Crop freezes and land-use change in Florida

Draining the state's southern wetlands may have raised the incidence of harmful frosts.

South Florida experienced a significant change in land usage during the twentieth century, including the conversion of natural wetlands into agricultural land for the cultivation of winter vegetable, sugar cane and citrus crops. This movement of agriculture from more northerly areas was intended partly to escape the risk of damaging winter freezes. Here we present evidence from a case study using a coupled atmosphere and land-surface computer-modelling system that suggests that the draining of wetlands may have inadvertently increased the frequency and severity of agriculturally damaging freezes in the south of Florida.

On 19 January 1997, a rare freeze inflicted severe damage in agricultural areas of south Florida that were once natural wetlands, with below-freezing temperatures extending to the tip of the peninsula. This event, chosen here for our case study, resulted in losses in the fresh-vegetable and sugar-cane sectors that alone exceeded US$300 million[1]. Furthermore, nearly 100,000 migrant farm workers were displaced or unemployed as a result of the freeze[2].

We used the Regional Atmospheric Modeling System (RAMS)[3], a comprehensive meteorological modelling system that includes a sophisticated land-surface scheme to represent the effects of surface properties on atmospheric processes[4], to investigate the impact of anthropogenic changes in land coverage on this freeze. A pair of simulations was undertaken in which the model configuration was identical, except that in one simulation the data represented pre-1900s (almost natural) land cover, whereas in the other they represented 1993 (near-present-day) land usage. These data sets (Fig. 1a, b) reflect the conversion of natural wetlands to agricultural land in the areas of south Florida that were affected by the freeze.

In key agricultural areas that were once natural wetlands, particularly the areas used for high-density cultivation of winter vegetables, sugar cane and citrus fruits to the south and southwest of Lake Okeechobee, the simulation incorporating current land coverage produced minimum temperatures that were generally colder (Fig. 1c) and were below freezing for a longer period (Fig. 1d) than that using natural land coverage. The results reveal that when land-surface properties were specified to represent natural land cover, a persistent heat flux from wetlands was sufficient to hold the simulated temperature above freezing throughout the night in many of these areas (results not shown).

In other agricultural areas of south Florida that were once natural wetlands, such as portions of the Kissimmee Valley (north of Lake Okeechobee), the model simulated a freeze regardless of the specification of land-surface properties. However, even in these areas, minimum temperatures were generally colder and were below 0 °C for a longer period when present-day land use was prescribed (Fig. 1c, d). The duration of exposure to sub-zero temperatures is critical in determining the amount of crop damage that occurs during a freeze[5].

Our results indicate that, even in areas where a freeze would have occurred irrespective of land-surface properties, the agricultural damage may have been worse than it would have been if natural wetlands had still been present in those areas. Results were similar when the same modelling method was applied to other recent agriculturally damaging freezes in south Florida, including the events of 26 December 1983 and 25 December 1989.

We have shown that the likelihood of agriculturally damaging freezes in south Florida has increased as a result of the conversion of its natural wetlands to agriculture. This is ironic, considering that the move was instigated partly to avoid the freezes that occur further to the north[6–8]. Our results provide another example of the potential for anthropogenic changes in land usage to perturb the climate system[9].

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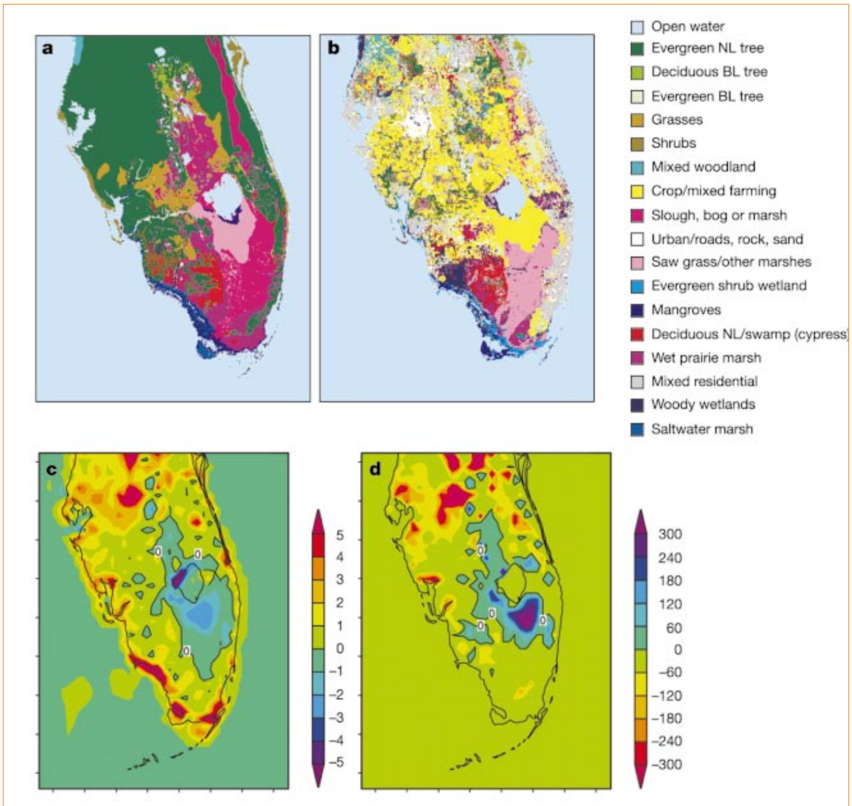

Figure 1 Minimum temperatures, and the duration of periods of of sub-zero temperatures, in areas cultivated from drained wetlands in south Florida. **a, b,** Classes of land use specifying model properties for simulations incorporating land-surface conditions before the 1900s (**a**) and in 1993 (**b**). NL, needleleaf; BL, broadleaf. **c,** Difference between the model's simulated minimum temperatures (in °C) near ground level on 19 January 1997; differences were determined as the values derived from 1993 usage minus those from pre-1900s usage. Locations inside the zero contour experienced colder minimum temperatures when 1993 land use was used in the model. **d,** Difference in the duration (in min) of subzero-temperature periods for the two different model simulations; differences were determined as in **c**. Areas inside the zero contour experienced freezing temperatures for longer when 1993 land use was used in the model.

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for two weeks. The spiders were subsequently presented with equally sized live and dead prey (dead prey was killed by freezing at −80 °C). Spiders were kept in the dark and observed under low light every hour for evidence of prey choice, which was verified by fang penetration and feeding for 5 min or longer.

In these experiments, 81.4% of *L. reclusa* chose dead over live waxmoth larvae (*Achroia grisella*; $n=59$), 75.6% chose dead over live domestic crickets (*Acheta domestica*; $n=41$)