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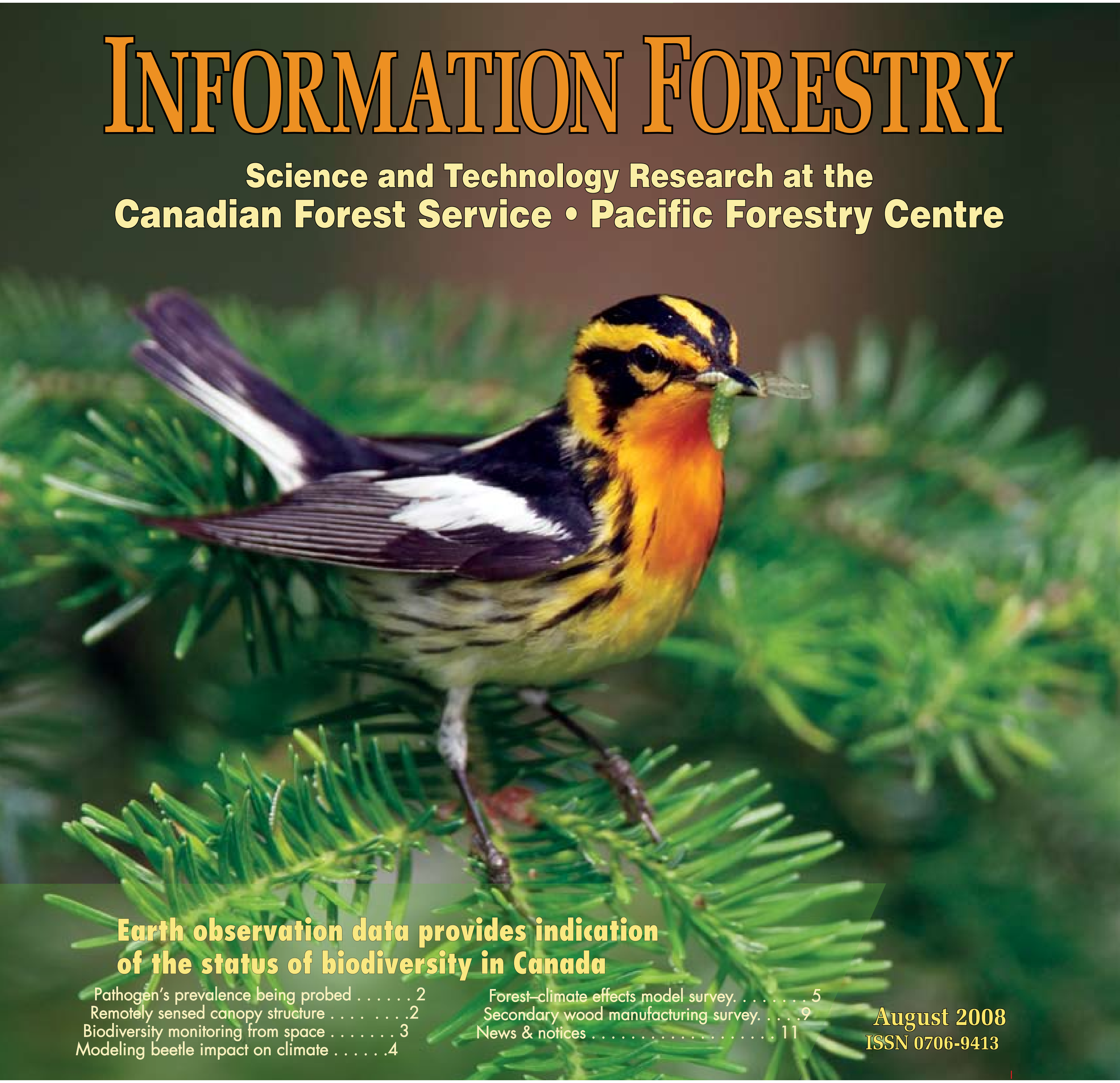

Earth observation data provides indication of the status of biodiversity in Canada

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Canada

Pathogen's presence prompts prevalence probe

Septoria musiva causes one of the most severe hybrid-poplar diseases in its native range. Throughout eastern North America, the fungus, which differs from less damaging relatives in having smaller spores, causes leaf spots, defoliation, cankers and stem breakage. Cankers girdling stems can kill young trees within two years.

Far from the pathogen's home range, hybrid poplar plantations in British Columbia have long been thought *S. musiva*-free. That is, until Natural Resources Canada Research Scientist Brenda Callan (bcallan@nrcan-rncan.gc.ca) cultured a single, small-spored *Septoria* isolate from stem cankers on young poplars growing in a Fraser Valley, British Columbia, hybrid-poplar nursery.

"We thought, small spores, lots of cankers... not good," says the mycologist. DNA tests run by Canadian Forest Service researchers "confirmed the identity beyond any doubt."

This is the first confirmed record of *S. musiva* causing widespread stem cankers in commercially grown hybrid poplars in British Columbia. About 12,000 hectares of the province's Fraser Valley are planted with hybrid poplar to provide fibre for pulp or biofuels.

Plantations managers are replacing diseased stock with resistant hybrids. As well, the province has approved use of a fungicide that will help to protect poplars from infections by *S. musiva*. Provincial forest officers are also overseeing a risk analysis of the introduced pathogen. The analysis will help determine the disease's extent in British Columbia, identify susceptible hybrids and species, and determine eradication or control feasibility.

So far, says British Columbia Ministry of Forests and Range Forest Pathologist Harry Kope, the disease has been found only on hybrid poplars already demonstrated in eastern plantations to be susceptible.

"There is concern that black cottonwood may be susceptible," he says. "If it is, the disease's presence here puts native ecosystems at risk." Black cottonwood is a dominant native poplar species. Although not commercially valuable, it is important to biodiversity, wildlife habitat and ecosystem function.

British Columbia exports no poplar logs and few poplar cuttings or seedlings.

Sources

"*Septoria musiva* isolated from cankered stems in hybrid poplar stool beds, Fraser Valley, British Columbia" was published September 21, 2007, in the e-journal *Pacific Northwest Fungi* (now *North American Fungi*). Callan also wrote the book on poplar diseases in British Columbia: *Diseases of Populus in British Columbia: A Diagnostic Manual.*

"Estimating canopy structure of Douglas-fire forest stands rom discrete-return LiDAR" can be ordered from the Canadian Forest Service online bookstore.

Forest canopy structure from afar

Lasers may soon be aimed at a forest near you.

Researchers from the University of British Columbia and Natural Resources Canada are testing lidar (light detection and ranging) technology to determine forest canopy characteristics such as crown size, volume, openness, and density of foliage.

"Forestry agencies across Canada and around the world are testing the potential of lidar to characterize forests," says Canadian Forest Service Research Scientist Mike Wulder (mwulder@nrcan-rncan.gc.ca). "Lidar data provides height information similar in accuracy to field measurements. So now we're interested in seeing what other kinds of information about the forest canopy we can get using lidar."

When the researchers compared data collected from diverse Douglas-fir stands on eastern Vancouver Island by airborne lidar and by ground crews, they found the lidar-collected data to be consistent—and more accurate—than those collected by the ground crews.

"Measuring crown volume and density is very difficult and often involves some judgment on the part of foresters," says Nicholas Coops, University of British Columbia Associate Professor of Forest Resources Management, Canada Research Chair in Remote Sensing, and the study's leader. "Lidar bypasses that. It is objective, quantifiable, and repeatable."

Because canopy foliage fuels tree growth, canopy information applies directly to forest management and inventory calculations. "It provides information about a tree's growth rates, growth potential, and tree health," Coops says. The information is also useful for monitoring biodiversity, as some animals and understorey plants thrive only in forests with particular canopy characteristics.

Lidar is a remote sensing technology in which pulses of near-infrared laser light are bounced off surfaces, and the time the light takes to travel from the laser, hit the target surface and return to the sensor is measured. Distance travelled by the light is calculated from the time measurement and the constant speed of light, with lidar instruments sending laser pulses at a very high rates—up to 160,000 pulses per second.

Sky-high eyes measure biodiversity across Canada

Orbiting the Earth more than 700 kilometres above Canada's forests, a set of satellite-borne sensors collects data from the light reflecting off the planet's surface.

Beneath the canopy of an eastern Ontario woodland, a Blackburnian warbler prepares to fly south for the winter.

Biodiversity Monitoring from Space, or BioSpace, a Natural Resources Canada-led project, is the first system of its kind in Canada to use Earth observation data to monitor biodiversity over large areas in a systematic and repeatable manner. Its developers hope it will come to serve as an early warning system to alert governments and resource managers to critical habitat losses and areas with potential species at risk in even the most remote, inaccessible regions of the country.

"Most of the current work used to characterize biodiversity in Canada is very detailed and locally specific, and usually involves someone going out into the field and inventorying specific species," says project leader Mike Wulder (mwulder@nrcan.rnan.g.ca), a research scientist with Natural Resources Canada. "With BioSpace, we're exploring the big picture: can we use Earth observation data from space to characterize national trends in biodiversity and identify locations where changes in certain conditions may indicate changes in biodiversity?"

BioSpace monitors four key indicators of biodiversity on the landscape, at one-kilometre spatial resolution. Topography drives climate. Land cover indicates types of cover (vegetated and non-vegetated) and their spatial arrangement. The dynamic habitat index incorporates measures of annual vegetation productivity or greenness, amount of snow cover in winter, and seasonal variation in landscape greenness (an indication of when food is available). The fourth indicator is disturbance of land cover over time.

The BioSpace team recently compared indicator-based predictions of biodiversity to field data collected for birds, such as the Blackburnian warbler, by the Ontario Breeding Bird Survey and on butterflies in the northeastern U.S.

"Land cover and seasonality are the two remotely sensed indicators that explain most variations in species richness for these two groups," says Nicholas Coops, a member of the BioSpace team,and University of British Columbia Associate Professor of Forest Resources Management, Canada Research Chair in Remote Sensing. "Birds and butterflies like edge environments: they might live in one habitat, breed in another, and feed in a third. If you're interested in using BioSpace to monitor the status of bird populations, you would focus on these two indices."

"It's very expensive to go out and monitor every single species," says Natural Resources Canada Biodiversity Science Advisor Brenda McAfee. "We don't have the resources to do that even in the regions that have roads, let alone in remote regions of the country with no transportation infrastructure." BioSpace, she says, would permit her group to report on the status of biodiversity on an ecosystem or landscape level anywhere in Canada.

Agreements that require Canada to report on biodiversity include the Convention on Biological Diversity, the Montreal Protocol's Criteria and Indicators of Sustainable Forest Management, the Canadian Biodiversity Strategy, and the National Forest Inventory.

In addition, information generated from BioSpace allows researchers and natural resource managers to prioritize field sampling. "BioSpace is not a substitute for field sampling," says Wulder. "You have to have boots on the ground in order to actually inventory the species and conditions." BioSpace may facilitate allocation of scarce resources for detailed field studies and species-at-risk conservation.

BioSpace is supported by the Government Related initiatives Program of the Canadian Space Agency.

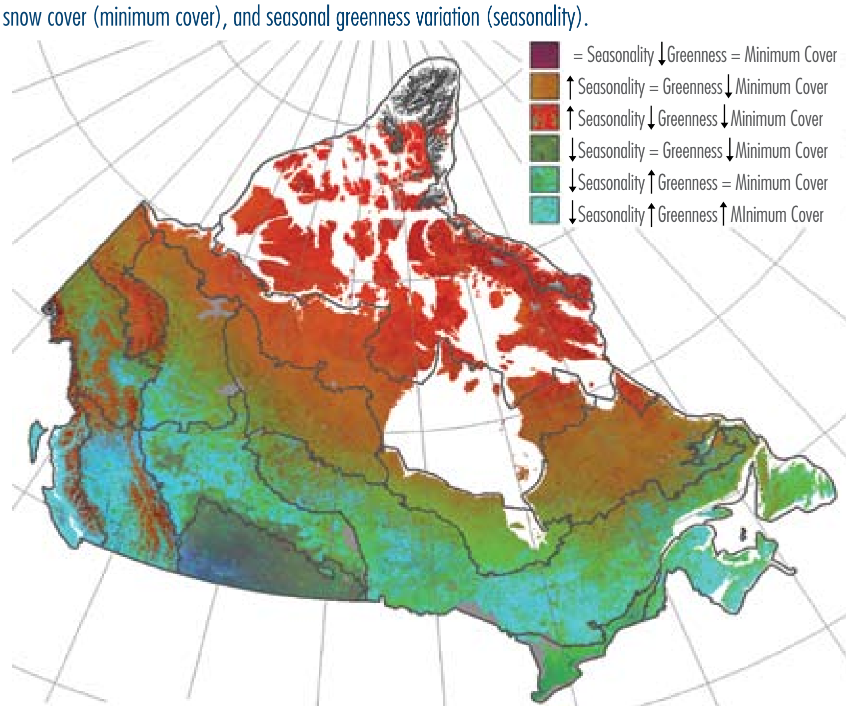
"The development of a Canadian dynamic habitat index using multi-temporal satellite estimates of canopy light absorbance" and "Development of a large area biodiverstiy monitoring system driven by remote sensing " can be ordered from the Canadian Forest Service online bookstore.

On the cover

Many bird species, such as the Blackburnian warbler, prefer fragmented forests and woodlands: land cover structure that BioSpace can identify.

photo: © Paul Tessier, iStock 2007

BioSpace uses indirect indicators of biodiversity to estimate habitat suitability for groups of animal species. The dynamic habitat index incorporates time-series measures of annual vegetation productivity (greenness), snow cover (minimum cover), and seasonal greenness variation (seasonality).



Beetle study shows infestation impact on climate

Sources

Publication of Kurz et al.'s "Mountain pine beetle and forest carbon feedback to climate change" in *Nature* this spring generated news coverage and response from around the world. See also "Impacts of Climate Change on Range Expansion by the Mountain Pine Beetle," by Carroll et al. Both articles may be ordered via the Canadian Forest Service online bookstore.

The billion-tonne beetle.That's what Natural Resources Canada Research Scientist Werner Kurz calls the mountain pine beetle, a tiny insect eating its way through western Canada's pine forests. The current beetle infestation in British Columbia encompasses more than 13 million hectares.

The beetle is driving the province's forest carbon budget into the red. Ten years ago, British Columbia's vast forests collected and stored slightly more carbon from the atmosphere than they released; now, they're a source.

A study by Kurz and his colleagues from the Canadian Forest Service and the British Columbia Ministry of Forests and Range shows that over the course of the current outbreak, from 2000 to 2020, the beetle epidemic will increase atmospheric carbon dioxide by almost one billion tonnes—an impact equivalent to about 10 percent of Canada's total annual human-caused greenhouse gas emissions.

"The beetle's impact is two-fold," says Kurz (wkurz@nrcan-rncan.gc.ca). "The beetle kills trees, so the trees stop taking up CO_2 through photosynthesis, and then, as the dead trees decompose, they release the CO_2 that they accumulated over their lifetime."

This is the first assessment of the impact of an insect outbreak over a large area on the carbon balance. "Clearly, when governments assess the response of terrestrial systems to climate change, they need look at not only fire responses but also responses of insects and other natural disturbances," says Kurz, a member of the Intergovernmental Panel on Climate Change that was awarded a Nobel Peace Prize in 2007.

Using the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3), Kurz and his colleagues summarized conditions in the province's forests based on inventory data and other information provided by the province, entomologists, fire researchers and other scientists. The team entered those data into the model's simulation framework to assess the beetle's contributions to the global greenhouse gas budget.

"We ran the model for about 98 percent of the infestation area—with and without beetle," Kurz says. "Then we quantified the difference between the base run and the with-beetle run. That came to 990 million tonnes of CO_2. When we added the impact of management responses to the beetle, we got 1.17 billion tonnes difference in ecosystem carbon."

Kurz says the results present an opportunity for British Columbians to examine how the numbers can be reduced. "What are we going to do with all this dead wood? If we leave it where it is, it will decompose or get burned in a fire; in either case the CO_2 will be released back into the atmosphere. But opportunities to mitigate the effects on the greenhouse gas balance exist."

For instance, studies funded by the federal mountain pine beetle program show that wood quality of beetle-killed trees deteriorates quickly after death if the tree is left on the landscape. Salvaging beetle-killed timber quickly and processing the wood into lumber and other building materials would lock up wood carbon for years. As well, using beetle-killed trees for biofuel, although causing emissions when burned, would replace some emissions from burning fossil fuels and reduce pressure to convert forested land or land used for food production to biofuel croplands.

The impact-forecasting framework used in this study can be applied to other insects. Kurz's team is now analyzing effects of spruce budworm defoliation on Canada's forest carbon balance.

Warmer temperatures contributed to the mountain pine beetle's recent spread into higher elevations in British Columbia, and north and east. Warmer winters have allowed beetle larvae to survive, increasing the beetle's population.

Colder temperatures in northern Alberta and British Columbia last winter reduced this year's beetle numbers, but the infestation continues to spread east and south.

Researchers investigate climate effects in forests

Planet Earth is no crystal ball when it comes to predicting the future.

Scientists around the world—including those at Natural Resources Canada—are working to determine how changes in global climate will affect the systems that support life and quality of life on Earth. The kinds of systems that researchers are investigating include globe-encompassing atmospheric and ocean circulation systems right down to regional ecosystems.

Measuring, monitoring and studying, researchers translate this information into equations that they then piece together in models—mathematical simulations of real-world systems and processes.

Even with our watery globe providing so much data or process information, models that simulate forest phenomena are often limited in their ability to project far into the future with any certainty.

"With many models, we can determine with reasonable confidence what will happen in our forests in a decade and even several decades from now," says Natural Resources Canada Research Scientist Werner Kurz, "but the further into the future we try to forecast, the more uncertainty there is—the more any errors there may be in our assumptions and the model parameters manifest. This applies to all models."

Kurz leads a team of researchers from the Canadian Forest Service and British Columbia Ministry of Forests to develop a model to track Canada's forest carbon balance and extrapolate that carbon capture into the future. His group is just one of a number of Natural Resources Canada research teams developing models to simulate climate-related effects in Canada's forests. Each of those models is designed to answer its own unique questions, use different approaches to answering those questions, and apply the questions to different geographic and data scales.

Several of the models are surveyed below, with information provided by their lead developers.

Carbon Budget Model of the Canadian Forest Sector (CBM-CFS)

Lead: Werner Kurz, Research Scientist, Carbon Accounting Team (wkurz@nrcan-rncan.gc.ca)

What the model is meant to do: Simulate the greenhouse gas balance of the forests and the impacts of human activities and natural forest disturbances on the greenhouse gas balance. CBM-CFS is a core model of Canada's National Forest Carbon Monitoring, Accounting and Reporting System: it is used to inform policy decisions and international climate negotiations, and by industry, provinces and academics in Canada and abroad.

Questions the model is meant to answer: What are the stand- to landscape-level analyses of forest carbon stock changes in the past? How might different scenarios of various management options translate into a carbon balance? How effective are various mitigation strategies to reduce greenhouse gas sources and increase sinks?

Approach: Empirical. It has limited process-modelling capability.

Information generated: Information about tree growth, carbon stocks and greenhouse gas balances. It deals with carbon dioxide and what we call non-carbon dioxide greenhouse gases—primarily methane. It also calculates a number of ecological parameters like primary net productivity and net ecosystem productivity.

Data demands: Traditional forest inventory information, growth and yield information, and activity data—as in harvesting, planting, slash burning—as well as natural disturbance data—fire, insects and other impacts. Lastly, land-use change—afforestation, deforestation. The model also requires ecological parameters, which are provided, but if you use the model elsewhere than Canada, you have to check or revise these.

Uncertainty: We're not yet able to translate the climate signal into a growth response signal. That's an area of active research right now. We have to prescribe the growth response at this point: you tell the model that trees will grow X-percent faster, that we'll have so many fires, and so on.

Constraints: as above, and also time required for runs. If we run all of Canada, we have just under three million inventory records. We've built a compressed version of the database with about 60,000 records, which brings computing time down to minutes, and allows us to do sensitivity analyses.

Strengths: It provides users with a framework and the analytical capability to do retrospective or projective analyses of forest carbon stocks.

Room for improvement: Some process representation is not yet implemented, and some of the data are lacking: we know much less about soils and soil carbon than we know about trees. There are also many environmental factors, like slope position and aspect and drainage, for which we have *no* data at the national scale. So, when we take the model projections down to individual sites, the model doesn't capture those sites well; but when we take it to regional averages, it does very well.

Landscape Dynamics Simulator (LANDDS)

Lead: David Gray, Research Scientist, Disturbance Ecology-Spatial Dynamics of Forest Insects Outbreaks (dgray@nrcan-rncan.gc.ca)

What the model is meant to do: Simulate changing landscape structure that would occur under a climate scenario as a forest matures, dies and regenerates, and is further affected by insect outbreaks, fire and harvesting. It attempts to integrate the major factors that cause forests to change over time—natural growth, succession issues, harvesting, fire and insect disturbances, and how those things play back and forth on each other.

Questions the model is meant to answer: What is the net impact of climate change on the forest landscape and our ability to use the resources it normally produces?

Approach: Empirical.

Information generated: The model generates an ever-changing description of the forest landscape: the species breakdown, the age distribution, the diameter distribution of the species on that pixel—and that information can be aggregated in any way. You can summarize by geographic unit—provincial jurisdiction, management unit, ecosystem or ecozone; you can summarize over the time period of the simulation: losses to any disturbance agent, amount you were able to harvest over that simulation, amount you would have harvested had you not harvested because of losses to disturbance agents. The model tracks the ever-changing forest landscape—what it looks like—but it also keeps track of what is being lost to disturbance agents and what is being harvested over time.

Data demands: Provincial inventories populate the model with a starting landscape: species distribution, age class, and diameter distributions. The model requires information about insect outbreaks, based on historical records, and analyses of the influence of forest habitat and climate on insects. The fire component is based on analyses of the Large Fire Data Base. The climate scenarios come from the Canadian Centre for Climate Modelling.

Uncertainty: High. The three dominant players—humans, fire and insects—affect each other and interact; as soon as there's a little bit of uncertainty on any one of them, it cascades. If you run the simulation for 200 years, those cascading effects escalate.

Constraints: Data requirements. You have to have a good picture of what your forest looks like when you start, and that requires a fair amount of pre-existing, reasonably accurate forest inventory information.

Strengths: It describes the forest well, because it describes it in detail.

Room for improvement: It does not model growth and succession over the long term well.

Climate envelope modelling to map vegetation distribution

Lead: Dan McKenney, Chief, Landscape Analysis and Applications (dmckenne@nrcan-rncan.gc.ca)

What the model is meant to do: Using a climate envelope framework, the models take observations of where plant species grow, and develop and map climatic profiles for the species. For the climate component, we ask where that climate is moving by using Intergovernmental Panel on Climate Change scenarios.

Questions the model is meant to answer: What are the potential distributions of plant species? What are their climatic tolerances? Where will there be stresses on plant migration and where might managers consider assisted migration?

Approach: Empirical: we're quantifying climatic tolerances of individual species based on known locations.

Information generated: The range of possible effects of climate on plant-species distribution. It provides information on where people might look for species, where people might want to test species for planting, and where some species might run into potential problems based on climate scenarios.

Data demands: Species occurrence and location information. This comes from vegetation plot data for most provinces, Canadian conservation data centre-type data, U.S. Nature Serve data, and individual ad hoc surveys from professional botanists and ecologists, plus master gardeners and, in some cases, the public. We use climate models and climate change scenario data.

Uncertainty: The uncertainty is largely based on how good the climate change scenarios are and what path climate change takes. We don't know that: a lot depends on how humans will respond to climate change.

Constraints: There is always room for more data, especially about where plants can grow beyond their known natural ranges.

Strengths: It quantifies climatic tolerances pretty well, it provides maps, it visualizes things well. Because the subject has practical application for gardeners and the public, the website (http://planthardiness.gc.ca) has 10,000 to 40,000 visitors each month.

Room for improvement: It is limited by available data from plant observations to climate and the quality of the climate change scenarios.

Canadian Integrated Biosphere Simulator (CanIBIS)

Lead: David Price, Research Scientist, Integrative Climate Change Impacts Modelling (dprice@nrcan-rncan.gc.ca)

What the model is meant to do: CanIBIS is a dynamic vegetation model. It attempts to account for all the physics related to exchanges of heat, water vapour and carbon dioxide between vegetation and the atmosphere, in response to hourly variations in weather, as well as recognize influences of soils and topography on water availability. Vegetation growth and species succession are represented by simulating a mixture of Plant Functional Types (PFT) parameterized to respond differently to environmental conditions. The objective is to try to recreate the spatial distribution of Canada's vegetation as observed in field observations and remote sensing when the model is driven by historical climate data.

Questions the model is meant to answer: How will the distribution and productivity of different types of vegetation change in the future, based on basic processes that drive growth?

Approach: Process.

Information generated: The model produces lots of different information, including net primary productivity, net ecosystem productivity, the distribution of vegetation types (classified from the simulated mixture of PFTs) within a landscape, as well as projections of how these may change in the future with changing climate.

Data demands: High. Each PFT requires parameters to define growth and survival in response to environmental factors. Spatial simulations at continental scale also require continental datasets of soils data and monthly climatology. The climate data sets (temperature, rainfall, radiation, wind speed, humidity) are interpolated from weather station records collected across North America, back to 1901, or interpolated for the future from global climate model (GCM) scenarios. Each (continues next page)

Mountain pine beetle climatic suitability model

Lead: Allan Carroll, Research Scientist, Insect Ecology (acarroll@nrcan-rncan.gc.ca)

What the model is meant to do: It relates a variety of parameters insofar as they affect mountain pine beetle directly, or indirectly through the host—whether there's sufficient warmth in the environment for the beetle to complete its development at the optimal time; whether an extreme winter cold event occurs; whether it's hot enough in the middle of summer for the beetles to emerge, fly and disperse; whether there's sufficient precipitation in the spring for the trees to defend against the beetle.

We then relate those parameters to climatic conditions to see if an area is climatically suitable for mountain pine beetle. We link the model to BioSIM, developed by Jacques Régnière at Laurentian Forestry Centre, which allows us to extrapolate information developed for single locations over the landscape. From this, we produce maps of suitable climate over very large landscapes.

Questions the model is meant to answer: Has distribution of climatically suitable habitat for the beetle increased? If it has, is the change based on real weather data in the distribution of climatically suitable habitats? Has the beetle expanded into these new areas?

Approach: A combination of empirical and process. The model is based on what we know of the beetle and the way it interacts with its environment and host; the model also relies upon certain observed empirical relationships.

Information generated: We use weather data to determine where historical changes in the distribution of climatically suitable habitat for mountain pine beetle have occurred. Then we assess whether the beetles actually followed that expanded range. We use simulated weather data based on global circulation models and, at time steps into the future and under various climate change scenarios, we map where distribution of climatically suitable habitats may occur. In other words, we have the capacity to predict where we expect mountain pine beetle to go in the future under climate change, based on these other parameters.

Data demands: Temperature and precipitation data. How the model is applied over landscapes and how it's used to assess beetle response require additional data.

Uncertainty: It's been very accurate, in the sense that the areas we first predicted to be climatically suitable have indeed become so. The beetle has moved into those areas. The certainty of the predictions is a function of our certainty around our climate change projections. We anticipate that the biology will remain the same, and hence the model will remain relevant.

Constraints: climate projections.

Strengths: It predicts the distribution of climatically suitable habitats over large landscapes.

Room for improvement: The 30-year normals—how we look at climate over a long period—and the changes at 10-year increments are less relevant to direct management efforts that work on a year-by-year basis. Also, when the predictions are spread over the landscape using BioSIM, they depend on a digital elevation model with one-kilometre resolution—which is not fine enough in mountainous areas, for instance.

GCM uses different assumptions about how global atmospheric circulation works, and is based on a different projection of human population, economic growth, and pattern of fossil-energy use. We also normalise the GCM scenarios based on what they simulate for today, so that observed spatial variations in climate are captured in projections into the future.

Uncertainty: The model is robust in that it tries to simulate many processes realistically (accounting for differences in scale), but this means that it is both horribly complicated and a gross simplification of reality. Forests across North America are diverse, and this diversity has many and complex causes: we are trying to simulate an extremely complicated system of interactions between ecosystems and the atmosphere, many of which are not properly understood. Furthermore, when it comes to predicting future changes, we have to recognize the assumptions built into the GCMs are themselves gross simplifications of reality, and that the underlying scenarios of future greenhouse gas emissions and how these will affect future climate are hugely uncertain.

Constraints: The amount of data, the complexity of parameterizing the processes we think are important, the long time frames, the geographic scale of the model, and the required computing power and time. A cluster of 35 LINUX-running desktop PCs performs parallel processing and reduces turnaround.

Strengths: It captures the diversity of processes that contribute to how vegetation appears on the landscape at the large scale—the continental scale—and how this might respond to changes in environmental conditions.

Room for improvement: It has limited capacity to predict surprises. Models won't predict anything they're not programmed to predict. We're using climate data that are monthly values spread over 10-kilometre grids, and we're using soils data that are inadequate for high-latitude, high-elevation regions, again averaged out over relatively large grid cells. We're assuming that every 10-kilometre cell is homogeneous, but they're not. The model also doesn't simulate disturbances well yet, and the effects of major outbreaks of insect pests like spruce budworm and mountain pine beetle are missing. There's a lot of work to be done, but we think we're on the right track.

Western spruce budworm–BioSIM model

Lead: Vince Nealis, Insect Ecologist (vnealis@nrcan-rncan.gc.ca)

What the model is meant to do: We are trying to model synchrony in tree and insect development as a function of weather—of temperature, in particular. The model will help us to understand why we get budworm outbreaks in some summers in some areas and not in others; why the British Columbia interior has experienced chronic outbreaks of western spruce budworm since 1975; why we are getting outbreaks at higher elevations and further north than we've ever seen before; and whether or not there are areas no longer climatically suitable for outbreaks of the western spruce budworm. The model uses BioSIM, a climate and weather modeling framework developed by Natural Resources Canada scientist Jacques Régnière.

Questions the model is meant to answer: To what extent does local and landscape-level synchrony between the insect and the tree determine outbreak behaviour?

Approach: Process.

Information generated: Estimated times of emergence for any place for which you have, or can estimate, weather data from historical records. The combined information on weather and tree and insect responses allows us to map any life-stage event: time of spring emergence, time of pupation, time of moth flight. Past, present or future climate scenarios form the input.

Data demands: Estimates of the relationship between temperature and all aspects of insect development—not just feeding stages, but also hibernation. The influence of winter weather on budworm survival and spring emergence rate is not well understood.

Uncertainty: Most of the estimates are based upon controlled laboratory experiments, so there is less measurement error than if you were trying to drive this model with empirical estimates from the field. Field data, however, are used to calibrate the model by using independent sampling methods and experimental procedures.

Constraints: The inability to measure tree development in controlled conditions as can be done for insects. And trees have a fair degree of genetically based inter-individual variation in their responses to temperature compared to the budworm.

Strengths: It will give us a tool to query weather-related relationships that increase the likelihood of budworm outbreaks. We also want to understand if, under climate change scenarios, we can expect to live with increased western spruce budworm outbreaks for the foreseeable future.

Room for improvement: It won't give us a complete understanding of outbreak behaviour, because weather is just one piece of the equation. The other limitation of these models is we don't map microclimate well. That's too much detail, so we settle for averages.

Survey supplies snapshot of manufacturing sector

Labour and wood supply rank as the biggest constraints on British Columbia's secondary wood manufacturing industry, according to survey results recently published by Natural Resources Canada. *Secondary manufacturing of solid wood products in British Columbia, 2006: structure, economic contribution and changes since 1990* reports on the latest of five such surveys conducted since 1990, and provides the most recent, comprehensive snapshot of the sector in the province.

The survey shows how the sector has changed since the start of the decade. "Previously markets were consistently the main constraint, with wood supply right behind," says Canadian Forest Service Research Economist Brad Stennes (bstennes@nrcan-rncan.gc.ca), who co-authored the report with Canadian Forest Service–Pacific Forestry Centre Director of Industry, Trade and Economics Bill Wilson (bwilson@nrcan-rncan.gc.ca). "But now, wood supply is still in second place, but labour, which in 1999 was the limitation of least concern, is the primary constraint. Just like everybody else, the sector is having trouble finding workers."

Stennes and Wilson identify Alberta's job market and British Columbia's aging population as probable causes of the labour shortage.

Log-home manufacturing was one of the business areas that grew and benefitted rural British Columbia communities in the period, 2000 to 2006. Photo: © Vera Bogaerts, iStock, 2006.

"Experienced workers are retiring, and there are few people with appropriate skills and training to replace them," says Stennes.

The secondary wood manufacturing survey gathered operational, employment, production,

continues next page

Climate indices: eastern and western spruce budworm model

Lead: Alan Thomson, Research Scientist, Knowledge and Adaptive Management (athomson@nrcan-rncan.gc.ca)

What the model is meant to do: It tracks the interaction of climate indices and patterns in spruce budworm emergence and host bud-flush synchronization. The model takes a year's worth of minimum and maximum daily temperatures and determines how elevation affects the different stages of budworm and tree development. After the model's done its work, data analysis relates the model predictions to climate indices patterns.

Questions the model is meant to answer: When will different stages of budworm occur at different elevations? When will the tree be at its various stages of development? How do the budworm stages and tree development relate at those elevations? How do climate indices affect these values?

Approach: It's process-oriented in that the model works through the different stages of insect and tree development; it's empirical in that the relationships that go into it are based on data analysis.

Information generated: It generates the expected dates within particular years at which particular biological events occur—both the insect's and the tree's biological events.

Data demands: biological information for insect and host, weather data, global climate indices.

Uncertainty: The data on the spruce budworm development is well established by a number of studies; the data on Douglas-fir was from a single site, but the parameters that we came up with estimate the bud flush within about a day over a 10-year period. The real uncertainty is how well we can extrapolate those parameters to other locations.

Constraints: The biological data is not complete for eastern tree species' bud flush.

Strengths: It's good at estimating timings.

Room for improvement: It can't tell you the significance of these timings, in relation to whether the population is increasing, decreasing or outbreaking at all. We don't know what the given level of synchronization does to the survival of larvae, or what a given timing of emergence at a particular stage might do to population dynamics.

marketing and financial information on nine business types within the sector. The information is analyzed to provide both a quantitative and qualitative picture of the current structure and significance of secondary manufacturing in British Columbia, and sector trends through comparison to previous surveys, conducted at irregular intervals since 1990.

Overall, the sector's size is similar to what it was in 1999, when the last survey was conducted, but the relative economic contribution has shifted away from remanufacturing towards engineered wood products, cabinets and log-home and timber-frame manufacturing. Increased activity occurred in business types contributing most directly to British Columbia's domestic building boom, which is now showing signs of slowing.

Wilson says the survey series provides benchmark information about the industry, and allows governments and industry to track changes and problems within the sector. "Governments use the data to look at policies to encourage or maintain sector health," he says. "Industry specialty groups may use it to address aspects of business development within the sector."

The BC Wood Specialties Group (also known as BC Wood), for example, is using the data to develop its Business Innovation Partnership, a program that will provide its members with marketing, financial and human resources planning skills and tools to improve their businesses.

"Industry changes so much and so fast, we need regular snapshots," says the organisation's Director of Marketing and Communications Randi Walker. "The whole purpose in supporting this study was to get this picture of what was going on in the industry so we could identify the issues and move forward with programs that could help. If anything, I'd say we need to do the survey every three years or so."

BC Wood, with support from Forest Innovation Investment Ltd., partially funded the survey, as well as provided access to members. Other groups involved include the Independent Lumber Remanufacturers Association, the BC Log and Timber Building Industry Association, the Vancouver Island Association of Wood Processors, and the Canadian Plywood Association.

Source

Secondary manufacturing of solid wood products in British Columbia, 2006: structure, economic contribution, and changes since 1990 is available from the Canadian Forest Service online bookstore.

Key survey results

Remanufacturing decreased in relative importance, whereas cabinets, engineered wood products, and log-home and timber-frame manufacturing increased.

The relative importance of the U.S. market fell in this survey, replaced by an increase in British Columbia domestic sales. The U.S. remains important and is the destination for 43 percent of sector sales.

Compared to 1999, firms are less optimistic in their expansion plans, with notable decreases in the both the proportion of firms planning to expand and the mean level of planned expansion.

Labour and wood supply are now considered the most serious constraints to expansion.

The amount of secondary manufacturing as a proportion of harvest is much greater on the coast than in the interior. Some coastal firms are using interior species.

Most secondary manufacturing occurs in urban rather than remote rural areas. The main exceptions to this are log-home manufacturing and firms producing commodity-grade products such as finger jointing and wood pellets from low-value sawmill outputs.

The majority of firms are located in the Lower Mainland or the Okanagan region.

Compared to the previous survey, overall employment remains steady at 19,670 and sales, at $4.9 billion, although a fewer firms are involved. When adjusting the 1999 sales for inflation, sales have fallen 12 percent since 1999.

Wood use is virtually unchanged from 1999 estimates, at just under 18 million cubic metres (excluding use by panelboard firms in this estimate).

People

Arrivals

New Pacific Forestry Centre technician **Shelley Weber** is conducting a comprehensive environment scan on climate change adaptation, under the direction of Kelvin Hirsch (Northern Forestry Centre). Her research focusses on tree species vulnerability and adaptation to climate change. The project is being conducted under the auspices of the Canadian Council of Forest Ministers.

Departures

Forest Biology Research Scientist **Abul Ekramoddoullah** retires this year. During the 20 years he has worked with the Canadian Forest Service, Ekramoddoullah focused his research on the molecular host–pathogen interaction in the white pine blister rust fungus. He was the first to discover and report on a conifer pathogenesis-related protein (PR10) associated with resistance to the fungus in white pine, and the first to produce monoclonal antibodies to mycelia of the fungus and use them as probes to distinguish resistant and susceptible white pine seedlings.

Accolades

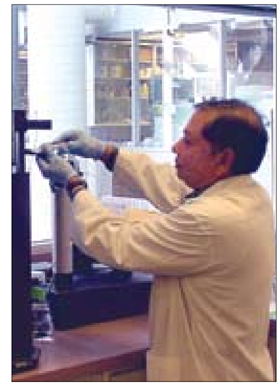
Research Scientist **Werner Kurz** was recognized for his contributions to the Intergovernmental Panel on Climate Change Assessment reports, and the award of the Nobel Peace Prize to the IPCC, at a ceremony in Ottawa this spring. He joined colleagues from Fisheries and Oceans Canada, Environment Canada and other departments at a reception on Parliament Hill hosted by Minister of the Environment John Baird. Later this summer, the executive of the Vancouver Island Section of the Canadian Institute of Forestry presented Kurz with the Tree of Life award, based on his work on the role of Canadian forests in carbon cycling, at a public ceremony at the University of Victoria.

The latest **Pacific Forestry Centre Graduate Student Awards** went to eight students studying forest science at British Columbia's universities.

From the University of British Columbia, Colin Ferster joins Research Scientist **Tony Trofymow** to study how inventory-based attributes can be used to characterize carbon stocks within eddy-flux covariance tower footprints, Samuel Coggins continues research with Research Scientist **Mike Wulder**, dealing with integration of multi-scale remotely sensed imagery with ground-survey information for forest inventory. Robbie Humber is forecasting changes in British Columbia forest carbon cycles under 21st-century climate and disturbance scenarios, under Research Scientist **Werner Kurz**.

From the University of Victoria, Brant Abbot is working with Research Economist **Brad Stennes** to study Canadian competitiveness and global changes in forest product industries, Nicole Dafoe studies the characterization of defensive proteins in hybrid poplars with Research Scientist **Abul Ekramoddoullah**, and Jed Long is examining spatial pattern implication of mountain pine beetle and its management, under Research Scientist **Mike Wulder**'s supervision.

From the University of Northern British Columbia, Matthew Klingenberg joins Research Scientist **Brian Aukema** to research how spatial patterns of salvage harvesting affect Warren root collar weevil pressure in regenerating stands. Honey-Marie Giroday is studying range expansion of mountain pine beetle into northeastern British Columbia, under both **Aukema** and Research Scientist **Allan Carroll**.



Abul Ekramoddoullah

Werner Kurz

Events

Canada's Forest: Manage for Change
Canadian Institute of Forestry's 100th National Annual General Meeting and 2008 National Forestry Conference
September 7–10, 2008
Fredericton, New Brunswick
www.cif-ifc.org/en/CIF_AGM2008

A Changing Climate: Economic, Political, Environmental & Labour
Forest Nursery Association of BC's Annual General Meeting 2008
Surrey British Columbia
September 8–11
www.fnabc.com

Bioenergy: Developing Trends and New Opportunities for a Changing Forest Industry
September 16–17 2008
Halifax, Nova Scotia
canbio@xplornet.com

Entomological Society of Canada 58th Annual General Meeting
Joint Meeting with the Entomological Society of Ontario
October 18–22, 2008
Ottawa, Ontario
www.esc-sec.org

Pest Management Forum 2008
December 2–4, 2008
Gatineau, Quebec
Information: stan.phippen@nrcan.gc.ca

National Forest Week
September 21–28
cfs.nrcan.gc.ca/events/73

Healthy Trees; Healthy People
8th Canadian Urban Forest Conference
September 23–26, 2008
Strathcona County, AB
www.cufc8.ca

National Science and Technology Week
October 13–22, 2008
www.nrcan-rncan.gc.ca/com/nstwsnst/index-eng.php

New from the bookstore

Information reports

Secondary manufacturing of solid wood products in British Columbia, 2006: structure, economic contribution, and changes since 1990. 2008. Stennes, B.; Wilson, W.R. Information Report BC-X-416.

Storing beetle-killed logs under snow to reduce losses after mountain pine beetle attack. 2008. Whitehead, R.J.; Wagner, W.L.; Nader, J.A. Natural Resources Canada, Canadian Forest Service, Canadian Wood Fibre Centre, Victoria, BC. Information Report FI-X-003.

Mountain Pine Beetle working papers

Exploring opportunities for mitigating the ecological impacts of current and future mountain pine beetle outbreaks through improved planning: A focus on northeastern British Columbia. 2008. Seely, B.; Nelson, John; Vernier, Pierre; Wells, R.; Moy, A. Mountain Pine Beetle Program Working Paper 2008-08.

Kraft pulp and paper mill utilization options for grey-stage wood. 2008. Radiotis, R.; Berry, R.; Hartley, I.; Todoruk, T Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria B.C. Mountain Pine Beetle Program Working Paper 2008-09.

Other publications

6th Pacific Rim Conference on the Biotechnology of Bacillus Thuringiensis and its Environmental Impact. 2007. Côté, J.-C.; Otvos, I.S.; Schwartz, J-L.; Vincent, C., editors. Érudit, Montréal, Québec.

Publications Digest. (L'Abrégé des publications). 2008. Bérubé, F., compiler. Vol. 17, 2007.

First Nations Forestry Program. Annual Report 2005-2006. 2008. Natural Resources Canada, Canadian Forest Service, Headquarters, Science and Programs Branch, Ottawa.

Programme forestier des Premières nations. Rapport annuel 2005-2006. 2008. Ressources naturelles Canada, Service canadien des forêts, Administration centrale, Direction des sciences et des programmes, Ottawa.

Le dendroctone du pin : penser stratégie. 2007. Régnière, J. Ressources naturelles Canada, Service canadien des forêts, Centre de foresterie des Laurentides, Quebec, Quebec. L'Éclaircie Numéro 38.

Thinking strategically to outsmart the mountain pine beetle. 2007. Régnière, J. Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, Quebec, Quebec. Branching out Number 38.

Canada's Natural Resources: Biodiversity in a Changing World, National Forest Week 2008 (Poster).

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bookstore.cfs.nrcan.gc.ca

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