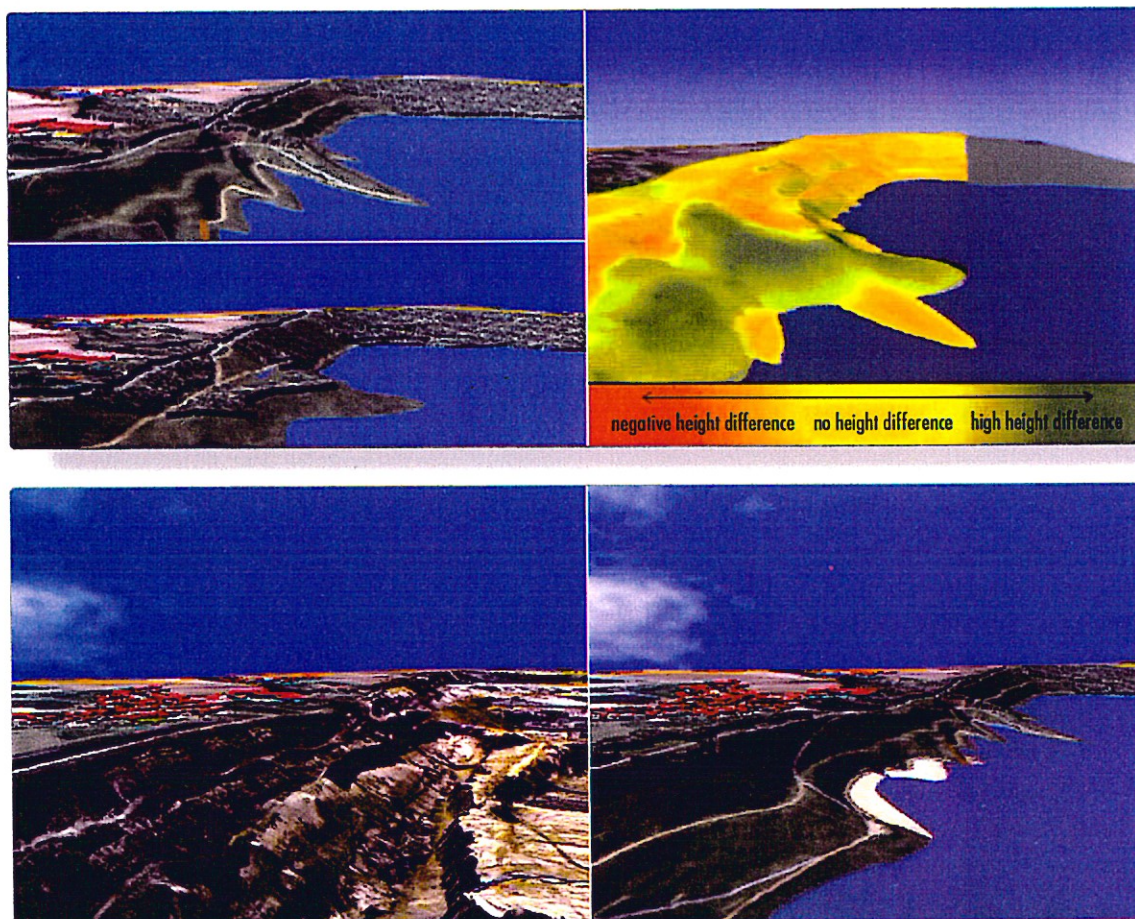


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Summary

The scientific work on the transformation of the usage and structure of a landscape as well as its influence on the productivity of the natural balance provides an important basis for landscape and regional planning and serves as decision-support instruments for regional and local planning agencies. In the case of the UFZ these include the Saxony Department of the Environment and Geology, the state environmental departments in Leipzig and Chemnitz, and the regional administration offices of the various districts in the Saale River basin. They are also important for a broad section of the local population as well as researchers from the State Department of Construction and Environmental Planning dealing with the long-term trends of spatial development in Germany since they show how the surrounding landscape changes and how planners' ideas will actually appear in the landscape.

So how far can mankind go before the natural regulatory mechanisms collapse? The investigations carried out by UFZ's landscape ecologists to date back up the opinion that a whole range of natural regulatory mechanisms in the landscape such as runoff and flood retention can only function to a limited extent and in some cases fail locally owing to the continuing consumption of floodplains and open spaces for construction.

In future the researchers will undertake additional specific investigations into trends of zoning development and their influence on natural landscape functions. This can be regarded as a module to help achieve genuinely sustainable »co-operation« between mankind and nature in the multifunctional central European cultural landscape.

THE CHANGING FACE OF THE LANDSCAPE

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One of the factors which has the most lasting impact on the condition and function of the landscape is land use. The land around us was and still is intensively used in many places, yet all too often this clashes with the aim of protecting the biotic and abiotic resources mankind needs. Central Germany is doubtless an extreme case given the extensive ravaging of the landscape by lignite mining and the subsequent complete reshaping of the areas concerned. But all over the world, the question of how far mankind can go before nature's regulatory mechanisms finally collapse has become highly relevant. Landscape ecologists are using cutting-edge technology to tackle this issue internationally. One of their key findings is that a landscape's history also needs to be taken into account.

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Figure 4: Factors which determine the change of landscapes.

The conflict

Mankind has always used – and hence altered – the surrounding landscape and its components such as soil, raw materials, water and biological resources. In addition, the landscape is exposed to natural processes of change which are virtually impossible for mankind to influence. The last major example of this in central Europe was the ice age about 22,000 years ago. By the time the land was finally free of ice about 10,000 years later, the landscape had been drastically reshaped. The history of anthropogenic landscape changes hence started all over again, the difference being that this time they were increasingly more frequent, more intensive and shorter than before. It was inevitable that usage and preservation would eventually clash. But what exactly do we mean nowadays by the preservation of nature and the landscape? According to the German Conservation Act, nature and landscapes:

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This conflict has been studied by scientists from almost all continents of the world for about 30 years. One important forum they use is the IALE (International Association of Landscape Ecology), under whose auspices over 1,000 landscape ecologists, geographers, biologists and agricultural scientists are involved in all sorts of projects. Examples of the questions they are trying to answer include: Have we reached a threshold at which nature's natural retention and regulatory mechanisms are increasingly failing and the overexploitation of the landscape can no longer be stopped? Have we perhaps already reached the end of an era of highly intensive agricultural land use, the expansion of built-up areas and biotope fragmentation which will abate over the next few decades? How long does it take to drastically change the landscape – and how intensive is this process?

UFZ's landscape ecologists are also involved in this discussion. One of their main objects of study is central Germany. This region is ideal for investigating land-use change and landscape structures, and how they affect the »productivity« of the natural balance and biodiversity. As well as studying historical states of the landscape, they also analyse what drives these developments and future trends of landscape development.



Starting from trend analysis of future land use based on economic, social and scientific indicators, and taking into account European Union funding policy and overall spatial planning in Germany, scenarios on the type and intensity of landscape changes are compiled. One of the results to emerge is that in central Europe agriculture is being increasingly restricted to just a few fertile areas and many areas previously used for farming have since been abandoned.

These descriptions of past and future landscape transformation provide a basis for models which are used to estimate how land-use changes will affect the water and substance regime. Management plans can then be drawn up as specified by for instance the EU's Water Framework Directive to ensure that surface water is ecologically and chemically sound and to safeguard the availability of groundwater (Figure 4). These general aspects are illustrated below with two examples.

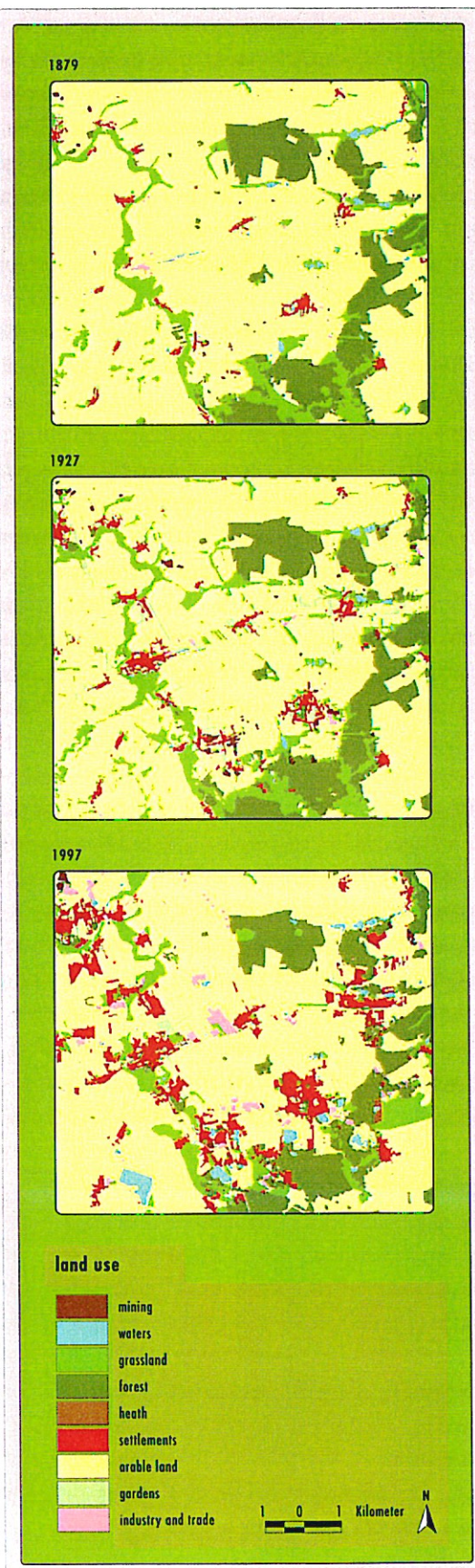
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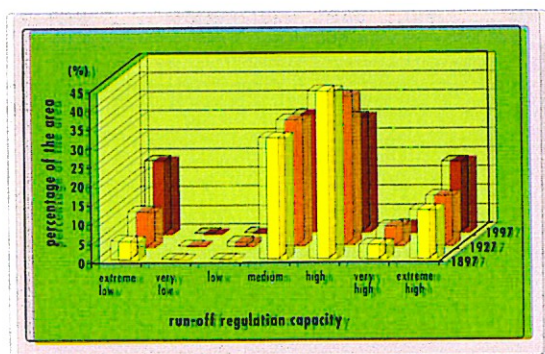


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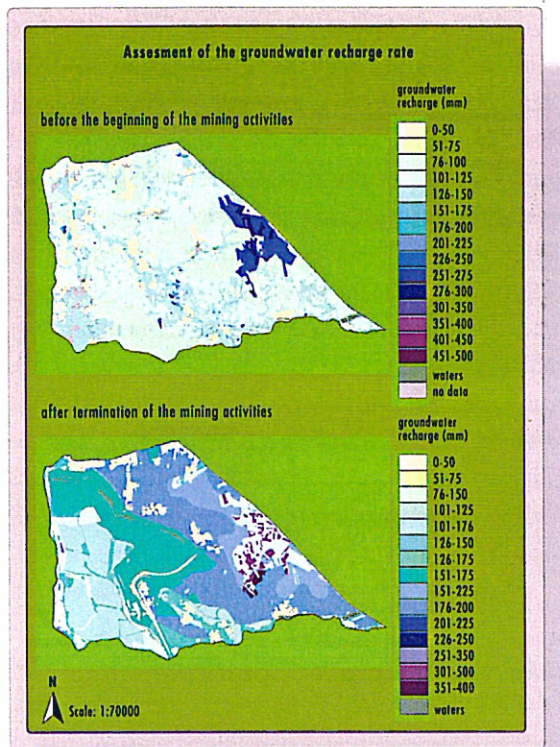


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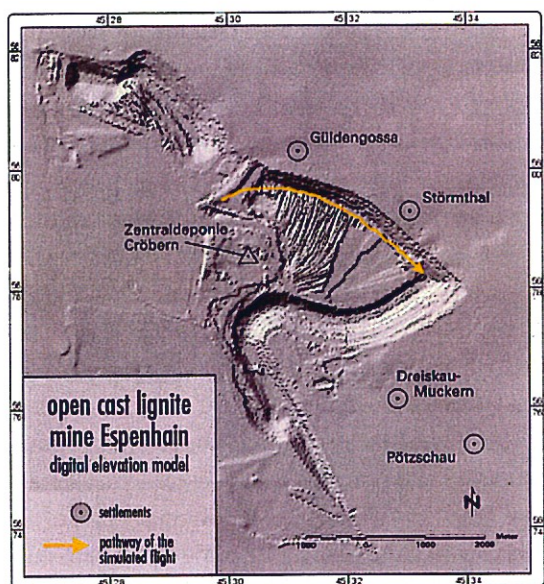


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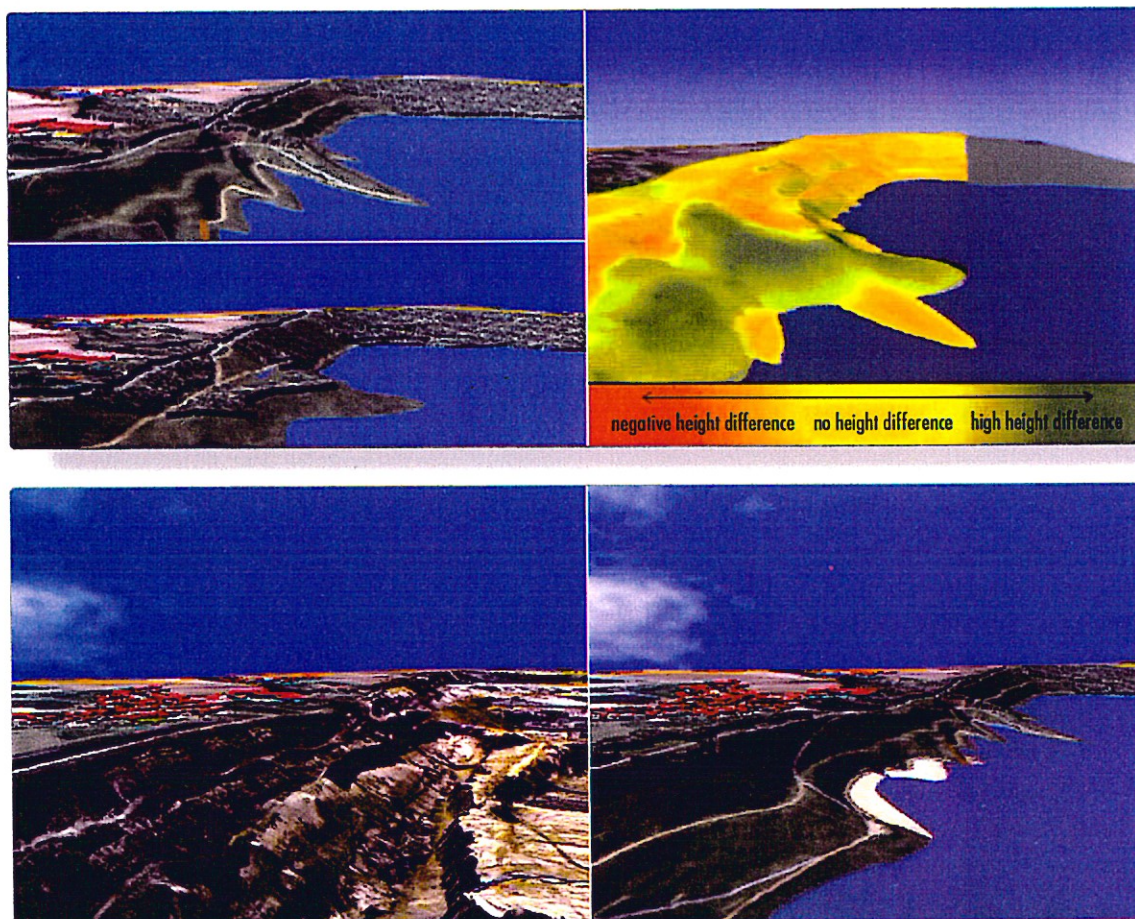


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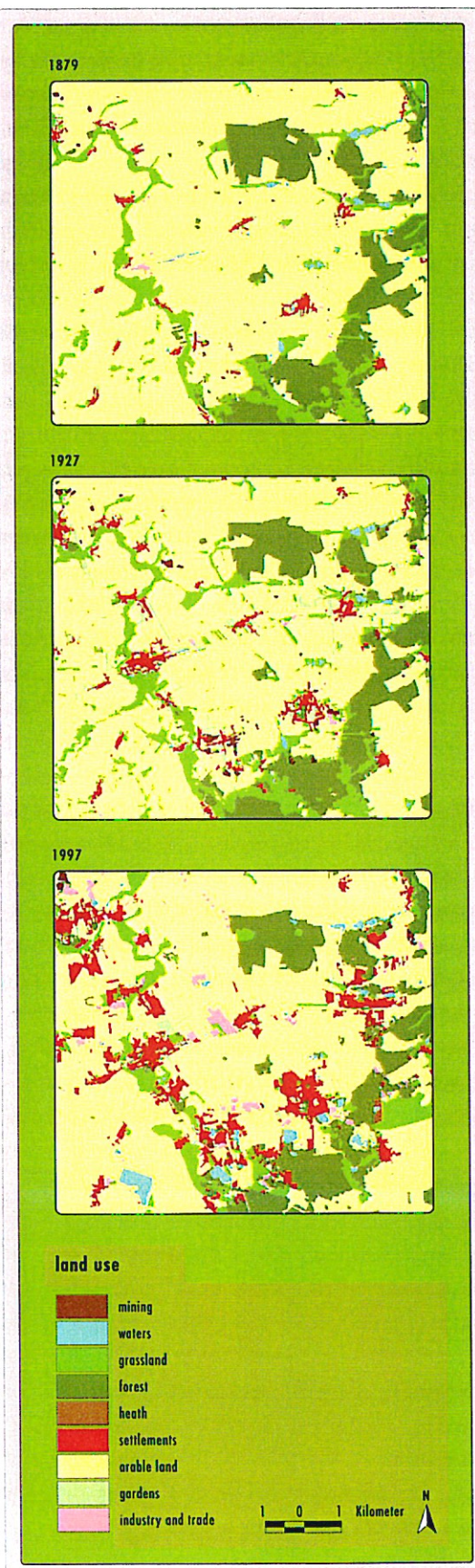
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First of all, they digitised historical maps using geographic information systems. Reading and interpreting old maps is an important skill among landscape ecologists (albeit not one they need every day) which calls for a great deal of experience in dealing with cartographic material. Having been computerised, these digital data were juxtaposed and compared with modern-day maps and aerial and satellite photographs in a geographic information system, enabling exact statistical analyses of zoning development and for example the expansion of paved land. In addition, the GIS's databases allow the effect of land-use changes on certain landscape functions to be determined, such as the impact of suburbanisation on the runoff behaviour and natural groundwater recharge. Both these aspects are important factors in an intact landscape, as shown to dramatic effect by

Figure 5: The increasing urban sprawl of the landscape around Taucha and above all the floodplains is clearly apparent from the three time segments. (Content, cartography and GIS: D. Thormann; data: Saxon Surveying Office)



the flood disasters which hit the Elbe and the Mulde in August 2002. Runoff behaviour characterises the ability of a landscape (chiefly the soil) to absorb and regulate the surface runoff of rainwater depending on the use to which the land has been put and hence minimise the danger of flooding. Natural groundwater recharge is a process which contributes to the renewal of water resources in a region. The two processes are directly interlinked: areas with high surface runoff have lower natural groundwater recharge, and vice versa.

Figure 5 shows the zoning changes in 1879, 1927 and 1997 in the Taucha region. They were treated as a basis for modelling runoff regulation. It can be easily seen that building development – and hence the proportion of built-up and paved land – on the north-eastern edge of Leipzig sharply increased, especially after the political changes in 1989/90, making floodplains and open spaces around the town increasingly rare. In other words, these changes sharply reduced local recreation opportunities for the residents of Leipzig. In addition, the River Parthe lost its function as a flood retention area. This was because the green band of floodplains so important as a retention area for water and sediments from the Parthe catchment and which in 1879 was clearly identifiable had by 1997 been interrupted and hence fragmented at many points by built-up areas and farmland. This in turn meant it was no longer able to promote the migration and spread of many species of flora and fauna, and for instance yellow irises (*Iris pseudacorus*) and the hairy star of Bethlehem (*Gagea arvensis*), both once common here, are now no longer found.

There is every reason to assume that these processes of urban sprawl will continue in the countryside around Leipzig, turning open spaces into a very rare commodity in the coming decades. Extrapolating the increase in paved land around Taucha between 1879 and 1997 of 1,181 hectares and taking into account current construction projects such as BMW's new car plant on the Parthe



Figures 7 and 8: So close and yet so different – views from the Parthe catchment today: relatively natural river sections adjacent to newly built commercial estates with high rates of paving.

floodplain along with other sites earmarked for housing development, it seems that despite the falling population of Leipzig and other regions in central Germany, some natural retention and regulatory mechanisms are increasingly failing – as demonstrated by the floods in 2002.

Nevertheless, UFZ's landscape ecologists believe that despite the huge amount of land affected by altered use since 1990, the over-usage of the landscape can still be stopped. In order to hone and underpin the current political and legal instruments available, landscape analyses of this type will become indispensable for many regions in Europe.

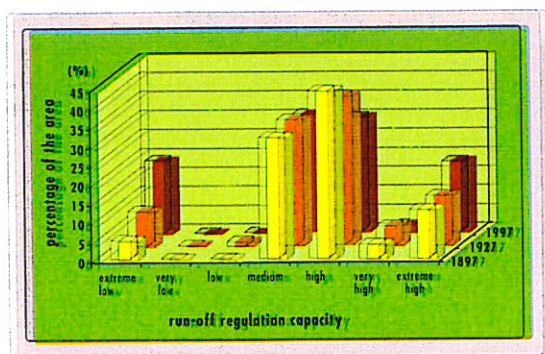


Figure 6: Paving the soil is drastically reducing the runoff regulatory potential of the earth's surface in this region.

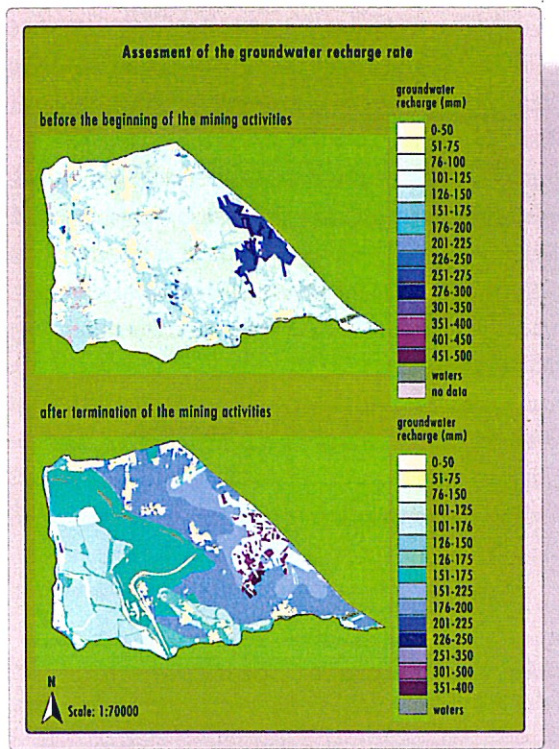


Figure 9: The area of the former Espenhain mine before the start of mining and nowadays shortly before the pit was flooded. Mining and the expansion of built-up areas drastically changed the spatial distribution of the natural groundwater recharge rate. (Content and cartographic processing: Yvonne Voigtmann)

Mines into lakes

After decades of devastation of arable land, woodlands, villages and floodplains and the diversion of rivers, by around 2050 the region south of Leipzig will have developed into a lake district with a total surface area of some 79 sq km of water with plenty of scope for a variety of usage and development. Nowadays less and less farmland is needed, and so disused mining pits are being ecologically landscaped to provide areas for tourism and recreation. This may mean leaving dumps as they are with as little remediation as possible (as called for by nature conservation), or alternatively afforestation, as is practised for example in large expanses south of Leipzig, an area which is low in woodlands. Over 570 million tonnes of lignite were mined here between 1937 and 1994 at Espenhain mine. The mine destroyed areas like the Gösel floodplain, which was an important regulation area for water and substance cycles in the Leipzig district. By the year 2020, a network of lakes including Lake Störmthal (6.9 sq km) and Lake Markkleeberg (2.5 sq km) will account for large parts of what used to be the Gösel floodplain before

it was turned into an opencast mine and its surroundings. Scientific analysis of landscape functionality south of Leipzig was carried out by researchers from various institutions in a pilot regional landscape monitoring scheme. It enables an integrated, ecological view of all the components of a landscape such as the soil, relief, climate, water balance, flora and fauna as well as changes to the landscape over time. The landscape monitoring concept used and tested in this particular case is designed to work out methods and parameters which are suitable for large areas. The aim is to enable an ecological analysis and assessment of very different natural areas in Saxony – and in the next stage in Germany. Since mining and post-mining landscapes are among the most dynamic areas in central Germany in terms of landscape change, alterations to the water and substance regime for example which can be attributed to this change of usage can be modelled and impressively visualised (Figure 9). The changes which took place in the Gösel floodplain agrarian district between 1944 and 1996 can be characterised as follows:

- Extensive change to the relief and the emergence of hollow and solid structures (mining pits, dumps, slagheaps);
- Changes to the substrate deposition conditions, with extensive mixing and restratification of soil and sediments;
- The destruction of natural soil, especially the Gösel floodplains important for the landscape balance, and the emergence of heterogeneous dump soils which need a few decades to undergo initial soil development;
- The regulation and canalisation of the main outlet (the Gösel), including the complete destruction of natural retention areas and wetland habitats in the floodplain.

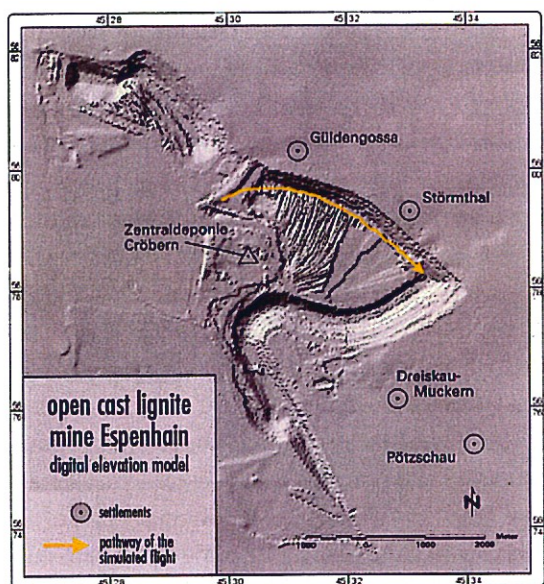


Figure 10: One major source of data for studies of landscape change is high-resolution digital terrain models – in this case one of Espenhain mine in 1998 (based on underground survey data from LMBV).

When planning the landscaping of Espenhain mine, researchers from the UFZ working together with the LMBV (Lusatian and central German mining administration company) developed a method which enables actual landscapes and the changes taking place in them to be depicted by using visual 3D simulation based on a GIS. This technique gives landscape planners a spatial impression of landscape changes. Moreover, it provides an important aid for visual communication and decision support in the planning process and in the development of planning alternatives – including with the local population.

Four visual dynamic simulations were developed for the future Lake Störmthal. They were produced by juxtaposing zoning data (planning documents, aerial and satellite images) and a digital elevation model obtained from survey data.

Figure 11: »Lake Störmthal mining district« – the 3D visualisation of two different planning options which differ above all in terms of bank heights.

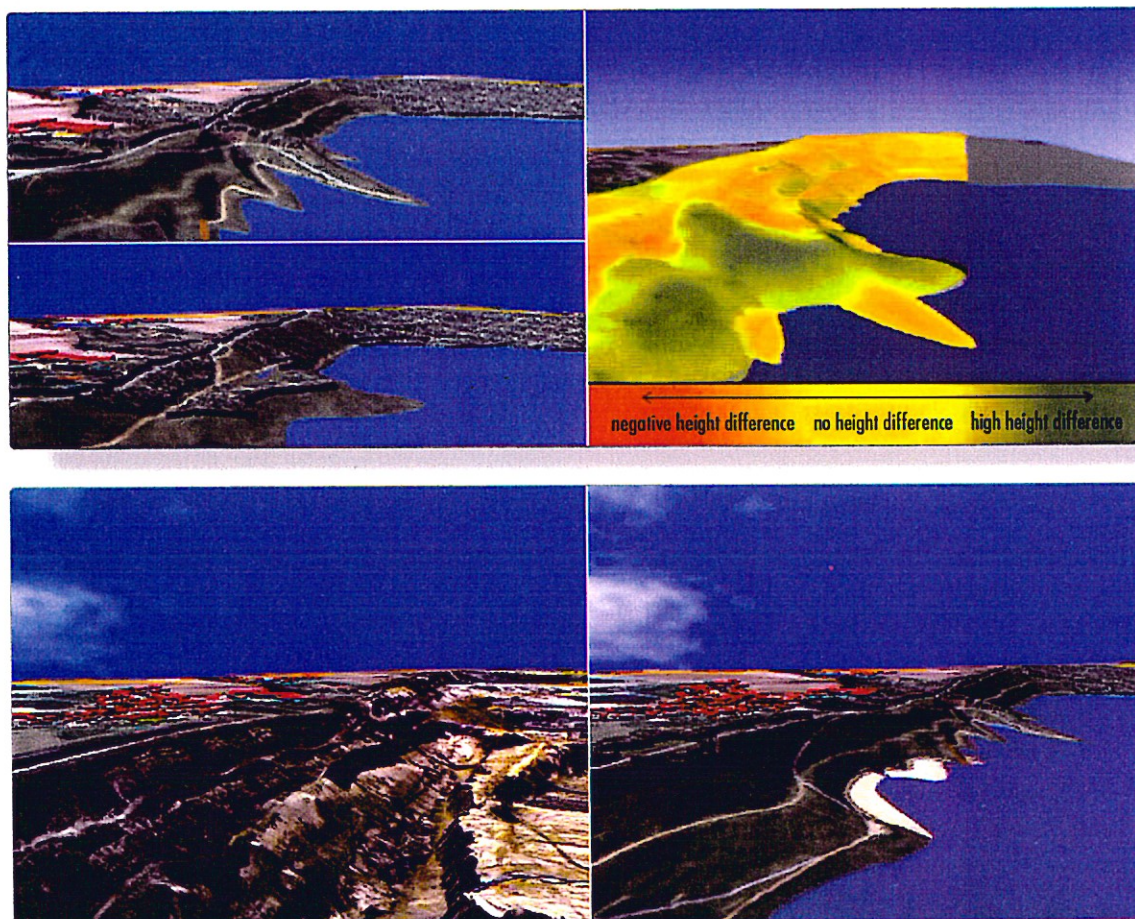


Figure 12: »Lake Störmthal mining district« – the 3D visualisation of the initial situation in 1998 as a mining pit and a planning variant for future landscaping.



Summary

The scientific work on the transformation of the usage and structure of a landscape as well as its influence on the productivity of the natural balance provides an important basis for landscape and regional planning and serves as decision-support instruments for regional and local planning agencies. In the case of the UFZ these include the Saxony Department of the Environment and Geology, the state environmental departments in Leipzig and Chemnitz, and the regional administration offices of the various districts in the Saale River basin. They are also important for a broad section of the local population as well as researchers from the State Department of Construction and Environmental Planning dealing with the long-term trends of spatial development in Germany since they show how the surrounding landscape changes and how planners' ideas will actually appear in the landscape.

So how far can mankind go before the natural regulatory mechanisms collapse? The investigations carried out by UFZ's landscape ecologists to date back up the opinion that a whole range of natural regulatory mechanisms in the landscape such as runoff and flood retention can only function to a limited extent and in some cases fail locally owing to the continuing consumption of floodplains and open spaces for construction.

In future the researchers will undertake additional specific investigations into trends of zoning development and their influence on natural landscape functions. This can be regarded as a module to help achieve genuinely sustainable »co-operation« between mankind and nature in the multifunctional central European cultural landscape.