PROTECT
Birds, Bees and Trees
INCLUDE
Anthropogenic Radiofrequency Electromagnetic Radiation in
Canadian Environmental Protection Act AMENDMENTS

WHITE PAPER
Updated APRIL 2022

Prevent Cancer Now and Canadians For Safe Technology
This updated white paper includes a proposed amendment to the *Canadian Environmental Protection Act, 1999*, and clarifies that this proposal specifically addressed radiofrequency electromagnetic radiation (RF-EMR) in Bill S-5. It is an update of the February 2022 version of "Protect Birds, Bees and Trees: Include Electromagnetic Radiation* in *Canadian Environmental Protection Act Amendments. * Anthropogenic Non-ionizing Electromagnetic Radiation."


The authors gratefully acknowledge the advice and drafting of the proposed amendments by Joseph Castrilli, Counsel, Canadian Environmental Law Association, and comments and feedback provided by David McRobert, Barrister and Solicitor, Peterborough, Ontario.

This white paper is a collaborative effort of Prevent Cancer Now and Canadians for Safe Technology. [www.preventcancernow.ca](http://www.preventcancernow.ca) and [www.c4st.org](http://www.c4st.org)

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Squares: Birds (D. Desender), Bee (M. van den Berg), Trees (J. Cornell), Bear, Turtles (T. Hitch), Frog (J. Cornell).
Modernizing the Canadian Environmental Protection Act and Ensuring the “Right to a Healthy Environment” Must Address Anthropogenic† Radiofrequency Electromagnetic Radiation‡ (“wireless radiation”)

Highlights

- Flora and fauna, including insects and birds, can be affected adversely by radiofrequency electromagnetic radiation (RF-EMR) used for wireless telecommunications (“wireless radiation”). Species’ collapse lends urgency to assessment and environmental protection from anthropogenic† RF-EMR. Canadian assessment and regulation focuses solely on human health.
- Unlike toxic substances, RF-EMR from modern technologies is not addressed as a risk to the environment under the Canadian Environmental Protection Act (CEPA), or other national laws.
- Health Canada’s Safety Code 6 “Limits for human exposure to radiofrequency electromagnetic energy” guidelines are implemented by Innovation, Science and Economic Development (ISED) to protect humans from “established,” adverse effects, specifically nerve stimulation at lower frequencies and over-heating of tissue at frequencies for telecommunications.
- In other species, biological effects of wireless radiation have been identified in all taxa that were adequately studied. Effects have been observed at ambient and low-intensity levels of exposure, such as from Wi-Fi and cell towers (base stations) at a distance.
- The dramatic worldwide decline of populations of birds, insects and other biota makes this an urgent issue. According to scientists who specialize in this field, exposure to wireless radiation at ambient levels may well be a co-factor, along with pesticides, habitat loss and climate change.
- The rollout of novel technologies is increasing wireless radiation levels, as well as introducing frequencies and modulations not previously used.
- Increasing numbers of structures with multiple cellular network antennas (specifically designed to emit RF-EMR) are being installed across Canada, in urban, rural and wilderness areas. These antennas will support the operation of hundreds of thousands additional smaller antennas (e.g., 4G, 5G) being mounted on non-tower structures (e.g., street furniture, buildings, lamp-posts and other utility poles). At the same time, tens of thousands more telecommunications satellites are being launched to emit RF-EMR.
- Wireless radiation is clearly an environmental agent that is potentially harmful, as a pollutant. Exposure to wireless radiation has serious implications for biodiversity and ecosystem health.
- Cumulative and synergistic effects may occur with wireless radiation plus chemical substances.
- We believe that the solution is for the federal government to begin to systematically regulate anthropogenic RF-EMR under provisions in an amended Canadian Environmental Protection Act. Such an approach will both modernize the Act and further support the key goal to establish a “Right to a Healthy Environment” in CEPA.

Protect fauna and flora, as well as human health, by amending the Canadian Environmental Protection Act, 1999 to address current gaps in the regulatory regime, by making anthropogenic radiofrequency electromagnetic radiation (RF-EMR or “wireless radiation”) subject to research and regulation (see page 2).

† Anthropogenic: originating from human activity.
‡ Radiofrequency Electromagnetic Radiation: see facing page (page 2) for definitions.
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1 Background

Canadian society relies heavily on wireless communications. This requires extensive infrastructure of large cell towers (base stations) and smaller antennas (on buildings, utility poles and other structures) to enable communications with wireless devices used by individuals, businesses and a diverse range of organizations. In addition to the existing infrastructure, more and more new cellular antennas, big and small, are being installed and are emitting increasing levels of radiofrequency electromagnetic (“wireless”) radiation into the environment.

Radiofrequency is a non-ionizing range of electromagnetic radiation. Unlike the well-recognized direct molecular damage from high-energy photons of ionizing radiation (e.g., x-rays), the lower-energy photons of non-ionizing radiation have been portrayed as harmless at doses that do not cause excessive heating of tissue. There is convincing evidence, however, that ongoing, lower intensities of wireless radiation can cause biological effects via other mechanisms, with serious implications for biodiversity and ecosystem health.

Health Canada guidance (Safety Code 6) addresses human exposure to radiofrequency electromagnetic radiation (RF-EMR), and compliance with Safety Code 6 is enforced by the Ministry of Innovation, Science and Economic Development (ISED) via Administrative Monetary Penalties. No Canadian policy or law is intended to protect non-human species from radiofrequency radiation. As described in Section 3.4 below, ISED regulations and criteria for devices, equipment and antenna-siting for cell towers all reference Safety Code 6, intending to protect people but not other biota. ISED references the Canadian Environmental Protection Act, 1999 (CEPA), whereas CEPA is silent on this topic.

It is well documented in peer-reviewed scientific literature, however, that wireless radiation used in telecommunications can cause harmful biological effects, at ambient levels. An extensive, authoritative review published in 2021 stated:2

Biological effects have been seen broadly across all taxa and frequencies at vanishingly low intensities comparable to today's ambient exposures. Broad wildlife effects have been seen on orientation and migration, food finding, reproduction, mating, nest and den building, territorial maintenance and defense, and longevity and survivorship. Cyto- and geno-toxic effects have been observed.

Wireless radiation on its own, or acting additively or synergistically with chemical substances, can damage living tissues and genetic material, and cause inflammation, dysfunction, cancers and other effects.3,4,5

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Including Anthropogenic Radiofrequency Electromagnetic Radiation (RF-EMR) in CEPA Amendments
2 The Canadian Environmental Protection Act (CEPA) is the Logical Law for Regulating Anthropogenic Radiofrequency Electromagnetic Radiation (RF-EMR)

In our view, the Canadian Environmental Protection Act (CEPA)\(^6\) is the most logical, effective statute for assessment and regulation of this rapidly increasing environmental agent. Bill S-5 Strengthening Environmental Protection for a Healthier Canada Act,\(^7\) introduced in the Senate on February 9th, 2022, is an opportunity to enact specific legislative provisions and enabling legislation to promulgate regulations that can be used to assess and regulate the increasing amounts of anthropogenic RF-EMR emitted by wireless telecommunications devices and infrastructure. Of relevance, safer non-wireless alternative telecommunication technologies using fibre and wired connections are also faster, and more secure, reliable, resilient and energy efficient,\(^8\) making these technologies the climate-wise options.

2.1 Environment and Climate Change Canada is Not Engaged; Health Canada is Not Required to Consult

The mandate of Environment and Climate Change Canada (ECCC) is to be “the lead department for a wide range of environmental issues” and includes “minimizing threats to Canadians and their environment from pollution.”\(^9\) That said, ECCC has no responsibility or program to monitor, assess and protect the biosphere from anthropogenic RF-EMR generated and used in telecommunications. In October 2021, ECCC confirmed in a response to an Environmental Petition to the Auditor General\(^10\) that,

“Environment and Climate Change Canada is not conducting research and monitoring activities on the potential impact of radiofrequency/microwave radiation exposure to biota to inform Health Canada or other regulatory organizations.” Furthermore, ECCC “is not examining energy and resources implications to sustainability and climate change from the use of various alternative technologies for telecommunications.”

In response to the same petition, in reference to doubled exposure limits for frequencies to be used for 5G, Health Canada stated that there is no legislative requirement for public notice and it is not required to consult Canadians regarding “interpretation” of radiation exposure limits from wireless devices and infrastructure. New interpretations are expected with the burgeoning “Internet of Things” and dense deployment of 4G/5G antennas in close proximity to living spaces. The petition response also stated that ISED (not the scientific authority) invited comment to improve the new standard, following publication in the Gazette.

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2.2 History of Engagement regarding the Canadian Environmental Protection Act, 1999

In March 2016, the new federal Liberal government led by Prime Minister Justin Trudeau fulfilled an election commitment to modernize CEPA by delegating to the Standing Committee on Environment and Sustainable Development (ENVI) the task of undertaking a 15-month comprehensive review of CEPA.

Five briefs submitted to the Standing Committee addressed biological harms associated with non-ionizing electromagnetic radiation used for wireless connectivity, and recommended inclusion in CEPA.

4. Magda Havas, PhD, Professor and Research Scientist, Trent University. https://www.ourcommons.ca/content/Committee/421/ENVI/Brief/BR8708953/br-external/HavasMagda-e.pdf
5. Margaret Friesen, MSc. https://www.ourcommons.ca/content/Committee/421/ENVI/Brief/BR8708951/br-external/FriesenMargaret-e.pdf

In June 2017, the Standing Committee submitted its final report, Healthy Environment, Healthy Canadians, Healthy Economy: Strengthening the Canadian Environmental Protection Act, 1999 to the House of Commons. The report included 87 recommendations such as: recognizing a right to a healthy environment, enhancing considerations of vulnerable populations, addressing cumulative impacts of substances, banning carcinogens and endocrine-disrupting chemicals (EDCs), strengthening transparency and public participation, improving the National Pollutant Release Inventory, establishing a more transparent assessment process for new living modified organisms, adopting a reverse-onus approach for substances of very high concern, adding a definition of “vulnerable populations,” and requiring investigations into effects of substances on vulnerable populations as well as cumulative and synergistic effects of multiple toxicants.

Recommendation 62 addressed electromagnetic radiation:

The Committee recommends that ... Environment and Climate Change Canada conduct studies on the effects of electromagnetic radiation on biota ... and report their findings back to the Committee.

A complete response to the Standing Committee was published in June 2018, with the Minister of the Environment and Climate Change committing to “work towards legislative amendments as soon as possible in future Parliamentary sessions.” Included in the report was the following commitment:

Environment and Climate Change Canada is reviewing the scientific evidence provided to the Committee on the effects of electromagnetic radiation on biota.  

11 http://www.ourcommons.ca/Content/Committee/421/ENVI/Reports/RP9037962/envirp08/envirp08-e.pdf
No review by ECCC has been made public, and with the response to Petition 456, we now know that there is no plan to do so.

As detailed below, scientific evidence since the 2016 Standing Committee submissions clearly demonstrates that anthropogenic RF-EMR can be harmful to biota, and that this can have consequential cascading effects on biodiversity and ecosystem health. Flora and fauna should be protected; there is currently a gap in the Canadian risk assessment and regulatory regime with regards to this environmental toxicant. Inclusion of anthropogenic RF-EMR in CEPA could rectify this serious gap.

Mandate letters from Canadian Prime Minister Justin Trudeau to both the Minister of Health and the Minister of Environment and Climate Change tabled in December 2019\(^\text{14}\) included the expectation “to better protect people and the environment from toxins and other pollution, including by strengthening the *Canadian Environmental Protection Act, 1999*.”

The 2019 mandate letters did not, however, include express requirements for the Ministers to address the effects of anthropogenic RF-EMR on biota as part of their work. Similarly, the 2021 mandate letters\(^\text{15}\) failed to acknowledge the importance of addressing this key issue.

### 2.3 Increasing Levels of Anthropogenic Radiofrequency Electromagnetic Radiation (RF-EMR) Emissions Have Been Accelerating Over Recent Decades

Ambient levels of wireless radiation continue to increase. There are currently tens of thousands of cell towers\(^\text{16}\) across Canada. The number of cellular network antennas is increasing rapidly, as they are installed on new and existing structures in urban, rural and wilderness areas. These can support the operation of hundreds of thousands more small 4G/5G antennas being mounted on non-tower structures (e.g., street furniture, buildings, lamp-posts and other utility poles). Of additional concern is the introduction of novel technologies that use frequencies and modulations not previously widely used outdoors. At the same time, tens of thousands more telecommunications satellites are being launched to transmit RF-EMR.\(^\text{17}\)

The medical journal *The Lancet* published a concise summary of increases in radiation for wireless communications, mounting to many-fold greater levels than the natural background.\(^\text{18}\) Figure 1, reproduced with permission, illustrates how instantaneous exposures have mounted from the 1950s, through the 1980s and during the 2010s.

Note that the scales are logarithmic – each increment is a 1,000-fold increase. At 1 GHz, within a commonly used frequency range for cell tower antenna emissions, the levels in some areas had increased up to a quintillion times natural background levels (a quintillion is 1 with 18 zeros).

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[Canada’s guidance is marginally lower for some frequencies.]

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[Figure 1: Graph showing typical maximum daily exposure to RF-EMF from man-made and natural power flux densities in comparison with ICNIRP safety guidelines. The graph illustrates the exposure levels across different frequency bands (MHz to GHz) for various time periods (1950s, 1980s, 2010s) and categories (occupational, public). The ICNIRP guidelines are indicated with different lines, and the natural background is shown in green. The graph also includes labels for different types of power flux densities such as medium-wave broadcasting, short-wave broadcasting, and television.]
2.4 Anthropogenic Non-ionizing Electromagnetic Radiation Can Cause Adverse Biological Effects at Low Intensity Levels

Non-ionizing electromagnetic radiation, which includes RF-EMR, is lower energy than ionizing radiation (e.g., x-rays) and by definition does not carry sufficient energy to remove an electron from an atom. Early animal and human experimentation led to the hypothesis (favoured by industry, and implemented by Health Canada) that only excessive heating may cause biological harms (“thermal effects”). Evidence, presented here and in hundreds of peer-reviewed publications, demonstrates that RF-EMR can cause harm at exceedingly low exposure levels. A few of the mechanisms and harmful effects that have been demonstrated in the laboratory and measured in various organisms include oxidative stress, cellular and DNA damage (including in insects), and effects on receptor proteins and channels through cellular membranes with exposure to purportedly safe intensities of common frequencies. These effects may impact function and viability of organisms, and lead to cancers.\(^5\)

Non-ionizing radiation is a broad swath of the electromagnetic spectrum, from extremely low-frequency Schumann resonance of the earth, through anthropogenic radiation associated with a wide range of technologies, and also that received from the sun, such as naturally occurring infrared, visible and ultraviolet light (on the nominal borderline of ionizing radiation). Global protection from ultraviolet light is implemented via CEPA, with restriction of atmospheric ozone-depleting substances (ozone absorbs solar ultraviolet light).

All biota evolved in an environment with much lower intensity natural RF-EMR, because the Earth’s atmosphere blocks much of this type of radiation. With the addition of anthropogenic RF-EMR, peak levels today can be more than trillions of times higher than historically (Figure 1).

3 Current Concerns

3.1 A Tipping Point?

Whether or not we sense electromagnetic radiation, electromagnetic interactions are intrinsic in living tissues. Effects may be central to life processes, occurring at the level of cellular membranes, impacting nerves and diverse chemical reactions within cells. As well, the cells of all life forms normally communicate within and among themselves with exquisitely low-intensity electromagnetic and chemical signaling. Ambient

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levels of anthropogenic RF-EMR in some areas now exceed historical natural levels by more than trillions-fold and have reached a level where it interferes with natural signaling. It appears that some biota (e.g., insects) may have reached a “tipping point” for population-wide effects.

### 3.2 Electromagnetic Radiofrequency Radiation (RF-EMR) as a Factor in the Decline of Bird and Insect Populations

Many bird and insect species are in decline worldwide. Interference with magnetoreception for navigation may be a contributing factor, as comprehensively reviewed by Levitt et al. in three recent publications.\(^2\)

The scientific literature was also systematically reviewed at the request of the European Parliament.\(^25\) An extract from the report states (emphasis added):

> Dielectric heating due to RF-EMR [radiofrequency electromagnetic fields] exposure of biological tissue is shown in all categories. ... which in turn has biological effects such as a thermoregulatory response. This implies that **there is always a level of RF-EMR power density that will cause biological effects**, referred to as thermal effects. Decoupling effects caused by elevated temperatures and the presence of RF-EMFs within biological tissue are major issues in this field of study.

Concerns that anthropogenic electromagnetic radiation may be a factor in the decline of insect populations were detailed in 2021.\(^26\) Due to insects’ size, resonance may result in greater heating, and insects have little capacity to thermo-regulate. Insect declines are widely recognized to present serious ecological as well as economic issues, because insects form the base of food chains, and pollination is essential for biodiversity and agriculture.

Serious adverse effects observed in animals and plants in field and laboratory studies are depicted in Figure 2, at exposure levels 50 to more than 2,000 times below Health Canada’s non-occupational human exposure guideline for radiofrequency radiation power density (Safety Code 6).\(^27\) The guideline levels range from 2,000 to 10,000 mW/m\(^2\) (2 to 10 W/m\(^2\)) depending upon the frequency (off the scale of Figure 2).

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\(^25\) Thielens, A. (2021). *Environmental Impacts of 5G. A literature review of effects of radio-frequency electromagnetic field exposure of non-human vertebrates, invertebrates and plants. Prepared at the Request of the Panel for the Future of Science and Technology (STOA) and Managed by the Scientific Foresight Unit, within the Directorate-General for Parliamentary Research Services (EPRS) of the Secretariat of the European Parliament*, 149. [https://doi.org/10.2861/318352](https://doi.org/10.2861/318352)


Including Anthropogenic Radiofrequency Electromagnetic Radiation (RF-EMR or “wireless radiation) levels, 50 to more than 2,000 times below Safety Code 6 limits (2,000 - 10,000 mW/m² depending upon the frequency).

(Data from Supplemental Materials Part 2, Levitt et al. 2021, and primary literature, listed in the Appendix.)

Figure 2. Examples of biological effects on biota exposed to anthropogenic radiofrequency electromagnetic radiation (RF-EMR or “wireless radiation) levels, 50 to more than 2,000 times below Safety Code 6 limits (2,000 - 10,000 mW/m² depending upon the frequency).

(BIRDS: DNA damage [Buriaka 2013], [Yakymenko 2018]
Embryogenesis altered [Tsybulin 2013]

INSECTS: Severely altered behaviour [Cammaerts 2013, 2014]
Pollinators affected [Lazar 2016]

MAMMALS: Immune changes [Fesenko 1992], [Novoselova 1999]
Tissue abnormalities [Alimohammadi 2018]
Infertility [Magras 1997]

PLANTS: Genetic abnormalities [Pesyna 2013]
Increased stress signals in cells [Moneselise 2011]
Defective germination [Cammaerts 2015]

TICKS (Arachnids): Altered behaviour [Fratzczak 2020], [Vargova 2017, 2018]

MAMMALS: DNA damage [Gandhi 2015], [Gulati 2016]
Increased cell death [Oszobic 2020]

BIRDS: Reproduction impaired [Balmori 2005]

PLANTS (trees):
Foliage damage, Tree death
(Waldmann-Salsam 2016)

AMPHIBIANS: Increased mortality
(Balmori 2010)

MAMMALS: DNA damage
(Güler 2014)

Power Density* (mW/m²)

* Power density is the rate that energy
(e.g., from an emitting device such as a cell tower antenna)
is intercepted by a surface (e.g., leaf or animal)
over an area measured perpendicular to the beam.

3.3 Non-ionizing Electromagnetic Radiation and Chemical Substances Can Act Additively or Synergistically

Non-ionizing electromagnetic radiation from communications and other infrastructure can be biologically active and harmful, and can interact with toxic substances with magnification of harmful effects.28,29 For

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example, a large 2013 review, further expanded in 2017, summarized synergistic effects with toxicants on carcinogenesis, teratogenesis, mutagenesis, inflammation and other outcomes; amelioration of harmful effects using agents such as antioxidants (e.g., vitamin C); and use of radiofrequency radiation to enhance therapeutic effectiveness.30

3.4 Unlike Toxic Substances and Ultraviolet Light, Radiofrequency Electromagnetic Radiation (RF-EMR) from Modern Technologies is not Addressed as a Potential Risk to Environmental Health in Canada

Guidance published by Health Canada, Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz: Safety Code 627 is referenced consistently by the Government of Canada (Health Canada, and ISED) in regulations addressing devices or infrastructure for telecommunications over the air. The Radiation Emitting Devices Act21 and regulations32 do not mention radiofrequency radiation or telecommunications devices, although a 2020 consultation33 undertaken by Health Canada did. Cell tower siting Client Procedures Circular CPC-2-0-0334 stipulates that in addition to requirements of the Canadian Environmental Assessment Act25 (now repealed; the Interpretation Act would require application of the Impact Assessment Act, 201936), proponents are responsible to ensure that antenna systems are installed and operated in a manner that respects the local environment and that complies with other statutory requirements, such as those under the Canadian Environmental Protection Act, 1999, the Species at Risk Act, 200227 and the Migratory Birds Convention Act, 1994,38 as applicable. None of these Acts address effects of RF-EMR used in telecommunications.

RF-EMR levels are regulated in areas that the public may access (per Safety Code 6), but not other locations accessible only to flora and non-human fauna, including airspace where animals fly.

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Extract: “The overall results clearly indicate that the multi-stress conditions were able to induce biochemical, physiological and behavioral alterations which severely threatened bee colony survival.”


Including Anthropogenic Radiofrequency Electromagnetic Radiation (RF-EMR) in CEPA Amendments
Interference with normal function of equipment is addressed in EMCAB-2 — Criteria for Resolution of Immunity Complaints Involving Fundamental Emissions of Radiocommunications Transmitters, yet interference with normal functions of biota is not addressed in Canada, to the best of our knowledge.

The Canadian federal policy gap, omitting consideration of effects on non-human species of radiation for wireless communications, parallels a similar gap in the USA. In August 2021, the District of Columbia Court of Appeals ruled that the Federal Communications Commission (FCC) — the USA regulator for cell tower and other wireless device radiofrequency emissions, to which Health Canada looks for guidance in setting its guidelines — had ignored a substantial body of knowledge that had been presented in submissions:

“The Commission failed to provide a reasoned explanation for its determination that its guidelines adequately protect against the harmful effects of exposure to radiofrequency radiation unrelated to cancer.”

This is not to say that the Court agreed with FCC conclusions; merely that the FCC had acknowledged the issue of cancer while it did not consider numerous other effects, including effects on fauna and flora.

### 3.5 Climate Change and Broader Environmental Implications

Energy consumption for wireless communications is a climate issue. Overall, greenhouse gas emissions related to information and communication technologies are estimated to be about 3% of global totals (aviation is 2%). These estimates are uncertain as they are based on yet-to-be-attained industry commitments and shifts to “green” energy (that could divert potential capacity from other uses). Nevertheless, estimates reflect a significant contribution to climate change of digital technologies, while fibre and wire connections offer many advantages, including energy efficiency.

Dense deployment of additional hundreds of thousands of cell network antennas across Canada for new technologies (e.g., 5G), and the myriad other devices that manufacturers hope to sell to Canadian consumers, means that much more hardware will be manufactured. Planned obsolescence of technologies ensures ongoing turnover of old for new; devices that are no longer supported are discarded and replaced. As new technology is deployed, sun-setting of 3G disproportionately affects elderly and low-income individuals, and may affect home alarms and medical devices, as well as navigation and aviation. Beyond risks of halting support of important, functional devices, and of associated e-waste, replacement entails petrochemical and mineral resources, and associated mining and pollution.

### 3.6 Safer Alternatives for Telecommunications: Fibre Optic and Wired Connections

An assessment of telecommunications alternatives, considering “substitution” and “essentiality,” would reveal that use of hard (fibre and wire) connections to transmit data requires less electricity than use of wireless infrastructure. Fibre optic to the premises (FTTP) and wired connections through the premises (WTTP) would substantially reduce RF-EMR used for wireless technologies. Networks with the hard connections emit minimal radiation and have the added, not insignificant benefits that fibre optic connections

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Including Anthropogenic Radiofrequency Electromagnetic Radiation (RF-EMR) in CEPA Amendments
will always be faster, higher bandwidth, and more secure, reliable, resilient and sustainable than wireless connections.\textsuperscript{8}

### 4 The Solution – Regulate Anthropogenic Electromagnetic Radiofrequency Radiation (RF-EMR) under provisions in an amended Canadian Environmental Protection Act

#### 4.1 A Protective Law to Address Effects on Environmental and Human Health

Canada needs a law governing environmental hazards, exposures, risks, climate implications, and impacts for the protection of wildlife, indeed, all organisms, from excessive exposures to anthropogenic RF-EMR. Determination of exposure limits must be transparent, based on research, high-quality scientific methodology including systematic scientific review, and public consultation. Once established, standards for ambient levels, emissions and exposures must be monitored, assessed and reported transparently, with enforcement of emission and cumulative exposure limits.

#### 4.2 Radiofrequency Electromagnetic Radiation (RF-EMF) as a Pollutant, and Closing the Gap

CEPA is an Act “respecting pollution prevention and protection of the environment and human health in order to contribute to sustainable development.” Exposures to RF-EMR are in open air and indoors, as the radiation may travel through solids such as walls and windows.

CEPA defines \textit{air pollution} as: “a condition of the air, arising wholly or partly from the presence in the air of any substance, that directly or indirectly endangers the health, safety or welfare of humans; interferes with the normal enjoyment of life or property; endangers the health of animal life; causes damage to plant life or to property; or degrades or alters, or forms part of a process of degradation or alteration of, an ecosystem to an extent that is detrimental to its use by humans, animals or plants.”

Anthropogenic RF-EMR meets all of these criteria. We propose that to close this gap in CEPA, to protect the flora and fauna in all taxa – the foundation of natural ecosystems and agriculture, as well as human health – that CEPA Section 44 be amended to incorporate anthropogenic RF-EMR as a pollutant to be rigorously and transparently assessed, restricted and monitored, with enforcement and remedies. Decision-making should place priority on pollution \textit{prevention}, implement the principles of \textit{precaution}, \textit{substitution} and \textit{essentiality}, consider cumulative effects, and be informed by independent scientific evaluation and public consultation. It is expected that this would result in some frequency ranges being regulated with scientifically based limits, and regulatory processes to protect environmental and human health and to ensure Canadians’ “Right to a Healthy Environment.”

\textit{We have a once-in-a-generation opportunity to include modern, escalating, bioactive radiofrequency electromagnetic radiation (RF-EMR) in Canada’s flagship legislation protecting the environment and human health.}

| Protect fauna and flora, as well as human health, by amending the \textit{Canadian Environmental Protection Act, 1999} to address current gaps in the regulatory regime, by making anthropogenic radiofrequency electromagnetic radiation (RF-EMR or “wireless radiation”) subject to research and regulation (see page 2). |

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Appendix. Reference list, with extracts, for Figure 2.

   
   EXTRACT: Our results showed significant increase in fetus weight and C-R [crown-rump] length and also enlarged liver, tail deformation in mice fetus in exposure group. ... The outcome of this study confirms the effects of radiofrequency radiation on growth parameters such as body weight, length and some tissues in mice fetuses ...
   
   https://doi.org/10.1016/j.dib.2018.06.107

   
   EXTRACT: Twelve nests (40%) located within 200 m of antennae never had chicks, while only one (3.3%) located further than 300 m had no chicks. The electric field intensity was higher on nests within 200 m (2.36 ± 0.82 V/m) than on nests further than 300 m (0.53 ± 0.82 V/m). Interesting behavioral observations of the white stork nesting sites located within 100 m of one or several cell site antennae were carried out. These results are compatible with the possibility that microwaves are interfering with the reproduction of white storks and would corroborate the results of laboratory research by other authors.
   
   https://doi.org/10.1080/15368370500205472

   
   EXTRACT: In the exposed group (n = 70), low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality (90%) was observed...This research may have huge implications for the natural world, which is now exposed to high microwave radiation levels from a multitude of phone masts.
   
   https://doi.org/10.3109/15368371003685363

   
   EXTRACT: Conclusion: Exposure of developing quail embryos to extremely low intensity RF-EMR of GSM 900 MHz during at least one hundred and fifty-eight hours leads to a significant overproduction of free radicals/reactive oxygen species and oxidative damage of DNA in embryo cells. These oxidative changes may lead to pathologies up to oncogenic transformation of cells.
   
   http://dspace.nuft.edu.ua/bitstream/123456789/15543/1/Burlaka%202013.pdf

   
   EXTRACT: Under such an influence, ants followed trails for only short distances, no longer arrived at marked areas and no longer orientated themselves to a source of alarm pheromone. Also when exposed to electromagnetic waves, ants became unable to return to their nest and recruit congener; therefore, the number of ants collecting food increases only slightly and slowly. After 180 h of exposure, their colonies deteriorated. Electromagnetic radiation obviously affects social insects’ behavior and physiology.
   

   
   EXTRACT: The ants’ orientation towards their attractive alarm pheromone statistically became of lower quality. The ants still presented their trail following behavior but less efficiently. In this controversial issue, ants could be considered as possible bioindicators.
   
   https://doi.org/10.1007/s10905-014-9446-4

**EXTRACT:** [Exposed] seeds of Brassicaceae Lepidium sativum (cress d’Alinois) never germinated.... When removed from the electromagnetic field, seeds germinated normally.

http://hdl.handle.net/2013/ULB-DIPOT:oai:dipot.ulb.ac.be:2013/219257


**EXTRACT:** Chronic irradiation of mice for 7 days produced the decreasing of TNF production in peritoneal macrophages. The exposure of mice for 24 h increased the TNF production and immune proliferative response...


**EXTRACT:** Ticks were attracted to the irradiated area. This effect was significantly stronger for ticks infected with Rickettsia spp., suggesting that pathogens can alter the ticks’ response to environmental stimuli. These results lead to the question of whether man-made EMF may have an impact on I. ricinus activity and, as such, be a contributing factor to the ongoing changes in the distribution of the tick and its pathogens currently observed in Europe and elsewhere.

https://doi.org/10.1016/j.ttbdis.2020.101416


**EXTRACT:** Genetic damage parameters of DNA migration length, damage frequency (DF) and damage index were significantly (p = 0.000) elevated in the sample group compared to respective values in healthy controls.

https://doi.org/10.3109/15368378.2014.933349


**EXTRACT:** There was a significant increase in BMN frequency and TM value in exposed subjects (3.65 ± 2.44 and 6.63 ± 2.32) compared with control subjects (1.23 ± 0.97 and 0.26 ± 0.27).

https://doi.org/10.1007/s00244-015-0195-y


**EXTRACT:** Conclusions: It may be concluded that low level EMF at 2.45 GHz MWR increases the DNA damage in both brain tissues and plasma of the rats whereas it increases protein oxidation only in plasma. It may also be argued that the use of garlic decreases these effects.

https://doi.org/10.3109/09553002.2014.922717


**EXTRACT:** All pollinator groups except butterflies were affected by EMR... As EMR [electromagnetic radiation] affected the abundance of several insect guilds negatively, and changed the composition of wild pollinators in natural habitats, it might also have additional ecological and economic impacts on the maintenance of wild plant diversity, crop production and human welfare.

**EXTRACT:** A progressive decrease in the number of newborns per dam was observed, which ended in irreversible infertility.


**EXTRACT:** The 24 h exposure ... resulted in alanine accumulation in the plant cells, a phenomenon we have previously shown to be a universal stress signal... A unique biological connection has thus been made between exposure to RF-EMF and cell stress, in the vicinity of RF transmitting antennas.

[https://doi.org/10.1039/c1em10031a](https://doi.org/10.1039/c1em10031a)


**EXTRACT:** The mitogenic response in T lymphocytes increased after microwave exposure ...These results demonstrate that irradiation with low-power density microwaves stimulates the immune potential of macrophages and T cells ...

[https://doi.org/10.1016/s0302-4598(99)00059-8](https://doi.org/10.1016/s0302-4598(99)00059-8)


**EXTRACT:** Our findings show that EMR caused oxidative stress and apoptotic activation in HEK293 cells. Zn seems to have protective effects on the EMR by increasing SOD activity and bcl-2 immunopositivity, decreasing lipid peroxidation and caspas-3 immunopositivity.

[https://doi.org/10.1007/s12011-019-01811-6](https://doi.org/10.1007/s12011-019-01811-6)


**EXTRACT:** Importantly, GSM 900 mobile phone radiation increased the mitotic index, the frequency of mitotic and chromosome abnormalities, and the micronucleus frequency in a time-dependent manner.

[https://doi.org/10.1016/j.mrgentox.2012.08.010](https://doi.org/10.1016/j.mrgentox.2012.08.010)


**EXTRACT:** The lower duration of exposure led to a significant (p < 0.001) decrease in a level of DNA strand breaks in cells of 38-h embryos, while the higher duration of exposure resulted in a significant (p < 0.001) increase in DNA damage as compared to the control. CONCLUSION: Effects of GSM 900 MHz cellular phone radiation on early embryogenesis can be either stimulating or deleterious depending on the duration of exposure.

[https://doi.org/10.3109/09553002.2013.791408](https://doi.org/10.3109/09553002.2013.791408)


**EXTRACT:** We found that exposure induces an immediate tick locomotor response manifested either in a previously unreported jerking movement of the whole body or in jerking of the first pair of legs. Overall, ticks exhibited...
significantly greater movement in the presence of the RF-EMF. Significant sex differences relative to RF-EMF exposure were observed in both response variables. In the presence of RF-EMF, body jerking by females was greater than in males and vice versa for leg jerks.

https://doi.org/10.11158/saa.22.5.7


**EXTRACT:** The RF-EMF exposure to 900 MHz induced a higher concentration of ticks on irradiated arm of RST [radiation-shielded tube] as opposed to the RF-EMF at 5000 MHz, which caused an escape of ticks to the shielded arm... The projection of obtained results to the natural environment could help assess the risk of tick borne diseases and could be a tool of preventive medicine.

https://doi.org/10.1007/s10493-018-0253-z


**EXTRACT:** Statistical analysis demonstrated that electromagnetic radiation from mobile phone masts is harmful for trees. These results are consistent with the fact that damage afflicted on trees by mobile phone towers usually start on one side, extending to the whole tree over time.

https://doi.org/10.1016/j.scitotenv.2016.08.045


**EXTRACT:** RESULTS: The exposure of quail embryos before and during the incubation period to low intensity GSM 1800 MHz has resulted in expressive statistically significant oxidative effects in embryonic cells, including damages of DNA ... Finally, the exposure resulted in a significant, almost twice, increase of embryo mortality. CONCLUSION: The exposure of model biological system to low intensity GSM 1800 MHz MWR resulted in significant oxidative and mutagenic effects in exposed cells, and thus should be recognized as a significant risk factor for living cells.