



October 25, 2023

To: Senate Committee on Energy and Natural Resources

From: Environmental Health Trust

Testimony in opposition to S.2855

Chair Manchin, Ranking Member Barrasso, Members of the Energy & Natural Resources Committee, and Senator Sinema,

We write to today oppose S.2855 in its currently drafted form.

We support high-speed wired broadband deployment and believe it should be universally accessible to all Americans. Unfortunately this bill in its current form is likely to perpetuate the digital divide,<sup>1</sup> while causing irreversible environmental harm to our federal lands. These lands represent nearly 30% of all land area in the United States and are a national treasure for which we all aspire to be good stewards.

Our federal lands are reservoirs of natural resources, plants, and animals. We depend on these resources for water, food, and even the oxygen we breathe, which is produced in our national forests. A large and growing body of credible science indicates that radiofrequency emissions from wireless infrastructure threaten these ecosystems.<sup>2</sup> In addition, many rural communities depend on these natural resources for their livelihoods.

- This bill will undermine environmental protections for sensitive wilderness, national forests, and rangeland, as well as all other land<sup>3</sup>. Any telecommunications deployment, whether on federal, state, local, or private land, wired or wireless, should remain subject to the National Environmental Policy Act (NEPA) and National Historic preservation Act (NHPA).

---

<sup>1</sup> As a witness in a 9/21/23 House of Representatives hearing noted: "Fiber is the most scalable, reliable, long-term, future proof strategy we have. So the cost efficiency is really lost when we have to keep coming to these hearings and re-appropriating funds year after year to do technologies that are only are Band-Aid approaches to the solution."

[https://www.youtube.com/live/ptQJ\\_wbtHYc?si=ef-HupBMwr7M6hm8&t=6029](https://www.youtube.com/live/ptQJ_wbtHYc?si=ef-HupBMwr7M6hm8&t=6029)

<sup>2</sup><https://ehtrust.org/wp-content/uploads/Wireless-Impacts-to-Wildlife-Scientific-Research-Studies-Flyer-WiTh-Science-.pdf>, Levitt BB, Lai HC and Manville AM II (2022) [Low-level EMF effects on wildlife and plants: What research tells us about an ecosystem approach](#). Front. Public Health 10:1000840. doi: 10.3389/fpubh.2022.1000840 and Levitt, B. B., Lai, H. C., & Manville, A. M. (2021). [Effects of non-ionizing electromagnetic fields on flora and fauna, Part 3. Exposure standards, public policy, laws, and future directions](#). *Reviews on Environmental Health*.

<sup>3</sup> Section 7 of this bill would likely exempt "Section 6409" expansions of existing wireless facilities from NEPA and NHPA.

- We urge Congress to halt any legislation that promotes or encourages further proliferation of wireless antenna and/or increases the amount of radiofrequency (RF) radiation in the environment until the federal government has determined safe levels of radiofrequency radiation emissions from wireless technology, especially cell towers and transmission infrastructure, for humans, wildlife, and the environment.
- No federal agency has evaluated the scientific research on the health and environmental impacts of wireless radiation. The EPA was defunded from this work in 1996.<sup>4</sup> Current FCC limits were developed by industry groups, largely based on studies (IEEE 1991 standard) that based exposure limits on effects found after exposing a small group of monkeys and rats to wireless radiation for less than one hour, more than 40 years ago.<sup>5</sup> As the US Court of Appeals recognized, these antiquated studies are a far cry from properly assessing the health and environmental impacts of modern technology and ubiquitous wireless devices.<sup>6</sup>

Instead of fast-tracking wireless networks, Congress should take the following actions to protect the public and the environment:

- Require qualified, independent federal agencies to assess the evidence on wireless impacts and develop science-based exposure limits for humans, wildlife, and the natural environment.
- Fund the EPA to establish a federal program for nationwide RF measurements, environmental monitoring, oversight and compliance.
- Exercise Congressional oversight authority over the FCC and its lack of compliance with the US Court of Appeals order (*Environmental Health Trust et al. v. FCC*, DC Circuit 2021).
- Encourage the deployment of high-speed, affordable, wired broadband to bridge the digital divide with infrastructure that is faster, safer, and more secure.

The transmissions to and from wireless installations create radiofrequency emissions that are an environmental pollutant known to cause cancer (in both experimental animals and humans) and other adverse health and environmental effects, for example on birds, bees, and trees, according to internationally recognized authoritative research. The prestigious institutions that have studied radiofrequency include the U.S. National Toxicology Program, the nation's premier toxicology institute. The [Natural Resources Defense Council](#) has argued at the US Court of Appeals, an environmental impact assessment should be performed before building out 5G networks.<sup>7</sup>

In the attached Technical Annex, we document impacts to human health, wildlife, and the environment. This documentation helps to explain why more than [400 medical experts and scientists](#) are calling for a halt to 5G and for immediate reductions in public exposure to microwave wireless radiation.<sup>8</sup>

---

<sup>4</sup> <https://ehtrust.org/wp-content/uploads/5G-and-Cell-Tower-Radiation-Briefing-1.pdf>

<sup>5</sup> International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF), (2022). [Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP exposure limit determinations for radiofrequency radiation: implications for 5G](#). Environ Health. Oct 18;21(1):92.

<sup>6</sup> *Environmental Health Trust v. FCC* (DC Circuit, 2021) [https://www.cadc.uscourts.gov/internet/opinions.nsf/FB976465BF00F8BD85258730004EFD7/\\$file/20-1025-1910111.pdf](https://www.cadc.uscourts.gov/internet/opinions.nsf/FB976465BF00F8BD85258730004EFD7/$file/20-1025-1910111.pdf)

<sup>7</sup> <https://ehtrust.org/wp-content/uploads/20-1025-NRDC-amicus-brief.pdf>

<sup>8</sup> <http://www.5gappeal.eu/signatories-to-scientists-5g-appeal/>



Thank you for your consideration. We would be happy to speak further to discuss these matters.

Sincerely,

Theodora Scarato  
Executive Director, Environmental Health Trust

Environmental Health Trust (EHT) is a nonprofit think tank and policy organization dedicated to identifying and reducing environmental hazards. EHT provides independent scientific research and advice on controllable environmental hazards to local, state, and national governments.

Note: all web links herein are incorporated by reference.

## Technical Annex

### Table of Contents

FCC Limits Are Not Adequate To Protect People Nor Wildlife	4
Documented Impacts to Wildlife and the Environment	5
Electromagnetic Fields Alter Animal and Insect Orientation	6
Evidence Indicates Harm To Crucial Pollinators	8
Wireless Facilities Have Been Responsible For Damaging Wildfires	8
Wireless Radiation is Known to Harm Humans and Wildlife	9
Radiofrequency radiation exposure is increasing at a rapid pace.	12
Telecommunications Companies Warn Their Shareholders	12
July 8, 2020 Letter from the EPA	14
Key Research Studies on EMF impacts to Flora and Fauna	19

### FCC Limits Are Not Adequate To Protect People Nor Wildlife

We attached below a July 8, 2020 letter to EHT Director Theodora Scarato from the Environmental Protection Agency’s Director of the Radiation Protection Division and Office of Radiation and Indoor Air, Lee Ann B. Veal. This letter confirms that the EPA has never reviewed the impact to birds, bees, or trees. There is no federal health agency that has ever set safety limits for trees, birds, or bees. Our outdated wireless radiation limits were never intended to protect the nature around us. No agency has a funded mandate to ensure our flora and fauna are safe from cell tower radiation. In other words, it is a gaping hole in federal accountability. Thus, wireless infrastructure expansion should be halted until proper safety limits are developed.

The [U.S. Department of the Interior sent a letter](#) in 2014<sup>9</sup> reviewing several research studies showing harm to birds and concluding that “The electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today.”

A now-retired U.S. Fish and Wildlife Service wildlife biologist, the former lead on telecommunications impacts, Dr. Albert Manville, has [written to the FCC](#) on impacts to birds and on [higher frequencies to be used in 5G](#). Dr. Manville authored numerous [publications](#) detailing research showing harm to

---

<sup>9</sup> Washington DC, Veenendaal ME. [Department of Interior Letter](#). *United States Department of the Interior OFFICE OF THE SECRETARY*.

birds.<sup>10,11,12</sup>“The race to implement 5G and the push by FCC to approve the related 5G license frequencies to industry are very troubling and downright dangerous.”

### Documented Impacts to Wildlife and the Environment

- A landmark [research review](#) by U.S experts of over 1,200 studies on the effects of non ionizing radiation to wildlife entitled “Effects of non-ionizing electromagnetic fields on flora and fauna” published in Reviews on Environmental Health found adverse effects at even very low intensities including impacts to orientation and migration, reproduction, mating, nest, den building and survivorship. ([Levitt et al., 2021a](#), [Levitt et al., 2021b](#), [Levitt et al., 2021c](#)).
- “[A review of the ecological effects of RF-EMF](#)” reviewed 113 studies finding RF-EMF had a significant effect on birds, insects, other vertebrates, other organisms, and plants in 70% of the studies ([Cucurachi 2013](#)). Development and reproduction in birds and insects were the most strongly affected. As an example of the several studies on wildlife impacts, a study focusing on RF from antennas found increased sperm abnormalities in mice exposed to RF from GSM antennas ([Otitolaju 2010](#)).
- “[Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz](#)” published in Scientific Reports is the first study to investigate how insects (including the Western honeybee) absorb the higher frequencies (2 GHz to 120 GHz) to be used in the 4G/5G rollout. The scientific simulations showed increases in absorbed power between 3% to 370% when the insects were exposed to the frequencies. Researchers concluded, “This could lead to changes in insect behaviour, physiology, and morphology over time....”
- Studies on bees have found behavioral effects ([Kumar 2011](#), [Favre 2011](#)), disrupted navigation ([Goldsworthy 2009](#), [Sainudeen 2011](#), [Kimmel et al. 2007](#)), decreasing egg laying rate ([Sharma and Kumar, 2010](#)), and reduced colony strength ([Sharma and Kumar, 2010](#), [Harst et al. 2006](#)).
- Research has also found a high level of damage to trees from antenna radiation. For example, a field monitoring study spanning 9 years involving over 100 trees ([Waldmann-Selsam 2016](#)) found trees sustained more damage on the side of the tree facing the antenna.
- A study on Aspen trees near Lyons, Colorado entitled “[Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings](#)” published in the *International Journal of Forestry* found adverse effects on growth rate and fall anthocyanin production, concluding that “results of this preliminary experiment indicate that the RF background may be adversely affecting leaf and shoot growth and inhibiting fall production of anthocyanins associated with leaf senescence in Trembling Aspen seedlings. These effects suggest that exposure to the RF background may be an

---

<sup>10</sup> ECFS Filing Detail. <https://www.fcc.gov/ecfs/filing/1060315601199>. Accessed July 8, 2020.

<sup>11</sup> Albert M. Manville Ph.D. Former U.S. Fish and Wildlife Service Senior Biologist. [Memorandum on the Bird and Wildlife Impacts of Non-ionizing Radiation](#). Environmental Health Trust. Accessed July 8, 2020.

<sup>12</sup> Manville AM. *Collisions, Electrocutions, and Next Steps-Manville* [BIRD STRIKES AND ELECTROCUTIONS AT POWER LINES, COMMUNICATION TOWERS, AND WIND TURBINES: STATE OF THE ART AND STATE OF THE SCIENCE & NEXT STEPS TOWARD MITIGATION I.](#); 2002.

underlying factor in the recent rapid decline of Aspen populations. Further studies are underway to test this hypothesis in a more rigorous way.”<sup>13</sup>

- An analysis of 45 peer-reviewed scientific publications (1996–2016) on changes in plants due to the non-thermal RF-EMF effects from mobile phone radiation entitled “[Weak radiofrequency radiation exposure from mobile phone radiation on plants](#)” concludes, “Our analysis demonstrates that the data from a substantial amount of the studies on RF-EMFs from mobile phones show physiological and/or morphological effects (89.9%,  $p < 0.001$ ). Additionally, our analysis of the results from these reported studies demonstrates that the maize, roselle, pea, fenugreek, duckweeds, tomato, onions and mungbean plants seem to be very sensitive to RF-EMFs. Our findings also suggest that plants seem to be more responsive to certain frequencies...”<sup>14</sup>
- A 2023 controlled, experimental study over one growing season of common cellular frequencies found adverse impacts on European Clover, *Trifolium arvense*, which is in the same genus of common clovers found throughout North America and commonly used as cover crop. The authors of “[Do electromagnetic fields used in telecommunications affect wild plant species? A control impact study conducted in the field](#)” wrote “We conclude that the effects of RF-EMF exposure at environmentally relevant levels can be permanent and irreversible in plants growing in the open natural environment, however, these effects are restricted to specific species. This in turn suggests that future studies should examine whether the effects observed here occur also in more common *Trifolium* species or other legumes that are a keystone component within European grasslands.”

## Electromagnetic Fields Alter Animal and Insect Orientation

*Science of the Total Environment* published environmental scientist Alforso Balmori’s “[Anthropogenic radiofrequency electromagnetic fields as an emerging threat to wildlife orientation](#),” which states, “Current evidence indicates that exposure at levels that are found in the environment (in urban areas and near base stations) may particularly alter the receptor organs to orient in the magnetic field of the earth. These results could have important implications for migratory birds and insects, especially in urban areas, but could also apply to birds and insects in natural and protected areas where there are powerful base station emitters of radio frequencies. Therefore, more research on the effects of electromagnetic radiation in nature is needed to investigate this emerging threat.”<sup>15</sup>

---

<sup>13</sup> Katie Haggerty, “[Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings: Preliminary Observations](#),” *International Journal of Forestry Research*, vol. 2010, Article ID 836278, 7 pages, 2010. doi.org/10.1155/2010/836278.

<sup>14</sup> Malka N. Halgamuge (2017) [Review: Weak radiofrequency radiation exposure from mobile phone radiation on plants](#), *Electromagnetic Biology and Medicine*, 36:2, 213-235, DOI: 10.1080/15368378.2016.1220389.

<sup>15</sup> Alfonso Balmori, [Anthropogenic radiofrequency electromagnetic fields as an emerging threat to wildlife orientation](#), *Science of The Total Environment*, Volumes 518–519, 2015, Pages 58-60, ISSN 0048-9697, doi.org/10.1016/j.scitotenv.2015.02.077.



Multiple research studies have documented how animals' magnetoreception can be disrupted by external electromagnetic fields, from [mice](#)<sup>16</sup> to [cows](#) to [dogs](#) to [birds](#).<sup>17</sup> Electromagnetic exposure is especially disruptive to migratory birds.<sup>18</sup> Electromagnetic fields have been shown to disrupt the magnetic compass orientation used by birds to navigate.<sup>19,20</sup> Researchers have suggested this disruption of magnetoreception is due to cryptochrome photoreceptors that allow birds to use built-in receptors as a biological compass.

In 2012, the government of India's Ministry of the Environment and Forest issued a [report](#) on the potential impacts of communication towers on wildlife, citing hundreds of research studies that found adverse effects. Recommendations from the Ministry include, "Introduce a law for protection of urban flora and fauna from emerging threats like ERM/EMF as conservation issues in urban areas are different from forested or wildlife habitats."<sup>21</sup>

A [2017 report to UNESCO](#)<sup>22</sup> by botanist Mark Broomhall details the association between increasing amounts of electromagnetic radiation from cellular antennas on the Mt. Nardi tower complex and species disappearance and exodus from the Mt. Nardi area of the Nightcap National Park World Heritage Area during a 15-year period (2000–2015). He estimates "in both volume and species that from 70 to 90% of the wildlife has become rare or has disappeared from the Nightcap National Park within a radius of the Mt. Nardi tower complex. This statement can be summarised with concrete data: 3 bat species once common have become rare or gone, 11 threatened and endangered bird species are gone, 11 migratory bird species are gone, 86 bird species are demonstrating unnatural behaviours, 66 once common bird species are now rare or gone." The Report concludes, "With these short explanations of events we can appreciate that the effects of this technology and its application on Mt. Nardi over the last fifteen years, affect not only the top of the life chain species but they are devastating the fabric of the continuity of the World Heritage, causing genetic deterioration in an insidious, massive and ever escalating scale. To truly understand what these studies reveal is to stare into the abyss."

In considering antenna placement, there must be a full environmental assessment on migratory animal patterns (from the smallest to the largest) and not simply on birds and mammals like the pronghorn but also on impacts to amphibians and insects.

---

<sup>16</sup> Malkemper, E.P., et al. "[Magnetoreception in the wood mouse \(\*Apodemus sylvaticus\*\): influence of weak frequency-modulated radio frequency fields.](#)" *Scientific Reports*, vol. 4, no. 9917, 2015.

<sup>17</sup> Wiltshko Roswitha, Thalau Peter, Gehring Dennis, Nießner Christine, Ritz Thorsten, Wiltshko Wolfgang. [Magnetoreception in birds: the effect of radio-frequency fields.](#) 12. *Journal of The Royal Society Interface*.

<sup>18</sup> Engels, Svenja, et al. "[Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird.](#)" *Nature* 509.7500 (2014): 353-356.

<sup>19</sup> Wiltshko, Roswitha, et al. "[Magnetoreception in birds: the effect of radio-frequency fields.](#)" *Journal of The Royal Society Interface* 12.103 (2015): 20141103.

<sup>20</sup> Schwarze, S., et al. "[Weak Broadband Electromagnetic Fields are More Disruptive to Magnetic Compass Orientation in a Night-Migratory Songbird \(\*Erithacus rubecula\*\) than Strong Narrow-Band Fields.](#)" *Front Behav Neurosci.* 10.55 (2016).

<sup>21</sup> Expert Committee, Ministry of Environment and Forest, Government of India, [Report on Possible Impacts of Communication Towers on Wildlife Including Birds and Bees](#), Constituted on 30th August, 2010.

<sup>22</sup> Broomhall, Mark. "[Report detailing the exodus of species from the Mt. Nardi area of the Nightcap National Park World Heritage Area during a 15-year period \(2000-2015\).](#)" United Nations Scientific and Cultural Organization (2017).

## **Evidence Indicates Harm To Crucial Pollinators**

“[Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz](#)” published in Scientific Reports is the first study to investigate how insects (including the Western honeybee) absorb the higher frequencies (2 GHz to 120 GHz) to be used in the 4G/5G rollout. The scientific simulations showed increases in absorbed power when the insects were exposed to the frequencies. Researchers concluded, “This could lead to changes in insect behaviour, physiology, and morphology over time....”

- Research on bees has found behavioral effects including inducing artificial worker piping, a sign of stress ([Favre, 2011](#)), increased Queen loss (Lupi et al., 2020), altered pupal development ([Odemer 2019](#)), decreased rate egg laying rate and reducing colony strength ([Sharma and Kumar, 2010](#); [Harst et al., 2006](#)) and various biochemical changes([Badotra et al 2011](#)).
- A study published in the Journal of Insect Conservation on key wild pollinator groups on two Mediterranean islands correlated RF levels from telecommunication antennas to changes in the abundance and richness of wild bees, hoverflies, bee flies, beetles, and wasps ([Lazaro et al 2016](#)).
- A 22 week study on the impact of a telecommunications tower in Kwara State Nigeria found that as the RF levels increased closer to the tower, the diversity and abundance of insects decreased ([Adelaja et al 2021](#)).

## **Wireless Facilities Have Been Responsible For Damaging Wildfires**

- The California Public Utilities Commission (CPUC) determined that the 2018 Woolsey fire, which caused an estimated \$6 billion in damages, began after trees grew into a communications wire on a wooden utility pole.<sup>23</sup>
- In 2013, the CPUC fined the electric utility, AT&T, T-Mobile, and Verizon, a combined \$99 million after three utility poles fell during heavy winds causing the Malibu Canyon Fire, which burned over 3,800 acres and incurring an estimated \$14 million in damages.<sup>24</sup>
- Cell tower fires have been documented on the East Coast as well, such as in Ohio, Pennsylvania, and Virginia.<sup>25</sup>
- Electrical fires present secondary challenges for firefighters. Spraying water on a cell tower fire before the electricity is cut may electrocute the firefighters, therefore firefighters may wait until

---

<sup>23</sup>

<https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-and-enforcement-division/investigations-wildfires/sed-investigation-report---woolsey-fire---redacted.pdf>

<sup>24</sup> See page 8

<https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M077/K305/77305250.PDF>

<sup>25</sup> See PDF pages 153-182

<https://file.lacounty.gov/SDSInter/bos/supdocs/175337.pdf> and  
<https://ehtrust.org/cell-tower-safety-risks-fires-and-collapse/>



the electric utility cuts the power, or use only short bursts of water, potentially delaying response time to wildfires.

## Wireless Radiation is Known to Harm Humans and Wildlife

Human health effects include impaired reproduction, increased incidence of brain cancer, DNA breaks, oxidative stress, immune dysfunction, altered brain development, sleep changes, hyperactivity, and memory and cognitive problems.<sup>26</sup> Since the WHO/IARC [classified EMF as a Group 2B Possible Carcinogen](#) in 2011, the peer-reviewed research connecting wireless exposure to cancer has significantly strengthened and several scientists have published documentation that the weight of current peer-reviewed evidence supports the conclusion that radiofrequency radiation should be regarded as a human carcinogen.<sup>27,28,29</sup>

- The 10-year \$30 million National Institute of Environmental Health Sciences National Toxicology Program's (NTP) "Studies of the Toxicology and Carcinogenicity of Cell Phone Radiation"<sup>30,31</sup> found that RFR was associated with "clear evidence" of cancer due to the increased malignant schwannomas found in RFR-exposed male rats. The brain (glioma) cancers and tumors in the adrenal glands were also considered evidence of an association with cancer. In addition, exposed animals had significantly more DNA damage, heart damage, and low birth weight.
- The Ramazzini Institute published its [findings](#)<sup>32</sup> that animals exposed to very low-level RFR developed the same types of cancers as reported by the NTP.
- Long-term [research](#) on humans who have used cell phones has found increased tumors—schwannomas and glioblastomas—the same cell type as found in the NTP and

---

<sup>26</sup> For more information on acute health symptoms, see, e.g., Martin Pall, Microwave Frequency Electromagnetic Fields (EMFs) Produce Widespread Neuropsychiatric Effects Including Depression, 75 *J. Chemical Neuroanatomy* 43-51 (Sept. 2016); [Response of residents living in the vicinity of a cellular phone base station in France](#); [Electromagnetic Fields: A Hazard to Your Health?](#), Healthy Children.

<sup>27</sup> Adams, Jessica A., et al. ["Effect of mobile telephones on sperm quality: a systematic review and meta-analysis."](#) *Environment International*, 70, 2014, pp. 106-112.

<sup>28</sup> Deshmukh, P.S., et al. ["Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation."](#) *International Journal of Toxicology*, vol. 34, no. 3, 2015, pp. 284-90.

<sup>29</sup> Aldad, T.S., et al. ["Fetal Radiofrequency Radiation Exposure From 800-1900 MHz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice."](#) *Scientific Reports*, vol. 2, no. 312, 2012.

<sup>30</sup> National Toxicology Program, [Cell Phone Radio Frequency Radiation](#)

<sup>31</sup> [High exposure to radio frequency radiation associated with cancer in male rats](#)

<sup>32</sup> L. Falcioni, L. Bua, E. Tibaldi, M. Lauriola, L. De Angelis, F. Gnudi, D. Mandrioli, M. Manservigi, F. Manservigi, I. Manzoli, I. Menghetti, R. Montella, S. Panzacchi, D. Sgargi, V. Strollo, A. Vornoli, F. Belpoggi, [Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission](#), *Environmental Research*, Volume 165,

2018, Pages 496-503, ISSN 0013-9351, doi.org/10.1016/j.envres.2018.01.037.

Ramazzini Institute studies. Persons who started using cell phones under age 20 had the highest risk.<sup>33</sup>

- A 2015 Jacobs University [study](#) (replicating a [2010 study](#)) found that weak cell phone signals significantly promote the growth of tumors in mice and that combining a toxic chemical exposure with RF more than doubled the tumor response.<sup>34,35</sup>
- “[5G wireless telecommunications expansion: Public health and environmental implications](#),” is a research review published in *Environmental Research*, which documents the range of adverse effects reported in the published literature, from cancer to bacteria growth changes to DNA damage, concludes that “a moratorium on the deployment of 5G is warranted” and “the addition of this added high-frequency 5G radiation to an already complex mix of lower frequencies, will contribute to a negative public health outcome both from both physical and mental health perspectives.”<sup>36</sup>
- A [study published in Electromagnetic Biology and Medicine](#), “Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base station,” compared people living close and far from cell antennas and found that people living closer to cell antennas had higher radiation levels in the homes and several significant changes in their blood predictive of cancer development.”<sup>37</sup>
- A 2019 [study](#) of students in schools near cell towers found their higher RF exposure was associated with impacts on motor skills, memory, and attention ([Meo 2019](#)).<sup>38</sup> Examples of other effects linked to cell towers in research studies include [neuropsychiatric problems](#),<sup>39</sup> [elevated](#)

---

<sup>33</sup> [https://www.pathophysiologyjournal.com/article/S0928-4680\(14\)00064-9/fulltext](https://www.pathophysiologyjournal.com/article/S0928-4680(14)00064-9/fulltext)

<sup>34</sup> Lerchl, Alexander, et al. “[Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans](#).” *Biochemical and Biophysical Research Communications*, vol. 459, no. 4, 2015, pp. 585-90.

<sup>35</sup> Tillmann, Thomas, et al. “[Indication of cocarcinogenic potential of chronic UMTS-modulated radiofrequency exposure in an ethylnitrosourea mouse model](#).” *International Journal of Radiation Biology*, vol. 86, no. 7, 2010, pp. 529-41.

<sup>36</sup> <https://doi.org/10.1016/j.envres.2018.01.016>

<sup>37</sup> Zothansiam & Zosangzuali, Mary & Lalramdinpuii, Miriam & Jagetia, Ganesh & Siam, Zothan. (2017). [Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base stations](#). *Electromagnetic Biology and Medicine*. 36. 1-11. 10.1080/15368378.2017.1350584.

<sup>38</sup> Meo, S. A., Almahmoud, M., Alsultan, Q., Alotaibi, N., Alnajashi, I., & Hajjar, W. M. (2019). [Mobile Phone Base Station Tower Settings Adjacent to School Buildings: Impact on Students’ Cognitive Health](#). *American Journal of Men’s Health*. doi.org/10.1177/1557988318816914.

<sup>39</sup> G. Abdel-Rassoul, O. Abou El-Fateh, M. Abou Salem, A. Michael, F. Farahat, M. El-Batanouny, E. Salem, [Neurobehavioral effects among inhabitants around mobile phone base stations](#), *NeuroToxicology*, Volume 28, Issue 2, 2007, Pages 434-440, ISSN 0161-813X, doi.org/10.1016/j.neuro.2006.07.012.

[diabetes](#),<sup>40</sup> [headaches](#),<sup>41</sup> [sleep problems](#),<sup>42</sup> and [genetic damage](#).<sup>43</sup> Such research continues to accumulate after the 2010 landmark [review study](#) on 56 studies that reported biological effects found at very low intensities of wireless radiation, including impacts on reproduction, permeability of the blood-brain barrier, behavior, cellular changes, and metabolic changes, and increases in cancer risk ([Lai and Levitt 2010](#)).<sup>44</sup>

- Published research has found impacts from wireless radiation exposure to [reproduction](#) and [brain development](#) in addition to a myriad of other adverse effects.<sup>45,46,47,48</sup> Although renowned institutions, such as the [Cleveland Clinic](#), advise men to keep phones and wireless devices away from their reproductive organs, the public remains largely unaware.

Once towers are erected, they will be upgraded over time with new antennas. Recently deployed millimeter wave frequencies uniquely penetrate the eyes and skin,<sup>49,20,21,22</sup> and have been shown to accelerate bacterial and viral cell growth.<sup>50</sup> Millimeter waves were originally developed as a military weapon to create the sensation that the skin is burning.<sup>51</sup> Currently accepted standards are not sophisticated enough to measure effects on sweat glands or quantify the risks of cumulative

---

<sup>40</sup> SA, Meo & Alsubaie, Yazeed & Almubarak, Zaid & Almutawa, Hisham & AlQasem, Yazeed & Hasanato, Rana. (2015). [Association of Exposure to Radio-Frequency Electromagnetic Field Radiation \(RF-EMFR\) Generated by Mobile Phone Base Stations with Glycated Hemoglobin \(HbA1c\) and Risk of Type 2 Diabetes Mellitus](#). International Journal of Environmental Research and Public Health. 12. 14519-14528;. 10.3390/ijerph121114519.

<sup>41</sup> Hutter, H. P., Moshhammer, H., Wallner, P., & Kundi, M. (2006). [Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations](#). *Occupational and environmental medicine*, 63(5), 307–313. doi:10.1136/oem.2005.020784.

<sup>42</sup> R. Santini, P. Santini, J.M. Danze, P. Le Ruz, M. Seigne, [Enquête sur la santé de riverains de stations relais de téléphonie mobile: I/Incidences de la distance et du sexe](#), Pathologie Biologie, Volume 50, Issue 6, 2002, Pages 369-373, ISSN 0369-8114, doi.org/10.1016/S0369-8114(02)00311-5.

<sup>43</sup> Gursatej Gandhi, Gurpreet Kaur & Uzma Nisar (2015) [A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station](#), Electromagnetic Biology and Medicine, 34:4,344-354, DOI: 10.3109/15368378.2014.933349.

<sup>44</sup> B. Blake Levitt and Henry Lai, [Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays](#), Environ. Rev. Downloaded from www.nrcresearchpress.com by 172.58.41.200 on 04/10/19

<sup>45</sup> Adams, Jessica A., et al. ["Effect of mobile telephones on sperm quality: a systematic review and meta-analysis."](#) *Environment International*, 70, 2014, pp. 106-112.

<sup>46</sup> Deshmukh, P.S., et al. ["Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation."](#) *International Journal of Toxicology*, vol. 34, no. 3, 2015, pp. 284-90.

<sup>47</sup> Aldad, T.S., et al. ["Fetal Radiofrequency Radiation Exposure From 800-1900 MHz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice."](#) *Scientific Reports*, vol. 2, no. 312, 2012.

<sup>48</sup> Sonmez, O.F., et al. ["Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 MHz electromagnetic field."](#) *Brain Research*, vol. 1356, 2010, pp. 95-101.

<sup>49</sup> A [lecture](#) by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the [2017 IIAS Conference website](#). Feldman, Yuri and Paul Ben-Ishai. ["Potential Risks to Human Health Originating from Future Sub-MM Communication Systems."](#) *Conference on Wireless and Health*, 2017.

<sup>50</sup> Cindy L. Russell, [5G Wireless Telecommunications Expansion: Public Health and Environmental Implications](#), 165 *Env'tl Res.* 484 (2018).

<sup>51</sup> For information on Active Denial Systems, see, e.g., [Vehicle-Mounted Active Denial System \(V-MADS\)](#) ; [Active Denial System FAQs](#).

exposure.<sup>52,53</sup> Any future applications of these technologies must consider the biological effect of cumulative exposures to these frequencies.

### **Radiofrequency radiation exposure is increasing at a rapid pace.**

A [2018 article](#) published in *The Lancet Planetary Health* points to unprecedented increasing RF exposures, and the abstract concludes, “due to the exponential increase in the use of wireless personal communication devices (eg, mobile or cordless phones and WiFi or Bluetooth-enabled devices) and the infrastructure facilitating them, levels of exposure to radiofrequency electromagnetic radiation around the 1 GHz frequency band, which is mostly used for modern wireless communications, have increased from extremely low natural levels by about 1018 times...”([Bandara and Carpenter, 2018](#)).<sup>54</sup>

Another key finding from [Zothansiamia 2017](#) was that homes closer to antennas had measurably higher radiation levels—adding to the documentation that antennas increase RF levels. An [Australian study](#) also found that children in kindergartens with nearby antenna installations had nearly three-and-a-half times higher RF exposures than children with installations further away (more than 300 meters) ([Bhatt 2016](#)).<sup>55</sup>

A 2018 multi-country [study](#) that measured RF in several countries found that cell phone network tower radiation is the dominant contributor to RF exposure in most outdoor areas, exposure in urban areas was higher, and exposure has drastically increased. As an example, the measurements the researchers [took](#) in Los Angeles, USA was 70 times higher than the US EPA estimate 40 years ago.<sup>56</sup>

### **Telecommunications Companies Warn Their Shareholders**

---

<sup>52</sup> A [lecture](#) by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the [2017 IIAS Conference website](#). Feldman, Yuri and Paul Ben-Ishai. “[Potential Risks to Human Health Originating from Future Sub-MM Communication Systems](#).” *Conference on Wireless and Health*, 2017.

<sup>53</sup> Hayut, Itai, Paul Ben Ishai, Aharon J. Agranat and Yuri Feldman. “[Circular polarization induced by the three-dimensional chiral structure of human sweat ducts](#).” *Physical Review E*, vol. 89, no. 042715, 2014.

<sup>54</sup> Priyanka Bandara, David O Carpenter, [Planetary electromagnetic pollution: it is time to assess its impact](#), *The Lancet Planetary Health*, Volume 2, Issue 12, 2018, Pages e512-e514, ISSN 2542-5196, doi.org/10.1016/S2542-5196(18)30221-3.

<sup>55</sup> Bhatt, C. R., Redmayne, M., Billah, B., Abramson, M. J., & Benke, G. (2016). [Radiofrequency-electromagnetic field exposures in kindergarten children](#). *Journal Of Exposure Science And Environmental Epidemiology*, 27, 497. Retrieved from <https://doi.org/10.1038/jes.2016.55>.

<sup>56</sup> Sanjay Sagar, Seid M. Adem, Benjamin Struchen, Sarah P. Loughran, Michael E. Brunjes, Lisa Arangua, Mohamed Aqiel Dalvie, Rodney J. Croft, Michael Jerrett, Joel M. Moskowitz, Tony Kuo, Martin Rössli, [Comparison of radiofrequency electromagnetic field exposure levels in different everyday microenvironments in an international context](#), *Environment International*, Volume 114, 2018, Pages 297-306, ISSN 0160-4120, doi.org/10.1016/j.envint.2018.02.036.

In fact, a number of corporations already advise their shareholders that they could face serious financial risks from damages due to RF. For instance, Crown Castle's [2019 10-K ANNUAL REPORT](#) states that,

If radio frequency emissions from wireless handsets or equipment on our communications infrastructure are demonstrated to cause negative health effects, potential future claims could adversely affect our operations, costs or revenues.

The potential connection between radio frequency emissions and certain negative health effects, including some forms of cancer, has been the subject of substantial study by the scientific community in recent years. We cannot guarantee that claims relating to radio frequency emissions will not arise in the future or that the results of such studies will not be adverse to us.

If a connection between radio frequency emissions and possible negative health effects were established, our operations, costs, or revenues may be materially and adversely affected. We currently do not maintain any significant insurance with respect to these matters.

Most wireless companies, from [AT&T](#) to [Nokia](#) to [T Mobile](#) to [Verizon Wireless](#), have issued [similar warnings](#) to their shareholders. Why are shareholders being warned but not the people living near the equipment? These disclosures show that even corporations cannot assure safety.

Due to these evaluations and the published scientific evidence, cell phone manufacturers cannot insure against health damages from the radiofrequency radiation emitted by their products and networks. In fact, most insurance plans do not cover electromagnetic fields (EMF) and have very clear "electromagnetic field exclusions." In order for insurance companies to cover EMF, one often must purchase additional "[Pollution Liability](#)" or "Policy Enhancement" coverage.

According to CFC Underwriting LTD in London, the UK agent for Lloyd's:

The Electromagnetic Fields Exclusion (Exclusion 32) is a General Insurance Exclusion and is applied across the market as standard. The purpose of the exclusion is to exclude cover for illnesses caused by continuous long-term non-ionising radiation exposure i.e. through mobile phone usage.

Even [AT&T Mobile Insurance](#) excludes loss from "pollutants," and its policy defines "Pollutants" as "Any solid, liquid, gaseous, or thermal irritant or contaminant including smoke, vapor, soot, fumes, acid, alkalis, chemicals, artificially produced electric fields, magnetic field, electromagnetic field, sound waves, microwaves, and all artificially produced ionizing or non- ionizing radiation and waste" ([pg. 4](#)) [AT &T Mobile Insurance Policy, February 2014](#).

If insurance companies will not insure EMF, and if even telecommunications companies consider EMF as a "pollutant," how can governments allow such an environmental pollutant without also warning their citizens as companies do?



## **5G Will Increase RF Exposures to the Environment and 5G Antenna Beamforming Exposures Cannot Be Accurately Measured**

A 2019 European Parliament Report “[5G Deployment: State of Play in Europe, USA, and Asia](#)”<sup>57</sup> confirms increased exposure from the 5G/4G Densification, stating, “increased exposure may result not only from the use of much higher frequencies in 5G but also from the potential for the aggregation of different signals, their dynamic nature, and the complex interference effects that may result, especially in dense urban areas.” The report points out that it currently “is not possible to accurately simulate or measure 5G emissions in the real world,” stating,

[T]he 5G radio emission fields are quite different to those of previous generations because of their complex beamformed transmissions in both directions – from base station to handset and for the return. Although fields are highly focused by beams, they vary rapidly with time and movement and so are unpredictable, as the signal levels and patterns interact as a closed loop system. This has yet to be mapped reliably for real situations, outside the laboratory.

### **July 8, 2020 Letter from the EPA**

----- Forwarded message -----

From: **Veal, Lee**<Veal.Lee@epa.gov>

Date: Wed, Jul 8, 2020 at 11:32 AM

Subject: RE: Letter with specific Questions Related to the FDA review and to the EPA, CDC, NIOSH and FDA Jurisdiction on EMFs

To: Theodora Scarato <Theodora.Scarato@ehtrust.org>

Dear Director Scarato;

Thank you for sending us your questions and references regarding radiofrequency (RF) radiation. Up through the mid-1990s, EPA did study non-ionizing radiation. The Telecommunications Act of 1996 directs the Federal Communications Commission (FCC) to establish rules regarding RF exposure, while the U.S. Food and Drug Administration (FDA) sets standards for electronic devices that emit non-ionizing or ionizing radiation. EPA does not have a funded mandate for radiofrequency matters, nor do we have a

---

<sup>57</sup> BLACKMAN, C. and FORGE, S. (2019). *5G Deployment State of Play in Europe, USA and Asia*. [PDF] European Parliament's Committee on Industry, Research and Energy. Available at: [https://www.europarl.europa.eu/RegData/etudes/IDAN/2019/631060/IPOL\\_IDA\(2019\)631060\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/IDAN/2019/631060/IPOL_IDA(2019)631060_EN.pdf) [Accessed 24 Feb. 2020].



dedicated subject matter expert in radiofrequency exposure. The EPA defers to other agencies possessing a defined role regarding RF. Although your questions are outside our current area of responsibilities, we have provided a response to each one as you requested.

1. *What is your response to these scientists' statements regarding the FDA report and the call to retract it?*

EPA Response: The EPA does not have a funded mandate for radiofrequency matters, has not conducted a review of the FDA report you cited or the scientists' statements, and therefore has no response to it.

2. *To the FDA- What consultants were hired for the FDA review and report on cell phone radiation?*

EPA Response: This is not an EPA matter. Please refer this question to the FDA.

3. *What US agency has reviewed the research on cell phone radiation and brain damage? I ask this because the FDA only has looked at selected studies on cancer. If your agency has not, please simply state you have not.*

EPA Response: EPA's last review was in the 1984 document [Biological Effects of Radiofrequency Radiation \(EPA 600/8-83-026F\)](#). The EPA does not currently have a funded mandate for radiofrequency matters.

4. *What US agency has reviewed the research on damage to memory by cell phone radiation? If so, when and send a link to the review.*

EPA Response: EPA's last review was in the 1984 document [Biological Effects of Radiofrequency Radiation \(EPA 600/8-83-026F\)](#). The EPA does not currently have a funded mandate for radiofrequency matters.

5. *What US agency has reviewed the research on damage to trees from cell phone radiation? If so, when was it issued and send a link to the review.* [Note this study showing damage from long term](#)

[exposure to cell antennas.](#)

EPA Response: The EPA does not have a funded mandate for radiofrequency matters, and we are not aware of any EPA reviews that have been conducted on this topic. We do not know if any other US agencies have reviewed it.

6. *What US agency has reviewed the research on impacts to birds and bees? If so, when and send a link to the review. I will note the latest research showing [possible impacts to bees](#) from higher frequencies to be used in 5G.*

EPA Response: The EPA does not have a funded mandate for radiofrequency matters, and we are not aware of any EPA reviews that have been conducted on this topic. We do not know if any other US agencies have reviewed it.

7. *What is a safe level of radiofrequency radiation? I ask this because the FDA and FCC both state they do not need to test cell phones at body contact and it is proven that phones will create exposure that are higher than FCC limits when phones are tested in these positions.*

The Telecommunications Act of 1996 directs the FCC to establish rules regarding radiofrequency (RF) exposure. The U.S. Food and Drug Administration (FDA) sets standards for electronic devices that emit non-ionizing or ionizing radiation. The EPA defers to these regulatory authorities for the establishment of safe levels of radiofrequency radiation.

8. *The FDA and FCC have been provided with information and published data showing the fact that cell phones create cell phone radiation exposures that violate FCC limits. What agency has the job of ensuring accountability that the American public is not exposed to RF radiation that exceeds FCC limits. The FCC has test protocols that say body contact tests are not needed. The FDA refers to the FCC. Yet the fact is that cell phones exceed FCC limits when tested in body contact positions. Are the FCC limits legitimate? These FCC limits are being violated. Who is the responsible agency that will ensure Americans are protected? The FCC says their rules are not being violated as their rules allow for a space between the phone or device and the body? The FDA says there is a safety factor so there is no need for them to act (and will not state what the safety factor for a cell phone is) . YET government limits are being exceeded. Are agencies fine with limits being violated? If so please explain at what level of cell phone radiation a federal agency will step in? If so, which agency has jurisdiction? (March 12, 2019 [Publication on Om Gandhi's paper](#) on radiation emissions violating FCC limits 11 times and August 21, 2019 [Chicago Tribune cell phone testing data released](#))*

EPA Response: The Telecommunications Act of 1996 directs the FCC to establish rules regarding radiofrequency (RF) exposure. The U.S. Food and Drug Administration (FDA) sets standards for electronic devices that emit non-ionizing or ionizing radiation. The EPA does not have a funded mandate for radiofrequency matters, and the questions you raise are outside of EPA's areas of responsibilities and current expertise. Please refer this question to FCC and FDA.

9. *The National Toxicology Program states clear evidence of cancer was found and the FDA disputes this because it was just an animal study. However birds fly and nest on cell antennas mounted on towers, bees fly in front of antennas and family pets (dogs, cats) will sit directly on or near Wi-Fi routers and smart speakers despite the fact that the manuals state humans should be at a minimum of 20 cm from wireless devices (far more from antennas of towers). What about the impact to these animals? What is the US government doing to ensure safety for wildlife and family pets?*

EPA Response: The EPA does not have a funded mandate for radiofrequency matters, and the questions you raise are outside of EPA's area of responsibility and current expertise. We defer to FDA to provide a response regarding their findings.

10. *Please send me the staff member of your respective agency who is on the Interagency Radiofrequency Workgroup as I have repeatedly tried to get this information and it is never provided to me.*

EPA Response: The Radiofrequency Interagency Work Group (RFIAWG) is an informal forum for exchange of information and the group does not meet to set, or advise on, policy, rulemaking or guidance. The group has not met in more than two years.

11. *The FDA only reviewed selected studies on cancer until 2018. Most recently, the American Cancer Society funded radiation in people with genetic susceptibilities. The National Toxicology Program published [research](#) showing DNA damage. Will the FDA be updating its review with these studies? If not, then what agency is accountable to American public to ensure humans are not harmed?*



EPA Response: The questions you raise are outside of EPA's areas of responsibilities and current expertise. Please direct questions about FDA activities to FDA.

12. *What agency ensures safety related to extremely low frequency (ELF-EMF) electromagnetic fields- also non ionizing? Currently we have no federal limit, no federal guidelines and confirmed associations with cancer and many other health effects. Kaiser Permanente researchers have published several studies linking pregnant women's exposure to magnetic field electromagnetic fields to not only increased [miscarriage](#) and but also increased [ADHD](#), [obesity](#) and [asthma](#) in the woman's prenatally exposed children. A recent [large scale study](#) again found associations with cancer. Please clarify which US agency has jurisdiction over ELF-EMF exposures?*

EPA Response: There are no U.S. Federal standards limiting residential or occupational exposure to electric and magnetic fields (EMF) from power lines. The EPA does not have a funded mandate for radiofrequency matters.

13. When it comes to cell phone radiation SAR thresholds, what is your understanding of the "safety factor" in place?

EPA Response: EPA last commented on FCC proposals for SAR limits in the 1996 [FCC 96-236](#). The Telecommunications Act of 1996 directs the FCC to establish rules regarding radiofrequency (RF) exposure. The U.S. Food and Drug Administration (FDA) sets standards for electronic devices that emit non-ionizing or ionizing radiation. The EPA defers to these regulatory authorities for the establishment of safe levels of radiofrequency radiation.

Sincere regards,

Lee Ann B. Veal

Director, Radiation Protection Division

Office of Radiation and Indoor Air

[www.epa.gov/radiation](http://www.epa.gov/radiation)

---

## Key Research Studies on EMF impacts to Flora and Fauna

- A. Lázaro, A. Chroni, T. Tscheulin, J. Devalez, C. Matsoukas, & T. Petanidou. (2016). [Electromagnetic radiation of mobile telecommunication antennas affects the abundance and composition of wild pollinators](https://doi.org/10.1007/s10841-016-9868-8). *Journal of Insect Conservation*, 20(2), 315–324. <https://doi.org/10.1007/s10841-016-9868-8>
- Adelaja, O. J., Ande, A. T., Abdulraheem, G. D., Oluwakorode, I. A., Oladipo, O. A., & Oluwajobi, A. O. (2021). [Distribution, diversity and abundance of some insects around a telecommunication mast in Ilorin, Kwara State, Nigeria](#). *Bulletin of the National Research Centre*, 45(1), 222.
- Balmori, A. (2006). [The incidence of electromagnetic pollution on the amphibian decline: Is this an important piece of the puzzle?](#) *Toxicological & Environmental Chemistry*, 88(2), 287–299.
- Balmori A. (2010). [Mobile phone mast effects on common frog \(Rana temporaria\) tadpoles: the city turned into a laboratory](#). *Electromagn Biol Med*. Jun;29 (1-2): 31-5.
- Balmori, A. (2015). [Anthropogenic radiofrequency electromagnetic fields as an emerging threat to wildlife orientation](#). *Science of The Total Environment*, 518–519, 58–60.
- Balmori A. (2014). [Electrosmog and species conservation](#). *Science of The Total Environment*, 496:314-316
- Balmori A. (2022). [Corneal opacity in Northern Bald Ibises \(Geronticus eremita\) equipped with radio transmitters](#). *Electromagnetic Biol Med*.174-176.
- Balmori A. (2021) [Electromagnetic radiation as an emerging driver factor for the decline of insects](#). *Science of the Total Environment*. 767: 144913
- Borre, E. D., Joseph, W., Aminzadeh, R., Müller, P., Boone, M. N., Josipovic, I., Hashemizadeh, S., Kuster, N., Kühn, S., & Thielens, A. (2021). [Radio-frequency exposure of the yellow fever mosquito \(A. aegypti\) from 2 to 240 GHz](#). *PLOS Computational Biology*, 17(10), e1009460.
- Cucurachi, S., Tamis, W. L. M., Vijver, M. G., Peijnenburg, W. J. G. M., Bolte, J. F. B., & de Snoo, G. R. (2013). [A review of the ecological effects of radiofrequency electromagnetic fields \(RF-EMF\)](#). *Environment International*, 51, 116–140.
- Favre, D. (2011). [Mobile phone-induced honeybee worker piping](#). *Apidologie*, 42(3), 270–279.
- Fedele, G., Edwards, M. D., Bhutani, S., Hares, J. M., Murbach, M., Green, E. W., Dissel, S., Hastings, M. H., Rosato, E., & Kyriacou, C. P. (2014). [Genetic analysis of circadian responses to](#)

[low frequency electromagnetic fields in \*Drosophila melanogaster\*](#). *PLoS Genetics*, 10(12), e1004804.

Fernie, K. J., & Reynolds, S. J. (2005). [The effects of electromagnetic fields from power lines on avian reproductive biology and physiology: A review](#). *Journal of Toxicology and Environmental Health. Part B, Critical Reviews*, 8(2), 127–140.

Halgamuge, M. N. (2017). [Review: Weak radiofrequency radiation exposure from mobile phone radiation on plants](#). *Electromagnetic Biology and Medicine*, 36(2), 213–235.

Halgamuge, M. N., Yak, S. K., & Eberhardt, J. L. (2015). [Reduced growth of soybean seedlings after exposure to weak microwave radiation from GSM 900 mobile phone and base station](#). *Bioelectromagnetics*, 36(2), 87–95.

Haggerty, K. (2010). [Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings: Preliminary Observations](#). *International Journal of Forestry Research*, 836278.

Hutchison, Z. L., Gill, A. B., Sigray, P., He, H., & King, J. W. (2020). [Anthropogenic electromagnetic fields \(EMF\) influence the behaviour of bottom-dwelling marine species](#). *Scientific Reports*, 10(1), 4219.

Kaur, S., Vian, A., Chandel, S., Singh, D. H., Batish, D., & Kohli, R. (2021). [Sensitivity of plants to high frequency electromagnetic radiation: Cellular mechanisms and morphological changes](#). *Reviews in Environmental Science and Bio/Technology*, 20.

Lee, K.-S., Choi, J.-S., Hong, S.-Y., Son, T.-H., & Yu, K. (2008). [Mobile phone electromagnetic radiation activates MAPK signaling and regulates viability in \*Drosophila\*](#). *Bioelectromagnetics*, 29(5), 371–379.

Levitt BB, Lai HC and Manville AM II (2022) [Low-level EMF effects on wildlife and plants: What research tells us about an ecosystem approach](#). *Front. Public Health* 10:1000840. doi: 10.3389/fpubh.2022.1000840

Levitt, B. B., Lai, H. C., & Manville, A. M. (2021). [Effects of non-ionizing electromagnetic fields on flora and fauna, Part 3. Exposure standards, public policy, laws, and future directions](#). *Reviews on Environmental Health*.

Levitt, B. B., Lai, H. C., & Manville, A. M. (2022a). [Effects of non-ionizing electromagnetic fields on flora and fauna, part 1. Rising ambient EMF levels in the environment](#). *Reviews on Environmental Health*, 37(1), 81–122.

Levitt, B. B., Lai, H. C., & Manville, A. M. (2022b). [Effects of non-ionizing electromagnetic fields on flora and fauna, Part 2 impacts: How species interact with natural and man-made EMF](#). *Reviews on Environmental Health*, 37(3), 327–406.

Li, S.-S., Zhang, Z.-Y., Yang, C.-J., Lian, H.-Y., & Cai, P. (2013). [Gene expression and reproductive abilities of male \*Drosophila melanogaster\* subjected to ELF-EMF exposure](#). *Mutation Research. Genetic Toxicology and Environmental Mutagenesis*, 758(1–2), 95–103.



- Lopatina, N. G., Zachepilo, T. G., Kamyshev, N. G., Dyuzhikova, N. A., & Serov, I. N. (2019). [Effect of Non-Ionizing Electromagnetic Radiation on Behavior of the Honeybee, \*Apis mellifera\* L. \(Hymenoptera, Apidae\)](#). *Entomological Review*, 99(1), 24–29.
- Lupi, D., Palamara Mesiano, M., Adani, A., Benocci, R., Giacchini, R., Parenti, P., Zambon, G., Lavazza, A., Boniotti, M. B., Bassi, S., Colombo, M., & Tremolada, P. (2021a). [Combined Effects of Pesticides and Electromagnetic-Fields on Honeybees: Multi-Stress Exposure](#). *Insects*, 12(8), 716.
- Manta, A. K., Papadopoulou, D., Polyzos, A. P., Fragopoulou, A. F., Skouroliahou, A. S., Thanos, D., Stravopodis, D. J., & Margaritis, L. H. (2017). [Mobile-phone radiation-induced perturbation of gene-expression profiling, redox equilibrium and sporadic-apoptosis control in the ovary of \*Drosophila melanogaster\*](#). *Fly*, 11(2), 75–95.
- Mahmoud EA and Gabarty A (2021) "[Impact of Electromagnetic Radiation on Honey Stomach Ultrastructure and the Body Chemical Element Composition of \*Apis mellifera\*](#)." *African Entomology* 29(1), 32-41, (23 March).
- Molina-Montenegro MA, Acuña-Rodríguez IS, Ballesteros GI, Baldelomar M, Torres-Díaz C, Broitman BR, Vázquez DP. (2023) [Electromagnetic fields disrupt the pollination service by honeybees](#). *Sci Adv*. May 12;9(19)
- Migdał, P., Berbeć, E., Bieńkowski, P., Plotnik, M., Murawska, A., & Latarowski, K. (2022b). [Exposure to Magnetic Fields Changes the Behavioral Pattern in Honeybees \(\*Apis mellifera\* L.\) under Laboratory Conditions](#). *Animals: An Open Access Journal from MDPI*, 12(7), 855.
- Odemer, R., & Odemer, F. (2019). [Effects of radiofrequency electromagnetic radiation \(RF-EMF\) on honey bee queen development and mating success](#). *Science of The Total Environment*, 661, 553–562.
- Santhosh Kumar, S. (2018). [Colony Collapse Disorder \(CCD\) in Honey Bees Caused by EMF Radiation](#). *Bioinformation*, 14(9), 421–424.
- Schwarze, S., Schneider, N.-L., Reichl, T., Dreyer, D., Lefeldt, N., Engels, S., Baker, N., Hore, P. J., & Mouritsen, H. (2016). [Weak Broadband Electromagnetic Fields are More Disruptive to Magnetic Compass Orientation in a Night-Migratory Songbird \(\*Erithacus rubecula\*\) than Strong Narrow-Band Fields](#). *Frontiers in Behavioral Neuroscience*, 10.
- Scott, K., Harsanyi, P., Easton, B. A. A., Piper, A. J. R., Rochas, C. M. V., & Lyndon, A. R. (2021). [Exposure to Electromagnetic Fields \(EMF\) from Submarine Power Cables Can Trigger Strength-Dependent Behavioural and Physiological Responses in Edible Crab, \*Cancer pagurus\* \(L.\)](#). *Journal of Marine Science and Engineering*, 9(7), Article 7.
- Soran, M.-L., Stan, M., Niinemets, Ü., & Copolovici, L. (2014). [Influence of microwave frequency electromagnetic radiation on terpene emission and content in aromatic plants](#). *Journal of Plant Physiology*, 171(15), 1436–1443.

Stefi, A. L., Margaritis, L. H., & Christodoulakis, N. S. (2016). [The effect of the non ionizing radiation on cultivated plants of \*Arabidopsis thaliana\* \(Col.\)](#). *Flora*, 223, 114–120.

Thielens, A., Bell, D., Mortimore, D. B., Greco, M. K., Martens, L., & Joseph, W. (2018). [Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz](#). *Scientific Reports*, 8(1), 3924.

Thielens A, Greco MK, Verloock L, Martens L, Joseph W. [Radio-Frequency Electromagnetic Field Exposure of Western Honey Bees](#). *Scientific Reports*. 2020 Jan 16;10(1):461.

Tonelli, B. A., Youngflesh, C., & Tingley, M. W. (2023). [Geomagnetic disturbance associated with increased vagrancy in migratory landbirds](#). *Scientific Reports*, 13(1), Article 1.

Waldmann-Selsam, C., Balmori-de la Puente, A., Breunig, H., & Balmori, A. (2016). [Radiofrequency radiation injures trees around mobile phone base stations](#). *Science of The Total Environment*, 572, 554–569.

Wang, Y., Jiang, Z., Zhang, L., Zhang, Z., Liao, Y., & Cai, P. (2022b). [3.5-GHz radiofrequency electromagnetic radiation promotes the development of \*Drosophila melanogaster\*](#). *Environmental Pollution (Barking, Essex: 1987)*, 294, 118646.

Wang, Y., Zhang, H., Zhang, Z., Sun, B., Tang, C., Zhang, L., Jiang, Z., Ding, B., Liao, Y., & Cai, P. (2021). [Simulated mobile communication frequencies \(3.5 GHz\) emitted by a signal generator affects the sleep of \*Drosophila melanogaster\*](#). *Environmental Pollution (Barking, Essex: 1987)*, 283, 117087.

Wiltshko, R., Thalau, P., Gehring, D., Nießner, C., Ritz, T., & Wiltshko, W. (2015). [Magnetoreception in birds: The effect of radio-frequency fields](#). *Journal of The Royal Society Interface*, 12(103), 20141103.

Zhong, Z., Wang, X., Yin, X., Tian, J., & Komatsu, S. (2021). [Morphophysiological and Proteomic Responses on Plants of Irradiation with Electromagnetic Waves](#). *International Journal of Molecular Sciences*, 22(22), Article 22.