Linking Forest Ecosystem Models and Measurements to Management Options

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Overview

- Introduction – forests in Fukushima Prefecture
- Literature review
  - Radiocaesium behaviour in forests
  - Forest management options
  - Summary of what is and is not known
- Discussion of forestry management issues in Japan

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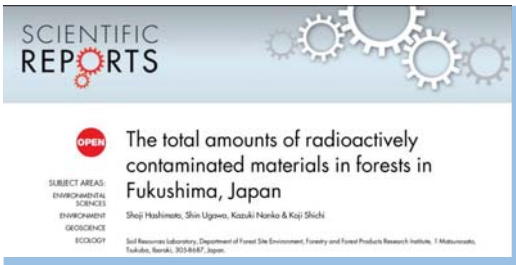


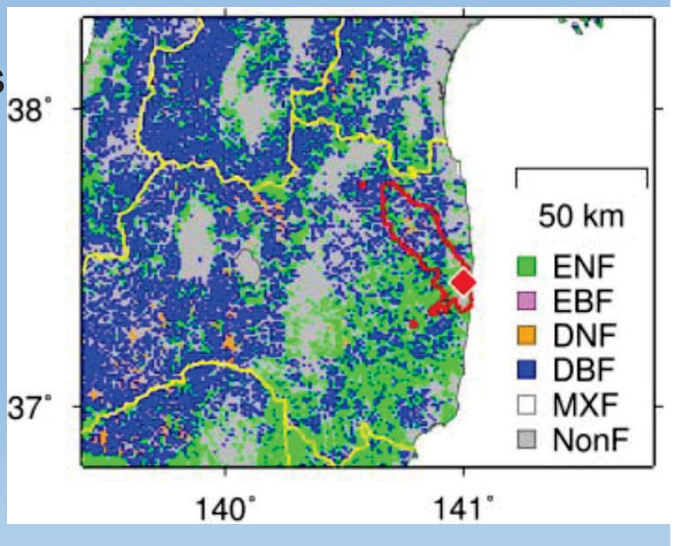
Distribution of Forest Types

From: Hashimoto et.al. (*Scientific Reports* **2**:416 2012)

Within area of >1000 kBq m^{-2} initial total Cs

- Evergreen Needleleaf Forests (ENF): 201 km^2
- Evergreen Broadleaf Forests (EBF)
- Deciduous Needleleaf Forests (DNF):17 km^2
- Deciduous Broadleaf Forests (DBF): 210 km^2
- Mixed Forests (MXF)

- Estimated tree biomass 11x10^6 m^3, 6x10^9 kg
- Estimated soils: 21x10^6 m^3, 13x10^9 kg



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Forest Contamination Concerns

- Radiological concerns:
  - External exposure to forest workers
  - External exposure to residents & visitors
  - Contamination of forest products
- Social concerns:
  - Fear of radiation exposure
  - Consumer confidence in forest products
  - Loss of recreational use of forest environments
  - Concerns over general health of the environment

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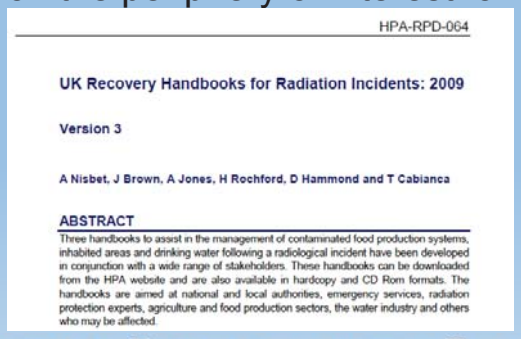
Post-Chernobyl Experience: Summary Literature Review

- Majority of studies in Eastern Europe
  - European Plain – no mountains
  - Limited studies in more mountainous regions
- Compared to agricultural areas, application of counter measures is not straightforward
- Forests on the periphery of interest for most radiological protection agencies



HPA-RPD-064

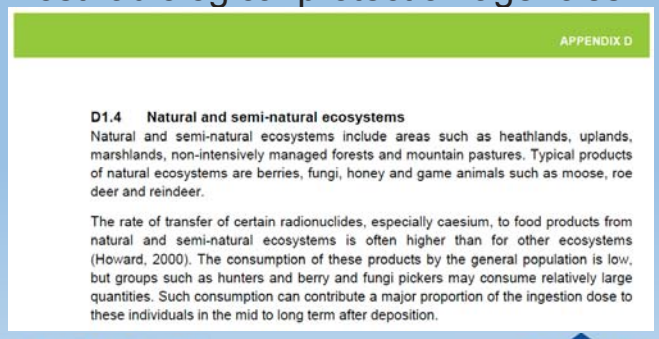
UK Recovery Handbooks for Radiation Incidents: 2009

Version 3

A Nisbet, J Brown, A Jones, H Rochford, D Hammond and T Cabianca

ABSTRACT

Three handbooks to assist in the management of contaminated food production systems, inhabited areas and drinking water following a radiological incident have been developed in conjunction with a wide range of stakeholders. These handbooks can be downloaded from the HPA website and are also available in hardcopy and CD Rom formats. The handbooks are aimed at national and local authorities, emergency services, radiation protection experts, agriculture and food production sectors, the water industry and others who may be affected.



APPENDIX D

D1.4 Natural and semi-natural ecosystems

Natural and semi-natural ecosystems include areas such as heathlands, uplands, marshlands, non-intensively managed forests and mountain pastures. Typical products of natural ecosystems are berries, fungi, honey and game animals such as moose, roe deer and reindeer.

The rate of transfer of certain radionuclides, especially caesium, to food products from natural and semi-natural ecosystems is often higher than for other ecosystems (Howard, 2000). The consumption of these products by the general population is low, but groups such as hunters and berry and fungi pickers may consume relatively large quantities. Such consumption can contribute a major proportion of the ingestion dose to these individuals in the mid to long term after deposition.

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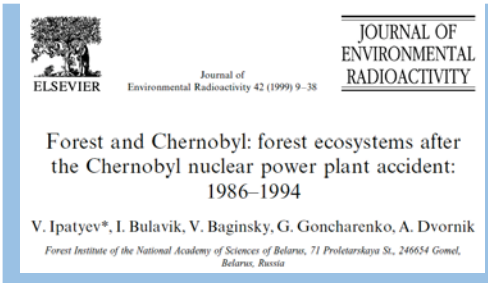

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Journal of Environmental Radioactivity 42 (1999) 9–38

JOURNAL OF ENVIRONMENTAL RADIOACTIVITY

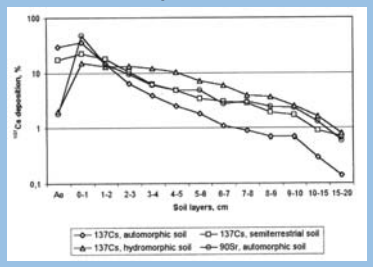
Forest and Chernobyl: forest ecosystems after the Chernobyl nuclear power plant accident: 1986–1994

V. Ipatyev*, I. Bulavik, V. Baginsky, G. Goncharenko, A. Dvornik

Forest Institute of the National Academy of Sciences of Belarus, 71 Proletarskaya St., 246654 Gomel, Belarus, Russia

Some post-Chernobyl studies

- Studies of Belarusian forests over 8 years
- 35 authors (lead author for each chapter listed in citation)



Distribution in soil profiles in 1993

Observations of radionuclide migration:

- Initially (few days) 70-80% of activity above ground
- Within a year <10% in the trees, rapid migration to litter and soil
- 1988, 1-5% in the trees, 80% in soil
- For most soils, 90% of activity in top 5cm of soil in 1993
  - Extremely wet soils the exception <70% of activity in top 5cm
- Above ground biomass activity mainly in new needles, leaves and shoots, and young growth stands

Forest organisation and management principles:

- Forests serve specific ecological functions
  - Prevent horizontal migration of radionuclides
- Forest fires lead to secondary contamination
  - Fire prevention measures needed
  - Radiological protection of personnel
- Role of undergrowth in reducing ^{137}Cs accumulation in trees
  - Accumulation 4-5x greater due to root system

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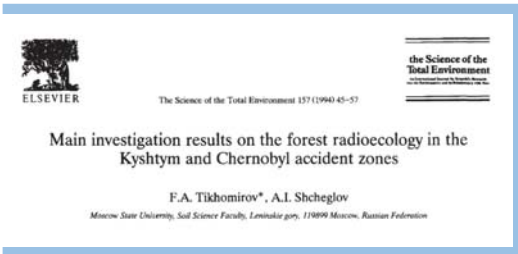

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The Science of the Total Environment 157 (1994) 45–57

the Science of the Total Environment

Main investigation results on the forest radioecology in the Kyshtym and Chernobyl accident zones

F.A. Tikhomirov*, A.I. Shcheglov

Moscow State University, Soil Science Faculty, Leninskie gory, 119899 Moscow, Russian Federation

Some post-Chernobyl studies

- Review of literature and authors own studies

Initial deposition:

- Areas of wet deposition: no noticeable difference in deposition in forests cf neighbouring pastures
- Areas of dry deposition: elevated deposition in forests
- Forests close to accident sites: forest edge effect 20-50m into forest higher deposition
- Majority of activity in canopy:
  - Russia & Ukraine 60-90%; Sweden 40% in birch and beech, 80% in pine; Germany 70% in aged spruce

Two stage redistribution leading to equilibrium

- Stage 1 (2-4 years) primary deposition on tree canopy; highest contamination leaves, branches, bark; transfer to forest litter; no dependence on soil characteristics
- Stage 2 (10-15 years) root uptake of deposition; importance of soil characteristics and tree physiology

Especially in Chernobyl zone: slow rate of radionuclide migration along vertical soil profile, low washout by infiltrating water, horizontal migration with surface water flow practically absent

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The Science of the Total Environment, 137 (1993) 307–314
Elsevier Science Publishers B.V., Amsterdam

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Decontamination methods for reducing radiation doses arising from radioactive contamination of forest ecosystems — a summary of available countermeasures

O. Guillitte[a], F.A. Tikhomirov[b], G. Shaw[c], K. Johanson[d], A.J. Dressler[e] and J. Melin[f]

ELSEVIER

the Science of the Total Environment

Principles and practices of countermeasures to be carried out following radioactive contamination of forest areas

O. Guillitte[a,*], F.A. Tikhomirov[b], G. Shaw[c], V. Vetrov[d]

Forest Management: Literature

- Guillitte etal 1993 identifies extensive range of counter measures with different objectives, and time periods. Considers effectiveness and practicality
- Objectives:
  - Reduction of dose to forest residents/visitors
  - Reduction of dose to forest workers
  - Reduction of dose to consumers of forest products
- Guillitte etal 1994 specific reference to three different European forest types

- Restrict access and activities in forests
  - Mediterranean forests: access already difficult and restrictions due to fire risk already common: low impact and practical
  - Temperate forests: high population density and forest use, regionally variable economic impact: important but less practical
- Removal of fallen leaves and needles
  - Generally regarded as impractical, could be used in popular recreational areas. Efficiency variable
- Scraping and removal of surface soils
  - Mediterranean forests: almost impossible to implement, severe soil erosion
  - Temperate forests: already used to stimulate natural regeneration in some forests
  - Boreal forests: impractical due to loss of soil fertility and volume of material to be removed
- Clear felling and removal of timber
  - Temperate forests: likely to cause least ecological damage
  - Mediterranean and boreal forests: severe ecological damage, loss of soil fertility, erosion and water table contamination

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Forest Management: Literature

- Presents a cost-benefit analysis which can be used to screen management options
- Long-term counter measures are considered
  - Specifically excludes emergency measures (eg: detergent washing of foliage)
  - Also excludes soil scraping as impracticable
- Costs considered:
  - Dose to members of the public and workers (in forest and associated activities eg: pulp mills)
  - Economic cost of implementation, direct and indirect
- Benefits considered:
  - Reduced dose to public and workers
  - Increased economic activity
- Conclusions:
  - The number of management options likely to have a net economic benefit is extremely limited
  - These involve restriction of access to contaminated forest products
  - None of the industrially- or technologically-based options were proved to be cost effective
  - Possible alternatives to extract added value from existing timber crops without incurring excessive additional doses
  - Specific mention of biofuel extraction

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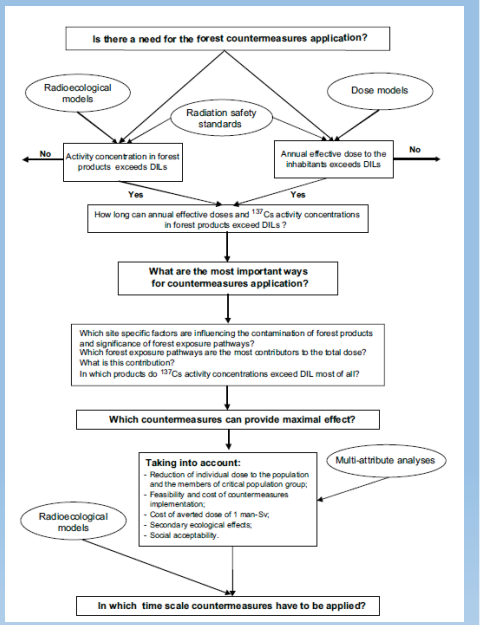
Forest Management: Literature

- Forest counter measures considered under four aspects
  - Radiological
  - Economic
  - Environmental/ecological
  - Social
- Need to consider perception of counter measures by local population and secondary ecological effects
- Presents a Multi Attribute Utility Analysis (MAUA) to quantify counter measure effectiveness and optimisation of counter measures
- Four stage approach:

1. Necessity of counter measures relative to intervention levels
2. Identification of relative importance of different exposure pathways
3. Identification of counter measure strategies with maximum effect
4. Justification of time scale



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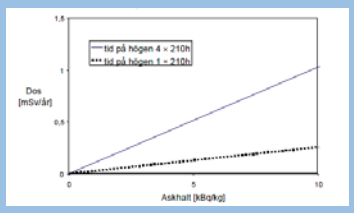
98:15 LYNN MARIE HUBBARD, HANS MÖRE

Strålskyddskonsekvenser från ^{137}Cs vid användning av biobränsle i stora anläggningar

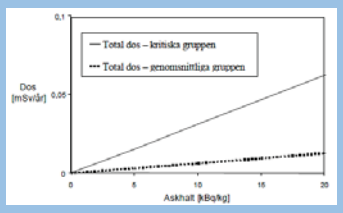
STATENS STRÅLSKYDDSINSTITUT

Forest Management: Literature

- Extensive analysis of use of ^{137}Cs contaminated biofuels
- Examination of potential for electricity generation and space heating
- Radiological consequences of disposal of ash to land fill or returning it to forests



Dose rate as a function of ash activity concentration for workers at a landfill



Dose rate as a function of ash activity concentration for average and critical groups of forest users

- Returning ash to forest returns nutrients, if source forest identified no net change in ^{137}Cs inventory
- Without sufficient source records (may be impossible for large commercial operation) ash unlikely to be returned to source forest – likely to spread contamination to less contaminated environments
- ^{137}Cs in ash more available than in the trees and litter

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Summary of Post-Chernobyl Experience

- Radiocaesium behaviour:
  - Interception of activity: increased dry deposition cf: adjacent unforested areas
  - Initially, activity present in canopy available for resuspension
  - Rapid migration to forest floor and soil
  - Longer term, forestry reduces remobilisation (forest fires an exception)
- Fukushima deposition earlier in growing season – greater contrast between deciduous and coniferous forestry
- Japanese forests in mountainous terrain, so run-off and soil erosional issues may be different
- Variable tree species, soil type, undergrowth density, wildlife, human use

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Summary of Post-Chernobyl Experience

- Forest Management:
  - Wide range of options, from do nothing to clear fell and plough
  - Choice of management option depends on goals and local environment
  - Balance of costs and benefits (economic, radiological, ecological, social)
  - Access and activity restrictions generally considered the most appropriate
  - Forest management low priority in most regions affected by Chernobyl
  - Active remediation not pursued
- In Japan, forestry is a much larger proportion of contaminated land
- High population density – more people live in forest environments and use them for recreational purposes
- Therefore, forest management is a higher priority and active remediation forms a part of that

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Recent and Ongoing Japanese Experience

- Small scale remediation studies
- Forest remediation in vicinity of homes to reduce external dose rates
  - Mostly removal of litter and scraping top soil
  - Generates considerable quantities of waste
  - Workers may receive a significant dose
  - What impact on soil stability, nutrient balance and ecosystem?
- SUERC backpack measurements in support of a remediation trial near Iwaki
  - January 2013: With Iwaki “Friends of the forest” NGO, contamination mapping prior to community resourced litter removal
  - 15x45m area, 2.1 tonnes of forest litter removed. 5 people, 160 person hours. Dose incurred approx. 50μSv
  - Dose rate reduction 0.31 μSv/h to 0.22 μSv/h. Dose rate from waste store: 0.62 μSv/h
  - February 2014: Repeat survey after litter removal shows 35-40% radiocaesium removed.

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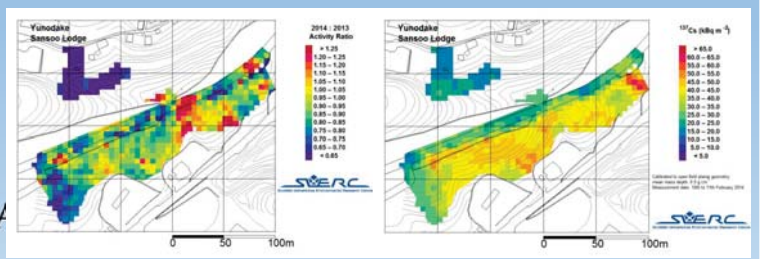
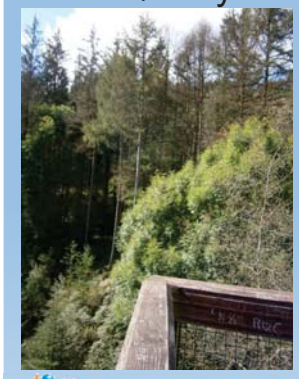
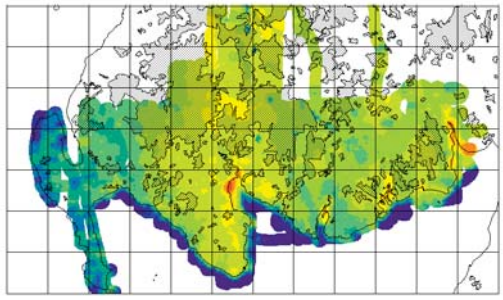


Conclusions

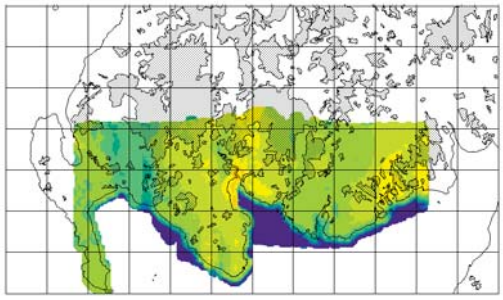
- Post-Chernobyl experience largely relates to forests which differ in some significant ways from Japanese forests (eg: topography, climate). Better analogues for Japanese forests may be needed to help understand long term radiocaesium behaviour
  - Forests in mountainous areas of UK, for example, are more similar to Japan
  - Quality airborne data available from over 20 years ago to present

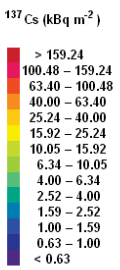


1993 Scottish Office Survey



2002 ECCOMAGS Exercise





Conclusions

- Selection of forest management option(s) will need to:
  - Reflect the aims of the management process
  - Account for local concerns and priorities
  - Take into account likely radiocaesium dynamics in particular environments
- It is unlikely that one option will be optimal for all situations
- High quality measurement data can support selection of management options and priority areas, and monitor management progress
  - Multi-scale from individual trees to full landscape

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Questions

- What is the aim of forest management?
  - Reduction of dose to residents, visitors & forestry workers?
  - Restoration of economic and social utilisation of forests?
  - Restoration of forests to pre-accident conditions?
- What is the benefit of a management option?
  - What is the reduction in dose rate? What is the reduction in dose to the population?
  - To what extent does it restore confidence and recover economic/social use of the forest?
  - Psychological and sociological improvements?
- What are the costs of a management option?
  - Doses incurred by forestry workers undertaking the management?
  - Does the process produce waste? How much? What to do with it?
  - Impact on forest ecosystem? Loss of habitat?
  - Impact on soil properties? Erosion rates? Does it remobilize activity?