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Reducing the Risk to Kiev and other Areas of Forest Fires with Radioactive Smoke from forests impacted by the 1986 Chernobyl nuclear disaster.

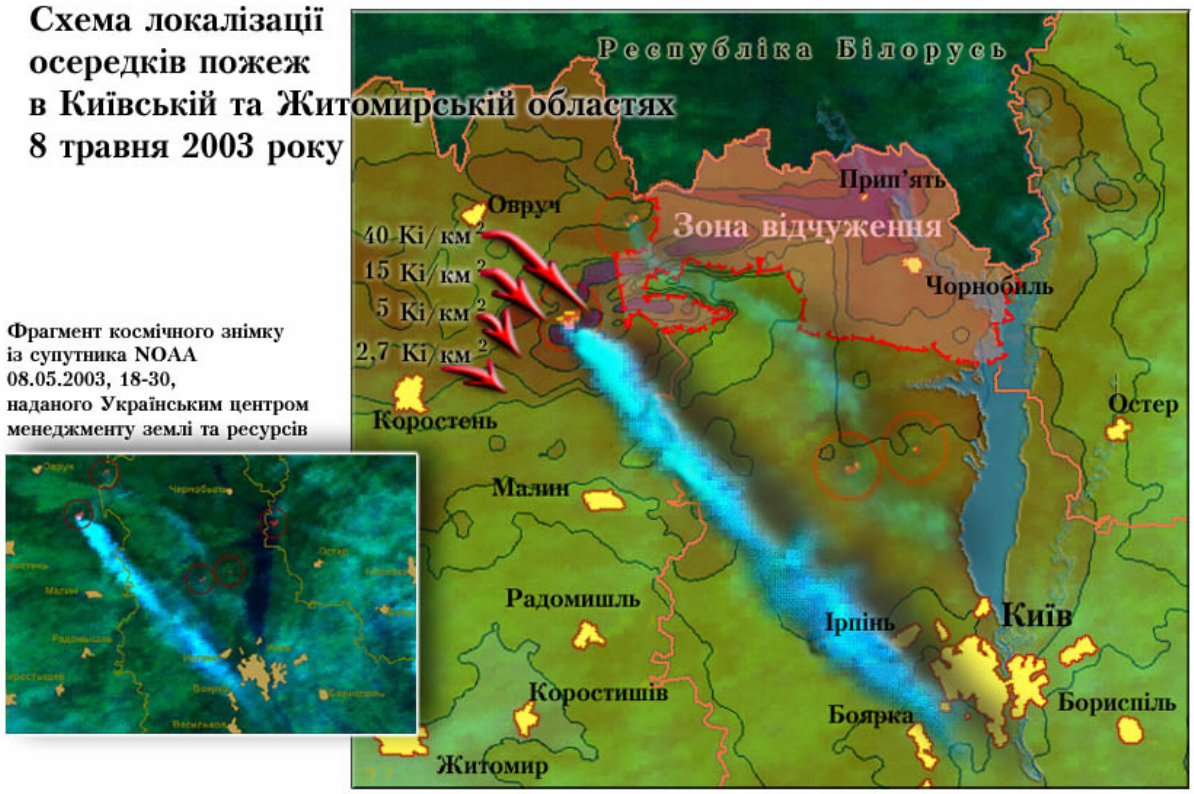
**A Joint Proposal of the National Agriculture University of Ukraine,
Yale University, School of Forestry and Environmental Studies,
and
DePaul University.**

Introduction

Radioactive smoke will cause millions of dollars in health and economic loss to Kiev and other parts of Ukraine because the present management regime means forest fires are inevitable in the forests contaminated by the 1986 (Chernobyl) nuclear disaster.

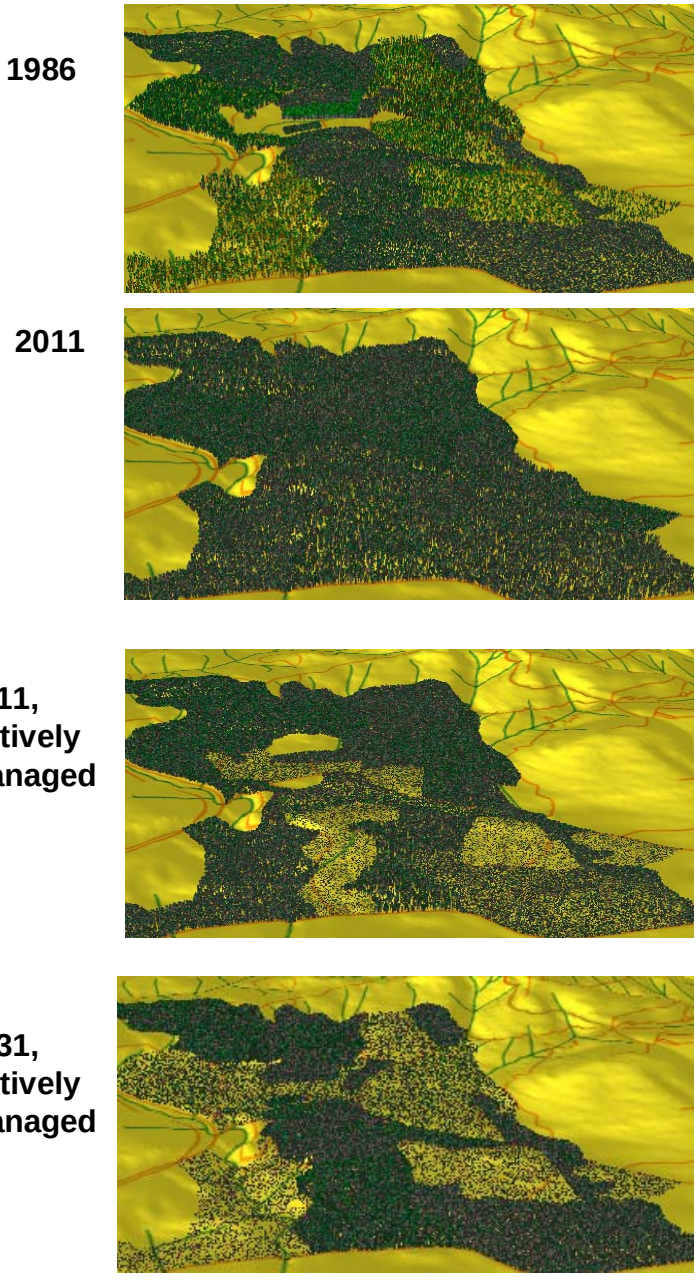
Such catastrophic fires will be especially bad for Kiev and other areas surrounding the contaminated forest zone, because wind will move the radioactive smoke (e.g., Figure 1). Radioactivity in the smoke gets into people's lungs and also lands on foods and affects their marketability as well as their usability.

Figure 1. Example of smoke blowing by wind from forest fire <u>outside</u> of most heavily contaminated forests. (Contaminated forests are shown in pink in upper center. Picture courtesy of Ukrainian Land and Resource Management Center)



The present management approach is to do little management and to prevent all forest fires. This approach will cause forests to grow and insects and fuel to increase until the fires become catastrophic and unstoppable (Figure 2; Azarof 1996, Dusha-Gudym 1966, Zibtsev 1998).

Figure 2. Simulated changes in a forest area with no management, using LMS. Species and growth are similar to Chernobyl forests. Note forests become more dense and susceptible to fires as they grow. Active management can prevent the fire-prone continuity of dense forests by creating a mosaic of open and closed forests which change over time with growth and tree harvest.



Unstoppable catastrophic fires resulted from similar management approaches in the Inland Western United States (Figure 3). Eventually, the fires become so unstoppable that no amount of fire fighting equipment can prevent them. Consequently, simply increasing the amount of fire fighting equipment but taken no other management action will not avert the fires.

The large area—nearly 260,000 ha--of such radioactively contaminated forests means the fires generated can become quite large, generating their own weather patterns and sending radioactive smoke many miles away (Figure 4).

During the fire radioactive cesium (Cs^{137}) can be resuspended in the atmosphere as particulate matter in smut and smoke or as a gas. Radioactivity is highest in the contaminated forest in the litter and upper layer of soil, followed by needles and bark. It is most likely that severe fires will mobilize Cs^{137} from the forest litter and upper soil layers (Amiro et al. 1999, Dusha-Gudym 1996). In the grassland, the radioactivity in litter is also higher than in the grass (Yoschenko et al. 2006). Cs^{137}, K^{40} (Potassium 40), and Sr^{90} (Strontium 90) were the dominant nuclides in ash samples during experimental burning of timber biomass in Finland. Levels of nadionuclide content in fly ash was 1.7 times higher than in bottom ash (Rantavaara and Moring 1999). Cs^{137} concentration fixed in smoke aerosols was 25 times more than the background level in a ground fire and 100 times more in a crown fire (Miroshnichenko and Strilchuk 2004, Azarof 1996). A recent study has shown that the radioactivity levels of Sr^{90}, Cs^{137}, Pu^{238}, Pu^{239}, and Pu^{240} (Plutonium 238, 239, & 240) on particulate matter near a forest or grassland fire in Chernobyl were several orders of magnitude higher than the ambient levels (Yoschenko et al. 2005, 2006). The plutonium nuclides are the dominating radioactive elements of the fine smoke particles and would have tremendous health repercussions on firefighters and the surrounding public.

Smoke particles and mineral dust are the main sources of atmospheric radionuclides in the Chernobyl Exclusion Zone. Smoke particles are more damaging than dust because they are smaller (Chakrabarty et al. 2006) and so are more readily inhaled into the lungs. In addition, smoke particles can travel several hundred to several thousand kilometers depending on the vegetation type burned, fire intensity, area burned, fire duration, and meteorological conditions. On the other hand, dust particles generated by construction or by windy conditions are generally redeposited close to the source (Brasseur et al. 1999).

Experimental data for a burned forest in the Chernobyl Exclusion Zone show also that the radionuclide runoff from the slopes increased more than one order of magnitude after forest fires and could reach 15-20 percent of the total deposition (Kutlahmedov et al. 1999).

Figure 3. Preventing all fires, but little active management was successful for several decades after it began in the 1930's in the United States. By the 1980's the fuel loads were so high that the fires were unstoppable despite high technology fire fighting equipment.

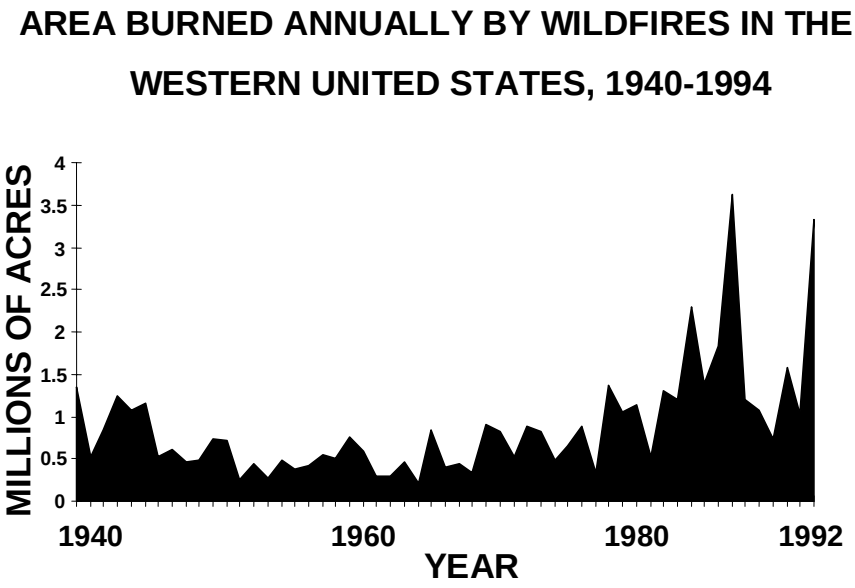
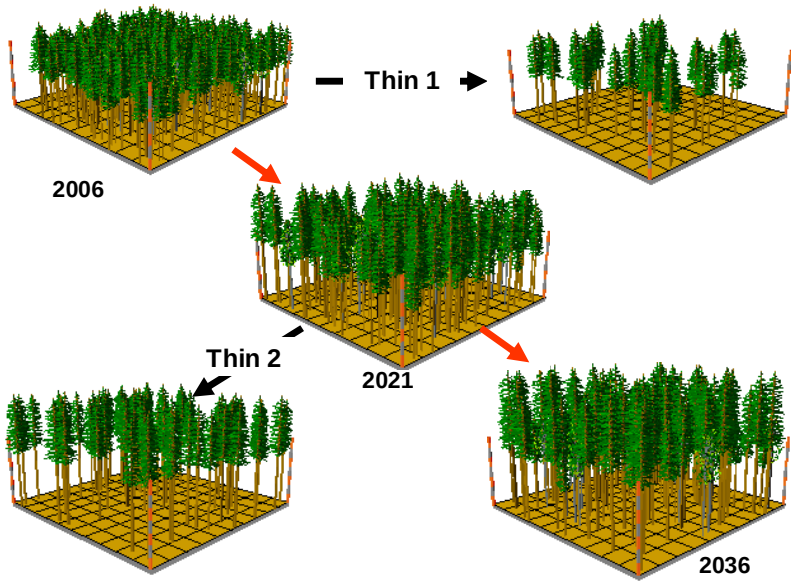


Figure 4. Cloud pattern generated by 100,000+ ha forest fire in northern Oregon, U.S.A. (Tillamook burn, 1930's). The Chernobyl forest has to potential to generate large forest fires that can generate their own weather patterns and send smoke many miles away. (Photo courtesy of Oregon Department of Forestry, U.S.A.)

These fires can be dramatically reduced in size, frequency, and severity and largely prevented altogether through appropriately planned, proactive forest management combined with modest increases in fire fighting equipment. Forests are primarily susceptible to fires when in certain structures (Figures 5 & 6), and active management that minimizes the amounts and contiguousness of these structures on the landscape will reduce the threat and sizes of any forest fires—and allow them to be controlled by fire fighting equipment.

Figure 5. Stand in Chernobyl forest (high contamination area) highly susceptible to forest fires. The crowded structure, many dead trees, and dry soils make these stands highly flammable. (Photo by C. Oliver, 2005).

Figure 6. Dense crowded forest "structures" (three stands diagonally upper left to lower right) are susceptible to forest fires, and become more susceptible as they grow. Active management can reduce the crowding and make the stands less susceptible to fires (Stands at upper right and lower left). Stands visualizations similar to Chernobyl forest stands were projected using LMS (Landscape Management System) to be used in this proposal.



Decay rates of the 260,000 ha of most radioactively contaminated forests suggest the forest smoke may be less dangerous in coming centuries years. In the meantime, the objective is to manage the area as active forests and to prevent fires--to keep these radioactive elements cycling between the forest floor and the standing trees.

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Proposal

We propose to reduce the likelihood of fires dramatically by using a technical, computerized decision support tool to develop and implement a management plan for the 260,000 ha area of most radioactively contaminated forests and grasslands in the nuclear disaster zone. When implemented, this plan, combined with a slightly increased fire fighting infrastructure, should dramatically reduce the potential of disastrous fires and radioactive smoke.

The proposed tool, LMS (for Landscape Management System; see http:/lms.cfr.washington.edu) has been used in fire management applications in the western United States, as well as for other purposes elsewhere. The tool is being developed by a cooperative of Universities and public agencies.