Long-term NEP

ping can also lead to other local contamination risks. In 1993, 174 illegal landfills were identified in Karelia.

DEVELOPMENT PLANS

The conclusion of this project was to initiate a HWM organization based on the existing know-how and resources of Spetstrans, the municipal-waste management body for Petrozavodsk. Spetstrans has long experience in municipal-waste and landfill management, with a large fleet of waste trucks and a staff of over 500. Services could be extended to other parts of Karelia or alternatively form a network with other, local waste-management companies. After the Russian Federal plans for HW management are implemented, the functions of Spetstrans should be linked to the Federal system. A strict Polluter Pays Principle should be used for this sector from the very beginning. This would be a starting point for economically viable sustainable waste management.

Spetstrans should start its HWM activities by organizing landfill investments for specified solid hazardous industrial wastes; mainly galvanic sludges. It could then manage the landfill and collect fees to cover costs from the waste producers. The environmental administration could insist that industry use this landfill.

For waste oil, oil/water mixtures and possibly also oily sludges an appropriate partner would be a regional oil distribution company. One such company has vast experience in treatment and transport of oil products, it has an old facility for waste-oil regeneration, and a large capacity for treatment of its own oil-contaminated wastewater. For some specific types of HW other existing companies can provide treatment services for, e.g., photochemical solutions, mercury waste, car batteries. A later HWM step would be to construct a treatment site for soil or other solids contaminated with oil products.

DISCUSSION

Absence of practical principles for defining hazardous waste is a problem in HWM development. The Russian guidelines (3) dictates the use of solubility, volatility and concentration data for toxicity-factor determination, but the practical procedures for implementation are still unclear.

For many years, the emission fee system was a central part of the environmental-management system during the Soviet era. In general, this system of economical incentives for environmental policies must be commended. However, in Karelia the task of compiling emission statistics, and charging fees is over-emphasized at the cost of using very little resources in waste-management planning and tackling the more practical waste problems. Waste minimization is not encouraged by the low costs of present management at landfills (4).

One solution to the problems of high unit cost of HW treatment due to the relatively small total amounts of each waste type is possible. For instance, the existing facility for waste-oil recycling in Karelia is currently standing idle due to the lack of raw materials. In addition, treatment of mercury lamps in Karelia is not feasible. Obviously, the situation could be improved by combining the efforts of regions bordering on Karelia. At present, there is little exchange of information, knowledge, and experience between environmental authorities in the neighboring regions. In future, cooperation should be encouraged between Karelia, Murmansk, Arkhangelsk, Vologda regions and Leningradskaya oblast.

References

1. Philips, D.J.H. 1997. The control of hazardous wastes: from strategy to implementation in transitional European economies. In: *Proceedings of the First International Conference on Environmental Management & Technologies.* Feb. 16–18, 1997. Cairo, Egypt, Cabinet of Ministers, EEAA, TCOE.
2. Lilja, R.K. (ed.). 1996. Industrial hazardous waste management, waste management development project in Petrozavodsk, Republic of Karelia. *Tacis/Bistro Project Final Report of Sub-project 1, BIS/95/288/044.* Rejlers Ltd., Mikkeli, Finland.
3. *Interim Classification of Toxic Industrial Waste and Methodical Recommendation on the Determination of Industrial Waste Toxicity Class.* 1987. Ministry of Health of USSR, Moscow, GKNT of USSR, No 4286-87. (In Russian).
4. Lilja, R.K. 1997. Strategical issues in hazardous waste management development. In: *Proceedings of the First International Conference on Environmental Management & Technologies.* Feb. 16–18, 1997, Cairo Egypt, Cabinet of Ministers, EEAA, TCOE.

5. This article is based on a project funded by the EU-program TACIS/Bistro (BIS/95/288/044). The authors also wish to thank the Ministry of Ecology and Natural Resources of Karelia and the Petrozavodsk Environmental Committee for providing the statistics and baseline information used in this article. The conclusions and suggestions represent only the opinions of the authors.

Raimo K. Lilja and Vladimir Morozov
Rejlers Ltd.,Environmental Technology
Vilhonkatu 1
50100 Mikkeli
Finland

Synopsis New Estimate of the Carbon Sink Strength of EU Forests integrating Flux Measurements, Field Surveys, and Space Observations: 0.17–0.35 Gt(C)

The terrestrial biosphere provides a strong sink for greenhouse gases (GHGs). Indeed, global studies confirm that the terrestrial biosphere takes up significant amounts of carbon dioxide (CO_2). However, some uncertainty remains attached to the relative strength of the sinks offered by different geographical regions and ecosystems around the world. The present synopsis of an article planned for a forthcoming issue of Ambio confirms the importance of European Union (EU) forests for carbon (C) sequestration. With the signature of the Kyoto Protocol (1) to the United Nations Framework Convention on Climate Change (2) signed on 11 December 1997, the sequestration of CO_2—as well as the five other GHGs listed in the Kyoto Protocol, namely methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons—has become an hot political issue. However, the forest sink strength estimation exercise presented in the present synopsis attempts to do more than to generate a pair of policy relevant numbers. Truly, the exercise makes three additional contributions. First, it offers a generic framework for the calculation of the net exchange of GHGs between the surface and the atmosphere; second, it provides a series of generic insights into the problems associated with such calculations; and, third, it sketches out a generic methodology to refine, reengineer, and organize data from sources as different as flux measurements by eddy covariance, field surveys, and space observations.

DATA

The present estimate incorporates two kinds of data: *in situ* CO_2 flux measurements and georeferenced data on forests and on administrative boundaries. The EUROFLUX (3) project managed and funded by the "Environment and Climate" Program (4) of the European Commission (Directorate General XII) provides continuous CO_2 flux measurements at 15 different sites throughout the European Union, encompassing a broad range of latitudes (41°45'N–64°14'N) and very different tree species. EUROFLUX relies on the eddy covariance method to measure the exchanges of CO_2 between forests and the atmosphere above them. Measurements span several complete annual cycles. The Forest Information from Remote Sensing (FIRS) (5) project and the World Conservation Monitoring Center (WCMC) (6) and Center for International Forestry Research (CIFOR) (7) databases of European Forests furnish the georeferenced forest data (8–20).

METHODOLOGY

The methodology unfolds as a sequence of five steps. The first step associates each of the 115 FIRS bioclimatic strata with a EUROFLUX site on the basis of climate and dominant vegetation. The second step combines the resulting table of correspondences with estimates of the aboveground biomass at EUROFLUX sites. Mean standing biomass serves as an average site productivity indicator, but not as a proxy for yearly Net Ecosystem Productivity (NEP). The third step calculates the regional minimum and maximum NEP values by weighing the EUROFLUX range of annual site NEP by the site productivity indices. The fourth step uses the WCMC map to single out forested areas and to generate a map of minimum and maximum NEP per unit area on a 1 km per 1 km grid. The fifth and final step employs the EUROSTAT map of EU administrative units to produce regional minimum and maximum NEP figures. Examining the approach leads to the formulation of a series of caveats. These caveats concern uncertainties and assumptions. Indeed, they relate to; (a) the uncertainties associated with the EUROFLUX forest biomass, the FIRS biomass, and the EUROFLUX NEP estimates; (b) those pertaining to the locations of the FIRS bioclimatic zones; and (c) the ones linked to the WCMC "forest/non-forest" classification and the fractional vegetation cover, as well as to the assumptions behind the methods used to; (d) calculate the site index and to regionalize *in situ* measurements.

RESULTS

Figures 1 and 2 display spatial estimates of the minimum and the maximum NEP on a 1 km per 1 km grid. Integrating spatially over the entire European Union yields a preliminary estimate of atmospheric carbon uptake by forests ranging between 0.17 and 0.34 Pg (or Gt) in 1997. This range exceeds the range of forest growth increment values of 0.09–0.12 Pg(C) per annum derived by Kauppi et al. (21) and of 0.10 Pg(C) a^{-1} estimated by Nabuurs et al. (22). Contrastlingly, the 0.30 Pg(C) a^{-1} figure calculated by inversion by Ciais et al. (23) falls within our range of estimates. Therefore, the order of magnitude of the present range matches that of previous results obtained by different methods and using independent data.

CONCLUSION

Eddy covariance flux measurements constitute the only means to directly estimate the net carbon exchanges of ecosystems. No other direct method exists to assess the overall ecosystem carbon uptake or release, including processes such as soil respiration. The regionalization approach qualifies as simple and exhibits recognized weaknesses, but unique and reliable background data along with a physically- and biologically-based logic make it robust. As mentioned above, three independent estimates of EU forest CO_2 uptake by forest inventories and by inversion—using independent data sets—support the assertion. The present preliminary results suggest that EU forests fixed 0.17–0.35 Pg (C) in 1997. EU forests could therefore have sequestered between 20 and 40% of all EU CO_2 anthropogenic emissions during that year. The significance of these figures and their importance for environmental security calls for the judicious management of European natural resources, in general, and EU forests, in particular. It encourages the continued refinement of estimation methodologies. It promotes the deployment of carefully designed observational networks aimed at providing environmental intelligence. Finally, the significance of these figures and their im-

Figure 1. Maximum NEP.

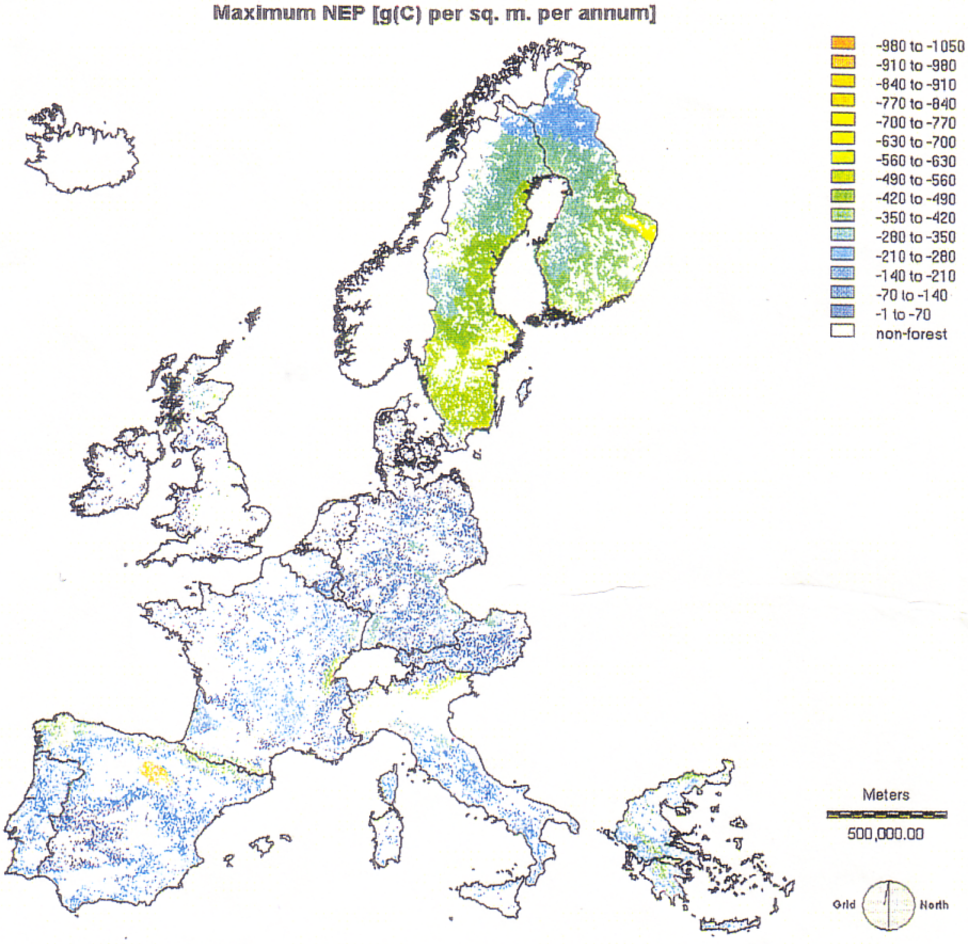
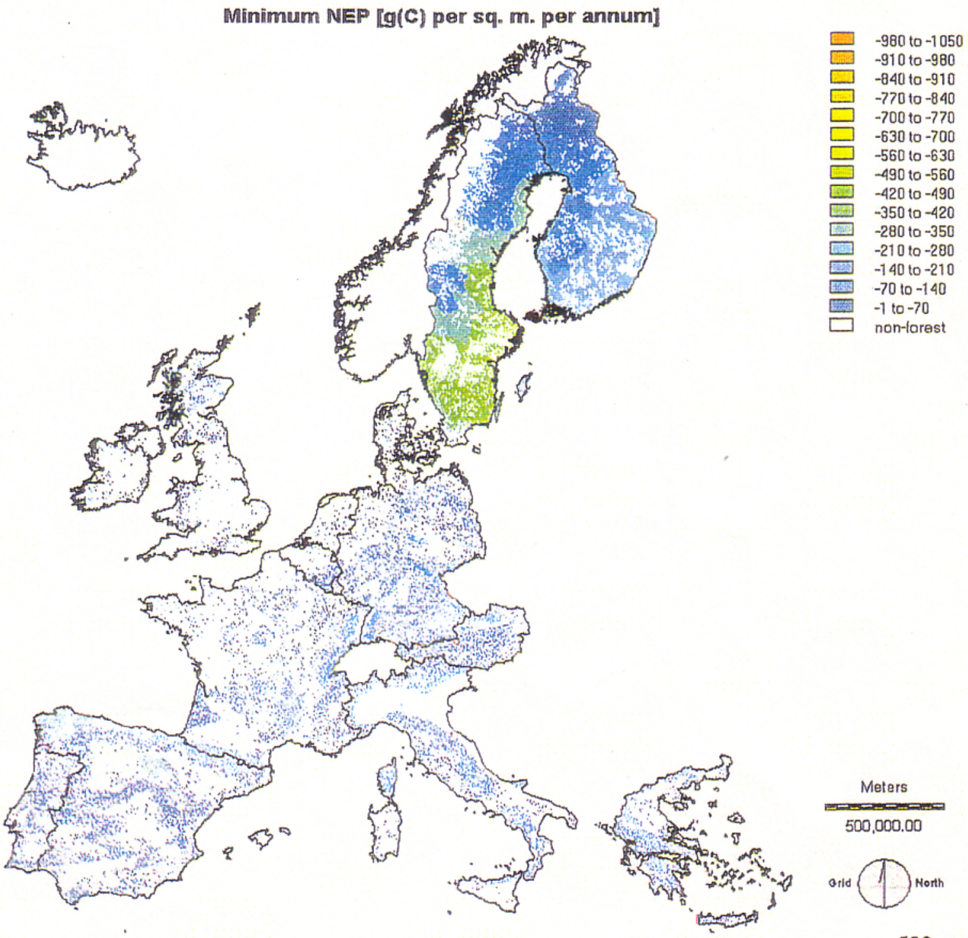


Figure 2. Minimum NEP.



portance for environmental security requires the design, implementation, and validation of powerful "data marts" and other smart information brokerage systems to insure an efficient access to and distribution of this vital environmental intelligence.

References and Notes

1. http://www.unfcc.de/fccc/docs/protintr.html
2. http://unfccc.de/fccc/conv/conv_toc.htm
3. http://www.pelagus.it/aesi/edb/homepage.htm EUROFLUX/ (Database URL)
4. http://europa.eu.int/comm/dg12/envir1.html
5. http://www.emap.sai.jrc.it/forecast/firs/
6. http://www.wcmc.org.uk/
7. http://www.cgiar.org/CIFOR/INDEX.HTM
8. CORINE land cover data, received in WCMC in 1996.
9. Dansk Ministeriet for Fødevarer, Landbrug og Fiskeri, Statens Planteavlsforsøg. *Forests of Denmark and Bornholm*. Received at WCMC in 1997, date of source unknow.
10. Holdridge, L.R. 1967. *Life Zone Ecology*. Tropical Science Center, San Jose, Costa Rica, 206 pp.
11. Iremonger, S., Ravilious, C. and Quinton, T. 1997. A statistical analysis of global forest conservation. In: *A Global Overview of Forest Conservation*. Iremonger, S., Ravilious, C. and Quinton, T. (eds). CD-ROM. WCMC/CIFOR, Cambridge, UK.
12. Köppen, W. and Geiger, R. 1954. *Klima der Erde*. Justus Perthers, Darmstadt, Germany; American distributor, A.J. Nystrom and Co., Chicago, IL, USA.
13. Leeman, R. and Cramer, W.P. 1992. IIASA database for mean monthly values of temperature, precipitation and cloudiness on a global terrestrial grid. Digital raster data on a 30 min geographic (lat/long) 360 x 720 grid. In: *Global Ecosystems Database Version 1.0: Disc A*. Boulder, CO:NOAA Geophysical Data Centre. 36 independent single-attribute spatial layers on CD-ROM, 15.6 MB (first published in 1991).
14. Rubner, K. and Reinholdt, F. 1953. *Das natürliche Waldbild Europas als Grundlage für einen europäischen Waldbau*. Verlag Paul Parey, Hamburg and Berlin, Germany. (In German).
15. Stockholm Environment Institute. 1996. *The Forests of Europe*. Data from the AVHRR source of the European Space Agency for forest cover in Europe, re-classified by the Stockholm Environment Institute (York, UK) according to FAO land use data.
16. Swiss Federal Institute for Forest, Snow, and Landscape Research (WSL). 1985. *Swiss National Forestry Inventory*. Data from the National Forest Inventory of 1983–1985, based on sample plots on a 1 km^2 grid.
17. Troll, C. and Pfaffen, K.H. 1966. *Karte der Jahreszeiten-Klimate der Erde*. Erdkunde, 18.
18. Walter, H. 1976. *Die Ökologischen Systeme der Kontinente (Biogeosphäre). Prinzipien ihrer Gliederung mit Beispielen*. Stuttgart, Germany, 131 pp.
19. Walter, H. 1979. *Vegetation of the Earth and Ecological Systems of the Geo-biosphere*. Heidelberg Science Library, Springer-Verlag, New York, NY, xx + 274 pp.
20. Walter, H. and Beckle, S.W. 1986. *Ökologie der Erde, Bd. 3: Spezielle Ökologie der Gemässigten und Arktischen Zonen Europ-Nordasiens*. UTB Grosse Reihe, Stuttgard 1983.
21. Kauppi, P.E., Mielikäinen, K. and Kuusela, K. 1992. Biomass and carbon budget of European forests, 1971 to 1990. *Science 256*, 70–74.
22. Nabuurs, G.J., Pävinen, R., Sikkema, R. and Mohren, G.M.J. 1997. The role of European forests in the global carbon cycle—a review. *Biomass and Bioenergy 13*, 345–358.
23. Ciais, Ph., Tans, P.P., Trolier, M., White, J.W.C. and Francey, R.J. 1995. A large Northern hemisphere terrestrial CO_2 sink indicated by C^{13}/C^{12} ratio of atmospheric CO_2. *Science 269*, 1098–1102.

Philippe H. Martin et al.
Institute for Systems, Informatics, and Safety
European Commission Joint Research Centre
TP 650
Via E. Fermi, 1
21020 Ispra (VA)
Italy
philippe.martin@jrc.it
http://www.jrc.org/jrc/

R. Valentini (2), M. Jacques and K. Fabbri (1), D. Galati and R. Quaratino (2), and J.B. Moncrieff and P. Jarvis, N.O. Jensen, A. Lindroth and A. Grelle, M. Aubinet, R. Ceulemans and A.S. Kowalski, T. Vesala and P. Keronen, G. Matteucci, A. Grainer, P. Berbingier and D. Loustau, and A. Grelle, E.-D. Schulze, J. Tenhunen and C. Rebman, A.J. Dolman and J.E. Elbers, C. Bernhofer and T. Grünwald, and H. Thorgeirsson
http://www.unitus.it/eflux/who.html

P. Kennedy and S. Folving
http://www.emap.sai.jrc.it/forecast/firs/

(1) Institute for Systems, Informatics, and Safety, European Commission Joint Research Centre, I-21020 Ispra (VA), Italy
(2) University of Tuscia, Department of Forest Science and Environment, Viterbo, Italy

Synopsis Introduction of Rainbow Trout in Tucumán Province, Argentina: Problems and Solutions

INTRODUCTION

The reasons for international and accidental introductions of aquatic organisms are many and have varied historically (1). Some of the most widely promoted exotic fishes include carp (*Carassius auratus*, Cyprinidae), pejerrey (*Odonthestes bonariensis*, Atherinidae), gambusia (*Gambusia affinis*, Poeciliidae), perca criolla (*Percichthys* sp., Percichthyidae) and Salmonids. The negative impact of salmonids on native stream fauna have been implicated in a variety of problem areas including habitat fragility, effects of amount released, and frequency of release to "natural" systems.

The rainbow trout (*Oncorhynchus mykiss*, Salmonidae) was introduced in Argentina in 1903; embryonic eggs being imported from the United States. Seven other salmonids were introduced later, only three of which survived: *Salmo fario* (brown trout), *S. salar* (landlocked salmon) and *Salvelinus fontinalis* (brook trout). About 30 years ago, due to the extraordinary headwater conditions of the rivers (above 1500 m), an office of the government (Natural and Renewable Resources Direction) decided to introduce and support brown trout and rainbow trout populations in Tucuman Province for sport fishing. In recent years, the salmonids have also been introduced for purposes such as aquaculture. It has also been decided to support rainbow trout because it is been shown to survive in running waters in subtropical climates.

Trout are released in the La Angostura reservoir, 1500 m a.s.l., Tucumán Province. Photo: H.R. Fernández.

Tucumán province, Argentina, (26°49'S, 65°13'W) has an area of 22 524 km^2; 43% mountain ranges and 57% plains. A complex river system drains from west to east into a large river, Río Salí, which crosses the territory from north to south. The Salí river has a mean flow of 85 m^3 s^{-1}. The river water volume is related to the rains (2000 mm in zones of headwater of the southwest), with a high flow between November and May, and an increase in flow volume in February and April. The drought period is from June to October (end of Fall to beginning of Spring) and is most severe between August and September.

The trout is a predator that lives in cool and oxygenated streams. Rainbow- and brown trout are attractive to fishermen for several reasons. They are scarce and difficult to catch, and are mainly found in places with difficult access.

However, fishermen are seldom aware that the successful introduction of a foreign species such as the trout can damage the native fish fauna (2–8) and amphibians (9).

In biological and evolutionary terms, the introduction of a species will almost certainly