

What We Know, Can Infer, and Don't Yet Know about Impacts from Thermal and Non-thermal Electromagnetic Fields (EMF) and Radiofrequency Radiation (RFR) on Birds and Other Wildlife: An Updated Briefing Memo with Suggested Best Management Practices to Help Protect Humans

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Abstract

This updated public briefing memo (of a previous document published in 2016; Manville 2016b) concisely summarizes the current peer-reviewed scientific evidence and state of knowledge regarding what is known, uncertain, or still unknown about the effects of non-ionizing electromagnetic fields (EMF), particularly in the higher-frequency ranges of radiofrequency radiation (RFR) on wildlife, and often by inference, on humans. Currently no acute or chronic low-level exposure standards or guidelines exist for wildlife. Thermal versus non-thermal radiation effects are discussed in some detail. The need for further involvement by the Environmental Protection Agency (EPA), the Federal Communications Commission (FCC), and the U.S. Fish & Wildlife Service (USFWS), among others, in recognizing biological effects and developing exposure guidelines with related regulatory responses is strongly recommended. Also suggested is the need to recognize EMF as a novel form of air pollution and develop rules at the pertinent regulatory agencies to address it. Suggested best practices for reducing exposure to wildlife and humans are reviewed, concerns over emissions from radio telemetry and tracking devices are briefly mentioned, as are the shortcomings of radiation shielding and blocking devices for cell phones. The ALARA radiation principles (“as low as reasonably achievable”) are discussed.

Introduction

It is glaringly clear there continues to be an active yet unsettled controversy about current radiation safety standards and their effects on humans and wildlife (www.livingplanet.be), most especially in the radiofrequency radiation (RFR) range of electromagnetic fields (EMF)¹ from 900 MHz to 2500 GHz, commonly used in communication devices such as cellular (cell) telephones, related “smart” phones, digital “smart meters,” computer Wi-Fi communication systems, and numerous other sources of point-to-point and Internet communication.

Negative reports of near-field (*i.e.*, very close to power sources such as on or very near cellular antennas), thermal radiation effects (capable of heating tissue) on laboratory animals and wildlife have been published in the scientific literature since at least 1950 (*e.g.*, Clark 1950, cited in Tanner 1966). A good deal of the controversy about effects involves near and far field, non-thermal, low-level radiation effects on both humans and wildlife. Effects can occur further away from the peak source of radiation (*i.e.*, the tower antennas), but can be difficult to interpret due to signal attenuation, signal interference from objects and water droplets in the air, and other physical obstructions and disturbances.² As concluded by Beason and Semm (2002), non-thermal effects have been the most difficult to explain because the mechanism by which they affect biological tissue is usually unknown or unclear. For human exposures, however, the Federal Communications Commission (FCC) has operating rules that require power to cell and other broadcast towers must be turned off when workers are on and/or climbing the towers — due to health impacts and safety concerns from the thermal radiation. This is in addition to more restrictive occupational exposure standards.

Complicating and broadening concerns from humans to environmental over biological effects from RFR, at issue is the fact that there currently are no acute or chronic EMF exposure standards or guidelines for wildlife — including by the licensing and regulatory rules and procedures of the FCC. Arguably, “effects” need to be determined by the Environmental Protection Agency (EPA), which has no funding for this effort, and regulated as part of a

¹ As a point of clarification, the term “non-ionizing electromagnetic fields” (EMF) includes frequencies ranging from extremely low frequency static to the high GHz ranges on the electromagnetic spectrum. When we consider the use of the whole range of frequencies, it is better to use the term “field” as opposed to “radiation.” However, if we intend to talk only about high-frequency fields, it is better to use the term “radiofrequency radiation” (RFR; 3kHz-300 GHz) instead of EMF (H.C. Lai 2024 pers. comm.).

² Tissue energy absorption depends on the distance and intensity of the radiation source. One cannot classify an effect as thermal or non-thermal based on the distance from the source alone (*i.e.*, near or far-field). Furthermore, it is very difficult to differentiate experimentally thermal and non-thermal effects (Lai and Levitt 2022). The strongest proof: under the same exposure conditions, electromagnetic fields of the same frequency and specific absorption rate (SAR) at different modulations produce different effects, with only a few reports of this in the literature. Even at low intensities, local micro-heating can occur, *e.g.*, in the semicircular canals of birds which could cause a sudden imbalance and disorientation during flight. Thus, an apparent non-thermal effect is actually a thermal one. However, we do not need to know whether a biological effect is thermal or non-thermal to declare that exposure to the electromagnetic field has an effect (H.C. Lai 2024 pers. comm.).

National Environmental Policy Act (NEPA) site review for all proposed cell towers, including both thermal and non-thermal effects. The U.S. Fish & Wildlife Service (USFWS) also needs to be actively engaged in avoiding or minimizing impacts since radiation can result in bird “take” (*i.e.*, the un-permitted killing, injuring and crippling loss of >1,000 species of protected migratory birds) as well as the “take” of Federally Threatened and Endangered species protected by regulations under the Endangered Species Act.

Undebatable, however, is the exponential growth of cell phone technologies, with an estimated 17.72 billion mobile devices currently available in 2024, forecast to be 18.22 billion by 2025 (R. Laricchia, 2023 Statista.com report), far above the 7.2+ billion devices estimated for 2016 in an NPR March 2016 news report. With the current estimated world human population at 8.1+ billion people, and growing, that’s more than 2 mobile devices for every man, woman, and child on the planet. With this growing cell phone use and the communication systems that transmit and receive the signals from them, as well as the paucity of government regulatory oversight, this memo very briefly summarizes some of the major studies and take-aways conducted primarily on laboratory animals and wildlife, including migratory birds. The latter is an issue of growing and troubling concern since migratory birds are in decline (at least 36% of which are in trouble species-wide in North America), and which face additional uncertain impacts from non-ionizing electromagnetic fields (Manville 2015, 2016a; Levitt *et al.* 2021a, b) as well as impacts from climate change, habitat loss/degradation, pesticides, contaminants and more. This memo also includes suggested best management practices to help mobile device users reduce exposures to EMF and suggestions to reduce levels of EMF on wildlife and their habitats.

Biological Systems and EMF³

Living systems operating in animals support a variety of oscillatory electrical and/or biochemical activities which have been well documented and known to be affected by EMF. However, the direct relationship between electromagnetic fields and wildlife health continues to be complicated, in part due to lack of research funding but also because in-field studies are extremely difficult to conduct and the variables are legion. There are, however, increased numbers of applicable studies to draw from today involving non-thermal effects including by Beason and Semm (2002) and Engels *et al.* (2014) — discussed below—that make direct connections to in-field adverse effects extensively discussed in Levitt *et al.* (2021a,b; and 2022), as well as the work of Balmori (2005); Everaert and Bauwens (2007); Zenos and Magras (2003), Panagopoulos and Margaritas (2008); Lazaro *et al.* (2016); Taye *et al.* (2017); Vijver *et al.* (2013), and others. In addition, animal models have been used for decades in research to set standards for human exposure that also provide sufficient information regarding how EMF/RFR couple with various animal physiologies. Plus, we know the basics of electromagnetic biology that can apply broadly to many mammalian species. We know, for example, that brain waves are

³ Ibid. Footnote 1.

electrical, the heartbeat is electrical, the cell membrane has an electric field potential, cell division is electrically influenced, some impulse conduction between neurons is electrical⁴, and all of the hormonal and enzymatic activities are electrically regulated via ion channels. Even the chemical-mechanistic model of the human and animal anatomy is essentially an electromagnetic model because all chemical reactions involve the sharing, trading, or exchange of electrons at the elemental level (Levitt *et al.* 2021b). Indeed, one can argue that the unusual thing would be if the “beings of frequency” that all living things are, were not affected in various ways by anthropogenic dosing of even low-level EMF’s (E. Friedman 2024 pers. comm.).

Early Studies on EMF

Dating back to at least 1950, Tanner (1966, citing Clark 1950) concluded that much had been published on effects of microwave radiation on body tissues and animals, but most of the early experiments were concerned with the production of heat and its physiological effects. Tanner *et al.* (1967) looked briefly at the effects of microwave radiation on domestic chickens, and concluded that thermal effects were manifested by a rise in temperature of the irradiated birds, which were accompanied by physiological responses based on intensity and duration of the radiation field — escape or avoidance — but that non-thermal effects that impacted other physiological systems were more difficult to discern. Tanner (1966) and Tanner *et al.* (1967) discovered that birds’ feathers are known to have piezoelectric properties, acting like an antenna, capable of conducting EMF/RF deep within bird body cavities. This finding could help, in part, explain increased bird sensitivity to EMF/RF radiation. In this early research, however, it remains unclear if thermal and non-thermal effects were adequately differentiated⁵.

Wasserman *et al.* (1984) conducted field studies on 12 flocks of migratory birds subjected to various combinations of microwave power density and duration under winter conditions at Monomet, MA, USA, with birds from 2 additional flocks serving as controls. Increased levels of aggression were noted in some of the irradiated birds suggesting effects, while calling for further study.

More Recent and Current EMF Studies on Birds, Other Wildlife and Laboratory Animals

There is an increasing body of published laboratory research finding DNA damage at low intensity exposures — well below levels of thermal heating — which may be comparable to far field exposures from cell antennas. Furthermore, very low intensities of radiation barely above natural background levels are being documented to cause biological effects to both laboratory

⁴ Neurotransmitters are generally used which are not electrical but rather biochemical.

⁵ It is worth noting that earlier researchers used a pulsed, milliwatt field at an averaged density of 46 mW/cm² which is a very high-power density compared to that which has been used in more recent studies. The effects were probably thermal (H.C. Lai 2024 pers. comm.).

research animals and to wildlife. These include, *e.g.*, DNA strand breaks; cancers and benign growths; metabolic changes; animal disorientation including during migration; fertility problems; behavioral abnormalities; impacts to food finding, reproduction, mating, nest and den building, territorial maintenance and defense; and reduction of longevity and survivorship (Levitt *et al.* 2021a). This body of work would apply to all wildlife species, including migratory birds. In fact, Levitt *et al.* (2021a,b,c), and an abbreviated summary in Levitt *et al.* (2022), represent the most thorough, detailed review of deleterious effects from EMF on wildlife, laboratory test animals, insects, and domestic livestock yet published. Over 130 scientific studies documenting deleterious biological effects are cited, referenced among some of the over 1,000 sources cited in Levitt *et al.* (2021a,b).

The first study on DNA damage by RFR was conducted by H.C. Lai and N.P. Singh in 1995 (Lai and Singh 1995). Their work has since been replicated (*e.g.*, Lai and Singh 1996, as well as many other published studies, *e.g.*, see supplement 1 in Levitt *et al.* 2021b). For more detail, see the list of “genetic effects” in Electromagnetic Radiation Safety (2024).⁶ The take-home message: low level transmission of EMF from towers and other sources probably causes DNA damage. The laboratory research findings infer this relationship. Since DNA is the primary building block and genetic “map” for the very growth, production, replication, and survival of all living organisms, deleterious effects can be critical and should be of significant concern. The entire thermal model and all FCC’s categorical exclusions for all of the devices we see today whose frequencies they license, rests on the incorrect assumption that non-ionizing radiation cannot cause DNA breaks because it is “*so low-power*” (B.B. Levitt and H.C. Lai, Comments Filed Jointly to FCC, ET Docket No. 13-84, 2013). These issues need to be adequately addressed by the appropriate authorities including the FCC, EPA, Food and Drug Administration (FDA), and USFWS. Currently they are not.

In laboratory studies by T. Litovitz (2000 pers. comm.) and DiCarlo *et al.* (2002), they demonstrated exposing domestic chicken embryos to extremely low power levels of the standard 915 MHz cell phone frequency (0.0001 the level emitted by an average digital cellular telephone) caused heart attacks and deaths in some of the embryos. In replicated experiments, similar results were obtained by Grigor’ev (2003) and Xenos and Magras (2003).

In field studies on wild birds in Europe, Balmori (2005) found negative correlations between levels of tower-emitted microwave radiation and bird breeding, nesting, roosting and survival in the vicinity of electromagnetic fields in Spain. He documented nest and site abandonment, plumage deterioration, locomotion problems, and death in Wood Storks, House Sparrows, Rock Doves, Magpies, Collared Doves, and other species. While these species had historically been documented to roost and nest in these areas, Balmori (2005) did not observe these symptoms prior to construction of the cell phone towers. Results were negatively correlated to proximity to

⁶ J.M. Moskowitz, Electromagnetic Radiation Safety 2024, Recent Research on Wireless Radiation and Electromagnetic Fields. www.saferemr.com, April 3, 2024.

antennas and Stork recruitment and survival. Twelve nests (40% of his study sample) were located within 200 m of the antennas and never successfully raised any chicks, while only 1 (3.3%), located further than 300 m, never had chicks. Strange behaviors were observed at Stork nesting sites within 100 m of one or several cell tower antennas. Those birds that the main beam impacted directly (at an electric field intensity/EFI > 2 V/m) included young that died from unknown causes. Within 100 m, paired adults frequently fought over nest construction sticks which retarded or halted nest development as sticks fell to the ground. Balmori (2005) reported that some nests were never completed, and the Storks remained passively in front of cell-site antennas. The electric field intensity was higher at nests within 200 m (2.36 ± 0.82 V/m) than at nests further than 300 m (0.53 ± 0.82 V/m). However, the EMF levels, including for nests < 100 m from the antennas, were not intense enough to be classified as thermally active. Power densities need to be at least 10 mW/cm² to produce heating of even 0.5 C (Bernhardt, 1992).

Balmori and Hallberg (2007) and Everaert and Bauwens (2007) found similar strong negative correlations among male House Sparrows and electromagnetic radiation in their studies.

In another review, Balmori (2009) reported health effects to birds which were continuously irradiated. They suffered long-term effects including reduced territorial defense posturing, deterioration of bird health, problems with reproduction, and reduction of useful territories due to habitat deterioration.

Beason and Semm (2002) demonstrated that microwave radiation used in cell phones produces non-thermal responses in several types of neurons within the nervous system of Zebra Finches. The brain neurons of anesthetized birds were tested with a 900-MHz carrier frequency, modulated at 217 Hz radiation. Stimulation resulted in changes in the amount of neural activity by more than half of the brain cells with most (76%) of the responding cells increasing their rates of firing by an average 3.5-fold as opposed to controls — a clearly definitive study showing non-thermal effects. The other responding cells exhibited a decrease in their rates of spontaneous activity suggesting potential effects to humans using hand-held cell phones affecting sleep (Borbely *et al.* 1999). The Beason and Semm (2002) theoretical model could also help explain why birds may be attracted to cell towers, an important theoretical premise that they previously hypothesized in regard to Bobolinks (Semm and Beason 2000).

In a review of studies through 2008, and based on laboratory research they conducted, Panagopoulos and Margaritis (2008) determined maximum radiation distances for both cell phones and for communication towers, operating on the Global System for Mobile Telecommunications (GSM; 900 MHz) and the Digital Cellular System (DCS; 1800 MHz). Both the GSM and DCS systems of the Digital Mobile Telephony Radiation used in Europe are also comparable to the systems used today in the United States. This maximum radiation distance corresponds to an intensity around 10 mW/cm² for both types of radiation — GSM and DCS — in regards to the radiofrequency (RF) components. They recorded an “*intensity window*” around 10 mW/cm² RF exposure where bio-effects became even more severe than at

intensities higher than 200 mW/cm². This “*intensity window*” appeared at a distance of 20-30 cm (~8-12 inches) from the cell phone antenna — greater than the average distance a cell phone user may keep his/her phone from one’s ear — corresponding to a distance of about 20-30 m (~66-98 ft) from a base station antenna. The noted decrease in reproductive capacity of fruit flies seemed to be non-linearly dependent on the radiation intensity. Since cell phone base station antennas are frequently located within residential areas where houses and workplaces are often situated at distances 20-30 m from such antennas, not to mention birds nesting close to these antennas (*e.g.*, Balmori 2005), humans, birds and other wildlife may be exposed up to 24 hours per day year-round from this radiation.

Based on their research and analyses, Panagopoulos and Margaritis (2008) concluded that large decreases in reproductive capacity in fruit flies were being caused by GSM and DCS radiation, including extensive DNA fragmentation on reproductive cells of experimental animals induced by these fields, exerting an intense biological action able to kill cells, damage DNA, and dramatically decrease the reproductive capacity of living organisms, including populations of birds and insects. They cautioned, however, that the physical parameters of these radiations, including intensity, carrier frequency, pulse repetition frequency, distance from the antenna, and similar factors lacked consistency and a measured lack of standardization, making it difficult to correlate specific thermal and non-thermal effects to specific types of radiation. Their take-away message, however, was clear: bio-effects to birds, other wildlife, insects, laboratory animals and humans continue to be documented from thermal and non-thermal exposures.

Cucurachi *et al.* (2013) reported on 113 studies from original peer-reviewed publications and relevant existing reviews. A limited number of ecological studies were identified, with the majority conducted in a laboratory setting on bird embryos or eggs, small rodents, and plants. In 65% of the studies, ecological effects of RF-EMF (50% of the animal studies and about 75% of the plant studies) were found both at high as well as at low dosages. Lack of standardization and limited sampling made generalizing results from the organism to the ecosystem level very difficult. Cucurachi *et al.* (2013) concluded, however, that due to the number of variables, no clear dose–effect relationship could be found especially for non-thermal effects.

Engels *et al.* (2014) investigated “electromagnetic noise” emitted everywhere humans use electronic devices including from cell phones and their towers. While prior to their study on European Robins, no “noise” effect had been widely accepted as scientifically proven, the authors of this experiment were able to show that migratory birds are unable to use their magnetic compass in the presence of urban electromagnetic noise. The findings clearly demonstrated a non-thermal effect on European Robins.

A range of effects to insects at low intensity RFR exposures far below ICNIRP/IEEE/FCC guidelines have been documented, raising critical issues regarding pollinator health including impacts to orientation, reproductive ability, flight dynamics, behavior, immune health and DNA (Levitt *et al.* 2021b, Thill *et al.* 2023). The fifth generation (5G) higher frequencies (shorter

wavelengths) are a resonant match with small insects at and above 6Ghz (Thielens *et al.* 2018). Both heating and non-heating effects are likely to occur.

Levitt and Lai (2010) reported numerous biological effects from exposure to RFR at very low intensities comparable to what the population experiences within 60–150 m (197–492 ft) of a cell tower, including effects that occurred in studies of cell cultures and animals⁷. These reported effects were genetic, growth and reproductive in nature, documented increases in permeability of the blood–brain barrier; showed behavioral responses; illustrated molecular, cellular, and metabolic changes; and provided evidence of increases in cancer risk — all applicable to migratory birds, other wildlife and to far field exposures in general. Levitt and Lai (2010) cited published, peer-reviewed examples of effects that included:

- Dutta *et al.* (1989) who reported an increase in calcium efflux in human neuroblastoma cells after exposure to RFR at 0.005 W/kg. Calcium is an important component in normal cellular functions.
- Fesenko *et al.* (1999) who reported a change in immunological functions in mice after exposure to RFR at a power density of 0.001 mW/cm².
- Magras and Xenos (1997) who reported a decrease in reproductive function in mice exposed to RFR at power densities of 0.000168–0.001053 mW/cm².
- Forgacs *et al.* (2006) who reported an increase in serum testosterone levels in rats exposed to GSM-like RFR at a specific absorption rate (SAR) of 0.018– 0.025 W/kg.
- Persson *et al.* (1997) who reported an increase in the permeability of the blood–brain barrier in mice exposed to RFR at 0.0004–0.008 W/kg. The blood–brain barrier is a physiological mechanism that protects the brain from toxic substances, bacteria, and viruses.
- Phillips *et al.* (1998) who reported DNA damage in cells exposed to RFR at the SAR of 0.0024–0.024 W/kg.
- Kesari and Behari (2009) also reported an increase in DNA strand breaks in brain cells of rats after exposure to RFR at the SAR of 0.0008 W/kg, and
- Belyaev *et al.* (2009) who reported changes in DNA repair mechanisms after RFR exposure at a SAR of 0.0037 W/kg — all sources above cited in Levitt and Lai (2010).

⁷ There is an update of “low intensity effects” in the Supplement 1 to Levitt *et al.* 2021b.

Summary Recommendations Regarding Thermal vs. Non-thermal Effects

Levitt and Lai (2010) noted that the obvious — and most easily observed — mechanism of effects from RFR are thermal (*i.e.*, tissue heating) and therefore convenient low-hanging fruit when it comes to setting human exposure standards. The actual biological picture is far more complicated than that, however. Unfortunately, the FCC continues to base its current radiation standards on a thermal-effects-only model, even if that model is more than 35 years out-of-date and rejected in part both by the Department of Interior and Department of Commerce (USDOJ 2014, Manville 2016a). For decades, there have been questions about non-thermal effects (*i.e.*, not dependent on a change in temperature) and what specifically causes such effects to appear. The sources cited above should dispel any doubt that non-thermal effects occur and can have significant deleterious effects on migratory birds and other wildlife.

Practically, as Levitt and Lai (2010) conclude, we do not actually need to know whether EMF/RF effects are thermal or non-thermal to develop and ideally set exposure guidelines for both humans and for wildlife. Most of the biological-effects studies of EMF/RF that have been conducted since the 1980s were under non-thermal conditions. In studies using isolated cells, the ambient temperature during exposure was generally well controlled. In most animal studies, the RFR intensity used usually did not cause a significant increase in body temperature in the test animals. Most scientists consider non-thermal effects as well established, even though the implications are not fully understood.

These points are further discussed in Lai and Levitt (2022) on, “The roles of intensity, exposure duration, and modulation on the biological effects of radio-frequency radiation and exposure guidelines.” For example, in the ongoing thermal-versus-non-thermal effects discussion, they note that, “...the underlying mechanisms of effects should *not* be a matter of concern in setting exposure guidelines as is common today. *What is important is the level at which energy absorption causes an effect.* One such powerful proof ... of non-thermal effects is evidenced in the fact that CW [continuous wave] and modulated-waves of the same frequency and incident power can produce different effects...” (Lai and Levitt 2022: page 248). A take-home: these are clearly complicated issues with results still open to interpretation and further investigation.

Scientifically, Levitt and Lai (2010) concluded that there are 3 rationales for the existence of non-thermal effects:

1. Effects can occur at low intensities when a significant increase in temperature is not likely — including at very low intensities barely above natural radiation background levels.
2. Heating does not produce the same effects as RFR exposure.
3. RFR with different modulations and characteristics produce different effects even though they produce the same pattern of specific absorption rate (SAR) distribution and tissue heating.

There is virtually no research to indicate what is safe for either humans or wildlife, including migratory birds which are highly sensitive to perturbations in ways humans are not (Levitt *et al.* 2021a). Unfortunately, there also is very little far-field, distance-to-safety research for wildlife as this has not been studied with that focus in mind. What little EMF/RF field research on wildlife that has been conducted, its focus has been on behavior, mortality, and reproductive outcomes (B.B. Levitt and H.C. Lai, Comments Filed Jointly to FCC, ET Docket No. 13-84, 2013; Balmori 2005 and 2009).

Given the rapidly growing database of peer-reviewed, published scientific studies (*e.g.*, <http://www.saferemr.com>, School of Public Health, University of California, Berkeley; see Footnote 6 regarding Recent Radiation Research and Radiation Safety), it is high time the FCC includes a thorough assessment of non-thermal effects from EMF-RFR in their tower permitting processes, and incorporate changes into their rulemaking regarding “effects of communication towers on migratory birds” (Levitt *et al.* 2021c). In a federal court case argued in January 2021 by Environmental Health Trust *et al.* v. FCC, the U.S. Court of Appeals DC Circuit in their August 2021 decision ruled against the FCC, determining that the FCC’s 1996 safety limits for human exposure to wireless radiation were “*arbitrary and capricious*,” and the Court specifically highlighted how the FCC had “*completely failed*” to address the “*substantive evidence of potential environmental harm*” on the record. As a result, the Court ordered FCC to (1) provide a reasoned explanation for its failure to justify why cell phones and other portable electronic devices comply with their guidelines. (2) Address the impacts of RF radiation on children, including the health implications of long-term radiation exposure. (3) Address the impacts of RF radiation on the environment, including migratory birds. At the time of this writing, the FCC has so far failed to respond to this Court order.

Moving Forward to Protect Wildlife and Public Health

It is time that EPA assess the impacts of EMF and RFR on wildlife, and for USFWS to acknowledge (in addition to the USDOJ 2014 letter) and address EMF effects to migratory birds and federally-listed fish and wildlife. This needs to include the development of publicly available guidelines for avoiding or minimizing “take” to birds and listed species — as previously mentioned — especially the development of exposure standards for wildlife including from chronic, low-level exposures. It is also time to recognize EMF as a novel form of air pollution and develop rules at the pertinent regulatory agencies — including the EPA, FCC, FDA, USFWS, the U.S. Forest Service, U.S. Department of Agriculture, the Department of Commerce, and others — and to designate air as “habitat” so EMF can be regulated like other pollutants. To begin to address these challenges, we need to incorporate the ALARA radiation principles where possible and feasible, attaining radiation levels “*as low as reasonably*

achievable.” The Centers for Disease Control and Prevention (CDC) has a very helpful site⁸ that discusses these principles.

While there is detailed information for reducing interior radiation exposures in homes, schools and offices discussed below, reducing daily involuntary environmental RFR radiation exposures from external sources is more challenging. Humans can try to avoid living close to cell, TV, radio, emergency broadcast or similar antennas — limiting the time and distance between the radiation source and our bodies. However, this is becoming more challenging due to the proliferation of base station antennas with 5G and new small cell network buildouts on public utility poles every 3-to-5 residences apart.

While increasing distance from antennas can significantly decrease exposure, it does not necessarily ensure protection. Due to the inverse square law of radiation, doubling one’s distance from an antenna will reduce exposure by a factor of 4 (NASA 2024). This calculation does not, however, include possible effects from the “intensity window” of 20-30 m (~66-98 ft) distance from the cell tower antenna to the body as previously discussed by Panagopoulos and Margaritis (2008), nor does it account for the reported numerous biological effects from cell tower radiation documented at very low intensities comparable to what the population experiences within 60-150 m (197-492 ft) distance of a cell tower antenna as reported by Levitt and Lai (2010), who along with several other researchers (Pearce 2020, Rodrigues *et al.* 2021), recommend a minimum setback of 457 m (1,500 ft.). The need for updated public exposure limits that protect for biological impacts from chronic, long-term exposure is critical. Building out networks based primarily on wired infrastructure is essential in addition to designing no or low-EMF-emitting devices. And we need to discuss backing away from some wireless technologies altogether — for humans and wildlife alike — since one of the confounding observations in bioelectromagnetics research includes seeming paradoxical nonlinear effects in which the lowest exposures can cause the greatest reactions. But nonlinear effects are actually quite common in biology, such as classic allergic reactions in humans to bee venom in which a tiny amount injected from a sting can cause an outsize systemic effect manifesting in anaphylactic shock.

Suggested Best Management Practices to Minimize EMF Exposure to Wildlife

There are numerous steps which we should take, or at the very least, seriously consider, that will begin to address the growing impacts of EMF on wildlife and humans. Using ALARA principles to safeguard birds, bats, insects and other affected wildlife from RFR emissions of specific communication towers is challenging since most towers are operating continuously. Shielding and physical avoidance barriers around towers are options, but are likely not practical or cost-effective. This is why RFR limits urgently need to be updated, and why a robust and

⁸ See the CDC’s website ([CDC.gov](https://www.cdc.gov)), search on ALARA, and open their window on Radiation and Your Health.

independent research program — not funded by the communications industry or its consultants — needs to be developed, funded, and implemented. Until then, new technologies and communication networks need to be designed with wildlife protective EMF and RFR reductions put in place as a priority (Levitt *et al.* 2021c, Froidevaux *et al.* 2023).

Some suggested measures to mitigate EMF impacts to wildlife:

- Develop extra protections for wildlife and their habitats in ecologically sensitive areas (*e.g.*, designated wilderness areas and critical habitats, national parks and monuments, national forests, national wildlife refuges, and world heritage sites, among others). To accomplish this, establish and maintain low and no-EMF zones. This may entail removing infrastructure and/or prohibiting new development.
- Regularly measure and monitor levels of EMF in wildlife conservation and ecologically sensitive areas and make those determinations available to the public.
- Where new communication networks are proposed, conduct environmental evaluations that include the proposed levels of radiation, as well as an assessment and implementation of strategic design modifications which could mitigate EMF levels. This could include aiming RF emissions from antennas away from foraging, nesting, and denning areas.
- Use barriers to maximize the distance between wildlife and EMF sources. While shielding towers may not be practical or cost-effective, there are antenna design and equipment components, many of which are being deployed by the electric utility industry on distribution and transmission structures (APLIC 2006, 2012) which are already available to the communications industry.
- All new frequencies being proposed for use must be tested and evaluated before deployment. Where wildlife species are suspected/documentated to be sensitive to particular frequencies, those frequencies should be avoided, or at the very least, evaluated from a cost-benefit and cumulative effects basis. For example, insects such as imperiled monarch butterflies, Federally-listed Karner blue butterflies, and honey bees may be particularly vulnerable to 5G and its sub-millimeter and millimeter wavelengths. Use of these frequencies should be prohibited until they are thoroughly and properly evaluated.
- All non-ionizing frequency bands should be matched to animal species and computer modeled for resonance relationships, particularly in the higher RF ranges planned for 5G and next generation wireless applications.
- For wildlife researchers, veterinarians, other wildlife professionals, animal trackers, and pet owners, among others, the use of radio telemetry gear, related tracking devices, and the radiation emitted from them has been assumed by most not to be a problem for target species, let alone their populations. EMF exposures and their effects from tracking gear

need to be more carefully assessed with recommended best management practices employed as discussed by Manville *et al.* (2024). For example, we recommend (1) keeping radio telemeters in sleep mode where feasible, (2) reducing the amount of tracking gear and the number of target animals used, and (3) reducing the frequency of gear use resulting in the subsequent reduction in EMF exposures.

Practical Steps to Minimize EMF Effects to Humans

There are a number of suggested best practices that have been designed to protect people in home, at school, and at work (Davis *et al.* 2023). These should be further evaluated and expanded, along with software and hardware changes for communications equipment, to better address the ALARA radiation principles (“*as low as reasonably achievable*”).⁹ This is an ongoing process.

Steps to Improve Radiation Safety and Reduce EMF Radiation Exposure for Humans:

- Turn OFF/power down cell phones at night when not in use; put them in airplane/Wi-Fi OFF mode such as when trying to avoid disturbing others, *e.g.*, such as at a movie theater, restaurant, or as required on aircraft.
- Turn OFF wireless devices to reduce radiation exposure to children, especially at night — who are more susceptible to impacts due to their softer skulls (Gandhi 1996) and developing brains (see the findings of the Adolescent Brain Cognitive Development Study, at abcdstudy.org). Many wireless devices in homes can be swapped out with safer, non-wireless options.
- When in use, keep cell phones in speaker mode, at least 12 inches from your head and other body parts. *E.g.*, Panagopoulos and Margaritis (2008) — discussed earlier — identified an “*intensity window*” of radiation at a distance of 8-12 inches from the cell phone antenna based on European GSM (900 MHz) and DCS (1800 MHz) frequencies. In the U.S., there are some identical, and other similar bands/frequencies currently used in the 4G/LTE and 5G bands by Verizon Wireless, AT&T, Sprint, T-Mobile, U.S. Cellular, and GCI Alaska in the 900 MHz and 1800 MHz frequencies (see PowerfulSignal.com for specific details). While more research and investigations are clearly needed, use of the precautionary approach is strongly recommended.
- Where possible, keep devices on a table, not on your lap.

⁹ A special thanks to Theodora. Scarato, Exec. Dir. of the Environmental Health Trust, who shared EHT’s website and best practices with me — many best practices, suggested simple steps, tech tips, and how-to’s noted below. See wildlifeandwireless.org and <https://healthytechhome.org/healthy-tech-guide/> for details. See also Davis *et al.* 2023.

- Text your messages as opposed to using voice or video communication. Be aware that certain situations can increase RF emissions, such as transferring video and large files, or usage in an area of low signal strength.
- Connect cell phones to the internet using an Ethernet cable, allowing you to use all internet functions without being irradiated by Wi-Fi. If your device does not have an Ethernet port, acquire an Ethernet adapter for your phone and connect it.
- Set up a 100% ethernet wired home, school, and office for internet connectivity, rather than Wi-Fi. Prefer using ethernet connections for streaming and video conferencing, rather than using your cell phone. Get wired!
- Avoid keeping cell phones and wireless devices near sensitive organs/tissues as much as possible, including reproductive, endocrine, neck, brain, and spinal cord body parts. This is especially important for pregnant women. Turn OFF cell phones when carried on your body.
- Turn OFF laptops, tablets, e-books, printers, wireless keyboards and mice, cordless phones, Bluetooth speakers, and other Wi-Fi controlled devices when not in use, and shut down routers, related Wi-Fi devices, and other transmitting/receiving booster antennas at night and when not in use, to minimize irradiation. As long as your Wi-Fi router is ON, it's emitting wireless radiation. By leaving devices ON 24/7, you're simply adding to cumulative effects from EMF to yourself, others, and your pets.
- To begin this process, identify what emits wireless radiation in your home, school, and office. EHT's website (Footnote 9) is especially helpful. For example, wireless smart speakers/assistants emit radiation nonstop and some families place them in children's bedrooms. Get an EMF radiation audit of your home, school, and office performed by a reputable investigator.
- Maintain a land-phone line if this is an option. If unavailable, consider a VOIP or internet based phone connected via Ethernet.
- Use corded versus cordless phones as cordless phone systems emit RFR, with the base station significantly emitting 24/7.
- Minimize the use of other "smart" devices ideally by not purchasing or at the least not activating "smart" technologies found in refrigerators, stoves, washers/driers, toasters and toaster ovens, microwave ovens, and other devices that include smart-tracking and monitoring technologies. Minimize use of "smart" wristwatches and fitness monitors powering them OFF when not in use, or better yet, choose devices that will go on airplane mode so you can transfer data when you choose, rather than 24/7.
- Avoid using digital "smart meters" for tracking electrical, gas, and water use. Instead, if your utilities provide opt-out options, use them. Analog electric meters are the best option.

Ensure they contain no “smart” devices which could be activated. Keep all installed meters on exterior walls, as far away from interior bedrooms, children’s play, and office spaces as possible.

Shielding Devices and Other Radiation Blockers:

Where it comes to cell phone radiation blocking and shielding devices placed around cell phones, while there are a number of such radiation protection devices available online, none to the best of this author’s knowledge nor to the knowledge of the Federal Trade Commission, has been independently tested by reputable radiation testing laboratories/companies with no vested interest in their outcomes to validate product company claims, efficacy, reliability, or the determination that additional radiation problems may exist. Un-assessed problems, *e.g.*, may include the increased power needed to send/receive signals to accommodate for the presence of lead shields and magnets in the sleeves of some of these products — resulting in more radiation, not less. Neither the FCC nor its consultants test the effectiveness of cell phone radiation shields, nor do they verify company claims. However, the Federal Trade Commission (FTC.gov) does provide a menu on its website that states, “*FTC offers tips to help consumers avoid cell phone radiation scams.*” Furthermore, FTC notes that the “*ads and websites often claim to have scientific evidence that their radiation shields work, but the Federal Trade Commission reports that there is no scientific proof that these products reduce exposure to electromagnetic radiation, and warn that these products may actually increase the radiation the phones emit.*”¹⁰ The take-home: the buyer should beware and do his/her full due diligence to assess claims, asserted findings, and suggested outcomes regarding radiation blocking shields and other radiation screening devices before investing in and/or using them. Such mitigation approaches only create false safety notions. The simple fact is that cell phones (and most wireless devices) function by transmitting to and receiving from a tower or nearby base station. Anything that blocks the device’s ability to reach the base station makes that device work harder, thereby putting out more RFR. This also requires more energy and reduces battery life. The only device-shielding approach that works pertains to blocking RFR from laptop computers with a nonconductive barrier placed between the computer and the human body, and is highly recommended for pregnant women. Note that this does not surround the entire computer from trying to reach a Wi-Fi router, the way that cell phone shields do, thereby increasing the RFR power output for cell phones. The best mitigation for laptops, however, includes a shielding pad as well as keeping the system completely wired.

Acknowledgements

¹⁰<http://www.consumer.ftc.gov/articles/0109-cell-phone-radiation-scams>; also search under FTC cell phone radiation scams, open the window: “FTC offers tips to help consumers avoid cell phone scams,” June 2011.

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Respectfully submitted,

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