Supplemental File S1

For the article **"World Scientists' Warning to Humanity: A Second Notice"** published in BioScience in 2017 by William J. Ripple, Christopher Wolf, Mauro Galetti, Thomas M Newsome, Mohammed Alamgir, Eileen Crist, Mahmoud I. Mahmoud, William F. Laurance

and **15,364 signatories** from **184 countries** (see supplemental File S2)

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Descriptions of variables and trends in Figure 1.

Ozone depletion, Figure 1a. During the 1970s, human-produced chemicals known as ozone-depleting substances, mainly chlorofluorocarbons, were rapidly depleting the ozone layer. In 1987, governments of the world came together and crafted the United Nations Montreal Protocol as a global attempt to address this issue. With protocol compliance, emissions of halogen source gases (ozone-depleting substances and natural sources) peaked in the late 1980s and since then they have significantly decreased (Figure 1a). Global ozone depletion is no longer increasing, and significant recovery of the ozone layer is expected to occur by the middle of this century (Hegglin et al. 2014).

Declining Freshwater availability, Figure 1b. Per capita freshwater availability is less than half of levels of the early 1960s (Figure 1b, AQUASTAT 2017) with many people around the world suffering from a lack of fresh clean water. This decrease in available water is nearly all due to the accelerated pace of human population growth. It is likely that climate change will have an overwhelming impact on the freshwater availability through alteration of the hydrologic cycle and water availability. Future water shortages will be detrimental to humans, affecting everything from drinking water, human health, sanitation, and the production of crops for food.

Unsustainable marine fisheries, Figure 1c. In 1992, the total marine catch was at or above the maximum sustainable yield and fisheries were on the verge of collapse. Reconstructed time series data show that global marine fisheries catches peaked at 130 million tonnes in 1996 and has been declining ever since (Figure 1c). The declines happened despite increased industrial fishing efforts and despite developed countries expanding to fishing the waters of developing countries (Pauly and Zeller 2016, updated).

Ocean dead zones, Figure 1d. Coastal dead zones which are mainly caused by fertilizer runoff and fossil-fuel use, are killing large swaths of marine life. Dead zones with hypoxic, oxygen-depleted waters, are a significant stressor on marine systems and identified locations have dramatically increased since the 1960s, with more than 600 systems affected by 2010 (Figure 1d, Diaz and Rosenberg 2008, updated).

Forest loss, Figure 1e. The world's forests are crucial for conserving carbon, biodiversity, and freshwater. Between 1990 and 2015, total forest area decreased from 4,128 to 3,999 million ha, a net loss of 129 million ha which is approximately the size of South Africa (Figure 1e). Forest loss has been greatest in developing tropical countries where forests are now commonly converted to agriculture uses (FAO 2015).

Dwindling biodiversity, Figure 1f. The world's biodiversity is vanishing at an alarming rate and populations of vertebrate species are rapidly collapsing (World Wildlife Fund 2016). Collectively, global fish, amphibians, reptiles, birds, and mammals declined by 58% between 1970 and 2012 (Figure 1f). Here, we display a diversity-weighted Living Planet Index that has been adjusted for taxonomic and geographic bias by accounting for the estimated number of species within biogeographical regions, and the relative species diversity within them. (McRae et al. 2017). Freshwater, marine, and terrestrial populations declined by 81%, 36%, and 35% respectively (McRae et al. 2017).

Climate change, Figure 1g, Figure 1h. Global fossil-fuel carbon dioxide emissions have increased sharply since 1960 (Figure 1g, Boden et al. 2017). Relative to the 1951-1980 average, global average annual surface temperature, in parallel to CO_2 emissions, has also rapidly risen as shown by 5-year mean temperature anomaly (Figure 1h, NASA's Goddard Institute for Space Studies (GISS) 2017). The 10 warmest years in the 136-year record have occurred since 1998. The most recent year of data, 2016, ranks as the warmest on record. Temperature increases will likely cause a decline in the world's major food crops, an increase in the intensity of major storms, and a substantial sea level rise inundating major population centers.

Population growth, Figure 1i. Since 1992, the human population has increased by approximately 2 billion individuals, a 35% change (Figure 1i, FAOSTAT 2017). The world human population is unlikely to stop growing this century and there is a high likelihood that the world population will grow from 7.2 billon people now to between 9.6 and 12.3 billon by 2100 (Gerland et al. 2014). Like the change in human population, the domestic ruminant population, which has its own set of major environmental and climate impacts, has been increasing in recent decades to approximately 4 billion individuals on Earth (Figure 1i, FAOSTAT 2017).

Note that the loss of soil productivity was listed as a concern in the 1992 scientists' warning, but this variable was not analyzed here due to a lack of global data on changes in soil productivity. For each variable listed below, we calculated percentage change since 1992 using the values for 1992 and the most recent year available. When data were unavailable for 1992, we used linear interpolation to estimate the value there. These change results are in the caption for Figure 1. See original data sources shown above for any statements on levels of uncertainty associated with the varibles in Figure 1. Some sources describe this uncertainty and others do not.

References for figure 1

Figure 1a, Hegglin, M. I., D. W. Fahey, M. McFarland, S. A. Montzka, and E. R. Nash. 2015. Twenty questions and answers about the ozone layer: 2014 Update: Scientific assessment of ozone depletion: 2014. World Meteorological Organization, Geneva, Switzerland.

Figure 1b, AQUASTAT. 2017. AQUASTAT - FAO's Information System on Water and Agriculture. http://www.fao.org/nr/aquastat/.

Figure 1c, Pauly, D., and D. Zeller. 2016. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. Updated. Nature Communications 7:10244.

Figure 1d, Diaz, R. J., and R. Rosenberg. 2008. Spreading Dead Zones and Consequences for Marine Ecosystems. Updated. Science 321:926–929.

Figure 1e, Food and Agriculture Organization of the United Nations. 2015. Global forest resources assessment 2015. http://www.fao.org/forest-resources-assessment/en/.

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Figure 1h, NASA's Goddard Institute for Space Studies (GISS). 2017. Global Temperature. https://climate.nasa.gov/.

Figure 1i, FAOSTAT. 2017. FAOSTAT Database on Agriculture. http://faostat.fao.org/.

World Scientists' Warning to Humanity (1992)

UNION OF CONCERNED SCIENTISTS
World Scientists' Warning to Humanity

Union of Concerned Scientists

This 1992 document was signed by 1,575 of the world's most prominent scientists (including 99 of the 196 living Nobel laureates) and was sent to governmental leaders all over the world. The document asks people to take immediate action to stop the ever-increasing environmental degradation that threatens global life support systems on this planet. The appeal was coordinated by Dr. Henry Kendall, Nobel laureate (1990, Physics), and former Chairperson of the Union of Concerned Scientists.

"World Scientists' Warning to Humanity"

Introduction
Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources. If not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life in the manner that we know. Fundamental changes are urgent if we are to avoid the collision our present course will bring about.

The Environment
The environment is suffering critical stress:

The Atmosphere
Stratospheric ozone depletion threatens us with enhanced ultra-violet radiation at the earth's surface, which can be damaging or lethal to many life forms. Air pollution near ground level, and acid precipitation, are already causing widespread injury to humans, forests, and crops.

Water Resources
Heedless exploitation of depletable ground water supplies endangers food production and other essential human systems. Heavy demands on the world's surface waters have resulted in serious shortages in some 80 countries, containing 40% of the world's population. Pollution of rivers, lakes, and ground water further limits the supply.

Oceans
Destructive pressure on the oceans is severe, particularly in the coastal regions which produce most of the world's food fish. The total marine catch is now at or above the estimated maximum sustainable yield. Some fisheries have already shown signs of collapse. Rivers carrying heavy burdens of eroded soil into the seas also carry industrial, municipal, agricultural, and livestock waste—some of it toxic.

Soil
Loss of soil productivity, which is causing extensive land abandonment, is a widespread byproduct of current practices in agriculture and animal husbandry. Since 1945, 11% of the earth's vegetated surface has been degraded—an area larger than India and China combined—and per capita food production in many parts of the world is decreasing.

Forests
Tropical rain forests, as well as tropical and temperate dry forests, are being destroyed rapidly. At present rates, some critical forest types will be gone in a few years, and most of the tropical rain forest will be gone before the end of the next century. With them will go large numbers of plant and animal species.

Living Species
The irreversible loss of species, which by 2100 may reach one third of all species now living, is especially serious. We are losing the potential they hold for providing medicinal and other benefits, and the contribution that genetic diversity of life forms gives to the robustness of the world's biological systems and to the astonishing beauty of the earth itself.

Much of this damage is irreversible on a scale of centuries or permanent. Other processes appear to pose additional threats. Increasing levels of gases in the atmosphere from human activities, including carbon dioxide released from fossil fuel burning and from deforestation, may alter climate on a global scale. Predictions of global warming are still uncertain—with projected effects ranging from tolerable to very severe—but potential risks are very great.

Our massive tampering with the world's interdependent web of life—coupled with the environmental damage inflicted by deforestation, species loss, and climate change—could trigger widespread adverse effects, including unpredictable collapses of critical biological systems whose interactions and dynamics we only imperfectly understand.

Uncertainty over the extent of these effects cannot excuse complacency or delay in facing the threats.

Population
The earth is finite. Its ability to absorb wastes and destructive effluent is finite. Its ability to provide food and energy is finite. Its ability to provide for growing numbers of people is finite. And we are fast approaching many of the earth's limits. Current economic practices which damage the environment, in both developed and underdeveloped nations, cannot be continued without the risk that vital global systems will be damaged beyond repair.
Pressures resulting from unrestrained population growth put demands on the natural world that can overwhelm any efforts to achieve a sustainable future. If we are to halt the destruction of our environment, we must accept limits to that growth. A World Bank estimate indicates that world population will not stabilize at less than 12.4 billion, while the United Nations concludes that the eventual total could reach 14 billion, a near tripling of today's 5.4 billion. But, even at this moment, one person in five lives in absolute poverty without enough to eat, and one in ten suffers serious malnutrition.

No more than one or a few decades remain before the chance to avert the threats we now confront will be lost and the prospects for humanity immeasurably diminished.

Warning
We the undersigned, senior members of the world's scientific community, hereby warn all humanity of what lies ahead. A great change in our stewardship of the earth and the life on it, is required, if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated.

What We Must Do
Five inextricably linked areas must be addressed simultaneously:

1. **We must bring environmentally damaging activities under control to restore and protect the integrity of the earth's systems we depend on.**

We must, for example, move away from fossil fuels to more benign, inexhaustible energy sources to cut greenhouse gas emissions and the pollution of our air and water. Priority must be given to the development of energy sources matched to third world needs—small scale and relatively easy to implement.

We must halt deforestation, injury to and loss of agricultural land, and the loss of terrestrial and marine plant and animal species.

2. **We must manage resources crucial to human welfare more effectively.**
   We must give high priority to efficient use of energy, water, and other materials, including expansion of conservation and recycling.

3. **We must stabilize population. This will be possible only if all nations recognize that it requires improved social and economic conditions, and the adoption of effective, voluntary family planning.**

4. **We must reduce and eventually eliminate poverty.**

5. **We must ensure sexual equality, and guarantee women control over their own reproductive decisions.**

The developed nations are the largest polluters in the world today. They must greatly reduce their overconsumption, if we are to reduce pressures on resources and the global environment. The developed nations have the obligation to provide aid and support to developing nations, because only the developed nations have the financial resources and the technical skills for these tasks.

Acting on this recognition is not altruism, but enlightened self-interest: whether industrialized or not, we all have but one lifeboat. No nation can escape from injury when global biological systems are damaged. No nation can escape from conflicts over increasingly scarce resources. In addition, environmental and economic instabilities will cause mass migrations with incalculable consequences for developed and undeveloped nations alike.

Developing nations must realize that environmental damage is one of the gravest threats they face, and that attempts to blunt it will be overwhelmed if their populations go unchecked. The greatest peril is to become trapped in spirals of environmental decline, poverty, and unrest, leading to social, economic, and environmental collapse.

Success in this global endeavor will require a great reduction in violence and war. Resources now devoted to the preparation and conduct of war—amounting to over $1 trillion annually—will be badly needed in the new tasks and should be diverted to the new challenges.

A new ethic is required—a new attitude toward discharging our responsibility for caring for ourselves and for the earth. We must recognize the earth's limited capacity to provide for us. We must recognize its fragility. We must no longer allow it to be ravaged. This ethic must motivate a great movement, convincing reluctant leaders and reluctant governments and reluctant peoples themselves to effect the needed changes.

The scientists issuing this warning hope that our message will reach and affect people everywhere. We need the help of many.

We require the help of the world community of scientists—natural, social, economic, political;
We require the help of the world's business and industrial leaders;
We require the help of the world's religious leaders; and
We require the help of the world's peoples.
We call on all to join us in this task.

Spanish versión translated by Emilio de las Heras

Advertencia de la Comunidad Científica Mundial a la Humanidad: Segundo Aviso

William J. Ripple, Christopher Wolf, Mauro Galetti, Thomas M Newsome, Mohammed Alamgir, Eileen Crist, Mahmoud I. Mahmoud, William F. Laurance

y 15,364 co-signatarios de 184 países (la lista completa de co-signatarios puede consultarse en los materiales suplementarios.)

Hace 25 años, la asociación norteamericana Union of Concerned Scientists y más de 1500 científicos independientes, incluyendo la mayoría de los Premios Nobel en Ciencias que vivían entonces, escribieron "La Advertencia de los Científicos del Mundo a la Humanidad", 1992 (ver material suplementario en la versión en Inglés). Estos profesionales preocupados, reclamaron a la humanidad que frenase la destrucción ambiental y avisaron de "sería necesario un gran cambio en nuestra forma de cuidar la Tierra y la vida sobre ella, si quería evitarse una enorme miseria humana...". En su manifiesto, mostraban que los seres humanos estaban en rumbo de colisión con el mundo natural. Expresaron preocupación acerca de daños actuales, inminentes y potenciales sobre el planeta Tierra por: La destrucción de la capa de ozono, la disponibilidad de agua dulce, el colapso de la pesca marina, el incremento de zonas muertas en los océanos, la pérdida de masa forestal, la destrucción de biodiversidad, el cambio climático y el crecimiento continuado de la población. Proclamaron que cambios fundamentales eran urgentes y necesarios para evitar las consecuencias que nuestro actual rumbo podrían acarrearnos.

Los autores de la declaración de 1992 temían que la humanidad estaba empujando a los ecosistemas de la Tierra más allá de su capacidad de soportar la red de la vida. Describieron cuán rápido nos estábamos aproximando a muchos de los límites de lo que el planeta puede tolerar sin daños serios e irreversibles. Los científicos alegaron que deberíamos estabilizar la población, describiendo como la enorme cifra - que ha crecido en 2000 millones desde 1992, un incremento del 35% - ejerce una presión sobre la Tierra que puede aplastar otros esfuerzos para conseguir un futuro sostenible (Crist et al. 2017). Imploraron que redujéramos las emisiones de gases efecto invernadero (en adelante, GEI) y eliminásemos los combustibles fósiles, redujéramos la deforestación y revirtiéramos la tendencia de extinción de la biodiversidad.

En el 25º aniversario de su llamada de atención, miramos hacia atrás a su alarma y evaluamos la respuesta humana, analizando la evolución en el tiempo de los indicadores disponibles. Desde 1992, con la excepción de que se ha estabilizado la capa de ozono, la humanidad ha fracasado en hacer suficientes progresos para resolver esos retos ambientales previstos y, de manera muy alarmante, en la mayoría de ellos, estamos mucho peor que entonces (figura 1, tabla suplementaria S1). Especialmente preocupante es la trayectoria actual del catastrófico cambio climático de origen humano debido a las crecientes emisiones de GEI procedentes de la quema de combustibles fósiles (Hansen et al. 2013), la deforestación (Keenan et al. 2015) y la producción agrícola - principalmente por la ganadería de rumiantes y el consumo de carne (Ripple

et al. 2014). Además, hemos desatado un evento de extinción masiva de especies, la sexta en unos 540 millones de años, mediante la cual muchos de las actuales formas de vida podrían ser aniquiladas o, como poco, comprometidas a la extinción hacia el final de este siglo.

Por la presente, damos un Segundo Aviso a la Humanidad, ilustrado por la alarmante tendencia de variables mostradas en la figura 1. Estamos poniendo en peligro nuestro futuro por nuestro desproporcionado consumo material y por no darnos cuenta de que el alocado crecimiento de la población mundial es el principal impulsor detrás de la mayoría de amenazas ecológicas e, incluso, societales (Crist et al. 2017). Con su fracaso en limitar adecuadamente el crecimiento de la población, en reevaluar el papel de una economía enraizada en el crecimiento permanente, en reducir la emisión de GEI, en incentivar la energía renovable, en proteger el hábitat, en restaurar los ecosistemas, en parar la extinción de fauna, en frenar las especies invasivas, la humanidad no está tomando los pasos urgentes que necesitamos para salvaguardar nuestra muy amenazada biosfera.

Puesto que la mayoría de líderes políticos responde a la presión, los científicos, los medios de comunicación y los ciudadanos deben insistir en que sus gobiernos pasen a la acción inmediata, como un imperativo moral hacia las actuales y futuras generaciones, humanas y de otras formas de vida. Con una marejada de esfuerzos desde organizaciones surgidas desde el pueblo, la obstinada oposición puede ser superada y los líderes políticos se verán obligados a hacer lo correcto. Es también el momento de re-examinar y modificar nuestros comportamientos individuales, incluyendo nuestra propia reproducción (idealmente, al nivel de reemplazo, 2 hijos por mujer, como máximo) y reducir drásticamente nuestro nivel de consumo per-cápita de combustibles fósiles, carne y otros recursos.

La rápida reducción mundial de las sustancias que destruían la capa de ozono nos muestra que podemos hacer cambios positivos cuando actuamos de manera decidida. También hemos hecho avances importantes para reducir la pobreza extrema y el hambre (www.worldbank.org). Otros progresos notables (no incluidos en la figura 1) incluyen: rápida reducción de las tasas de fertilidad en muchas regiones mediante políticas educativas entre mujeres y jóvenes (www.un.org/esa/population), la prometedora reducción de la tasa de deforestación en algunas regiones y el rápido despliegue de energías renovables. Hemos aprendido mucho desde 1992, pero el progreso de los cambios necesarios y urgentes en políticas ambientales, comportamiento humano y reducción de las inequidades globales está, todavía, lejos de ser suficiente.

Las transiciones hacia la sostenibilidad se pueden producir de diferentes maneras, pero todas requieren presión de la sociedad civil y argumentaciones basadas en evidencias, liderazgo político, políticas adecuadas, mercados y otras consideraciones. Ejemplos de acciones diferentes y efectivas que la humanidad puede tomar para la transición a la sostenibilidad incluyen (sin presumir orden de importancia o urgencia):

- Priorizando a la promulgación de grandes reservas protegidas de una proporción significativa de los hábitats terrestres, marinos, de agua dulce y aéreos de todo el mundo;

- Mantenimiento de los servicios ecosistémicos de la naturaleza parando la conversión de selvas, bosques, pastizales y otros hábitats naturales;

- Restaurar comunidades con plantas autóctonas a gran escala, principalmente, bosques;

- Devolver a la naturaleza salvaje zonas con especies nativas, especialmente con depredadores ápice, para recuperar procesos y dinámicas ecológicos;

- Implementar políticas adecuadas para remediar la extinción de especies animales, la caza furtiva y la explotación y comercio de especies amenazadas;

- Reducir el desperdicio de alimentos mediante educación y mejores infraestructuras;

- Promover un cambio hacia dietas más vegetales y menos animales;

- Promover la reducción adicional de los índices de fertilidad procurando que mujeres y hombres tengan acceso a la educación reproductiva y a los servicios voluntarios de planificación familiar, especialmente, en lugares donde falten tales recursos;

- Aumentar la educación ambiental para niños y fomentar un mayor aprecio por la naturaleza por parte de la sociedad.

- Desinvertir en inversiones monetarias e invertir en iniciativas que promuevan cambio ambiental

- Idear y promover tecnologías no contaminantes y adoptar masivamente energías renovables y, simultéaneamente, eliminar subvenciones a la producción de energía con combustibles fósiles.

- Revisar nuestra economía para reducir desigualdades y asegurarse que precios, impuestos y sistemas de incentivos tengan en cuenta los costes reales que nuestro patrón de consumo imponen en nuestro medio ambiente; y

- Evaluar de manera científica el tamaño de población humana sostenible a largo plazo y pedir a las naciones y a sus líderes que apoyen ese objetivo vital.

Para prevenir pérdidas catastróficas de biodiversidad y un deterioro generalizado de las condiciones de vida humana, la humanidad debe poner en práctica una forma de vida más sostenible ambientalmente que la actual (“business as usual”). Esta receta ya fue bien articulada hace 25 años por los científicos del mundo, pero en la mayoría de los temas, no hemos escuchado su llamada de atención. Pronto será demasiado tarde para cambiar el rumbo de la actual trayectoria que nos lleva al fracaso y nos estamos quedando sin tiempo. Debemos reconocer, en nuestras vidas diarias y en nuestras instituciones de gobierno, que la Tierra con toda su vida es nuestro único hogar.

Reconocimientos

Peter Frumhoff y Doug Boucher, de la Union of Concerned Scientists, así como las siguientes personas, han planteado profundas discusiones, comentarios y datos para este documento: Stuart Pimm, David Johns, David Pengelley, Guillaume Chapron, Steve Montzka, Robert Diaz, Drik Zeller, Gary Gibson, Leslie Green, Nick Houtman, Peter Stoel, Karen Josephson, Robin Comforto, Terralyn Vandetta, Luke Painter, Rodolfo Dirzo, Guy Peer, Peter Haswell, and Robert Johnson.

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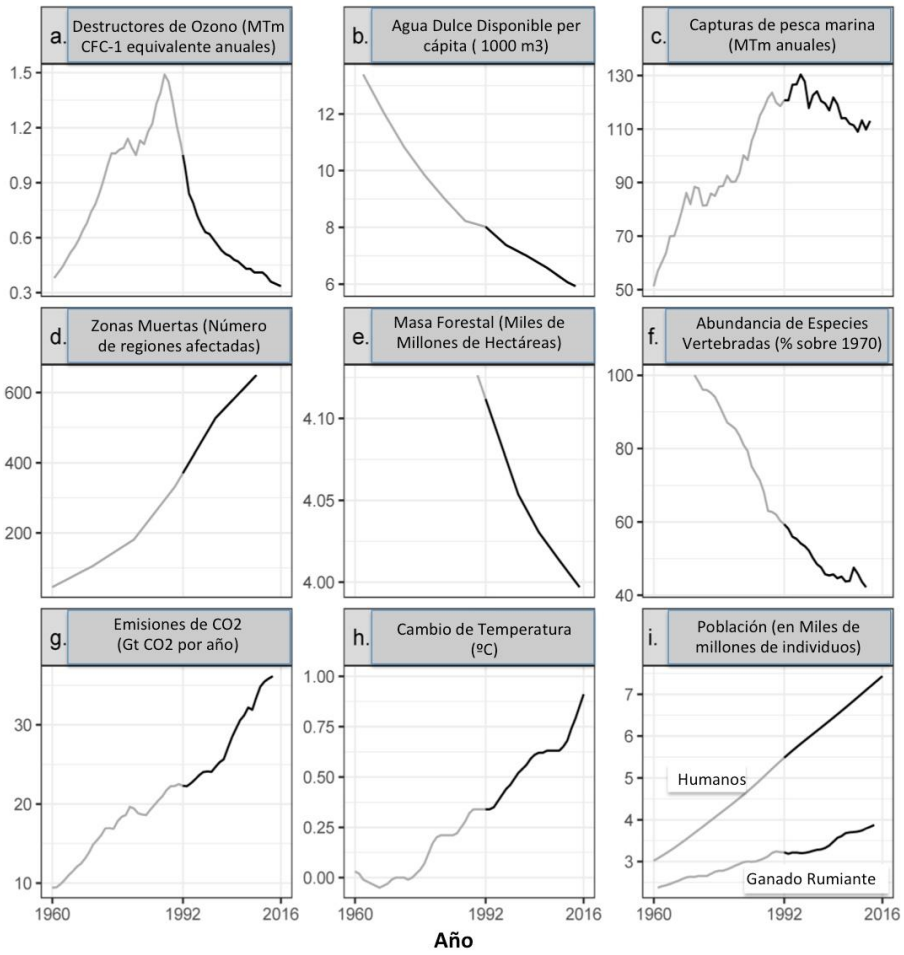

Figura 1. Tendencia a lo largo del tiempo de las variables ambientales identificadas en la Advertencia de 1992 de la Comunidad Científica a la Humanidad. Los años anteriores a la Advertencia de 1992 se muestran mediante una línea gris y los posteriores mediante una línea negra. (a) Muestra las emisiones globales de gases halógenos, que destruyen la capa de ozono de la estratosfera, suponiendo que los niveles naturales de emisión son constantes a razón de 0,11 millones de toneladas anuales (MTm/a) de CFC-11 equivalente. En (c) se muestra cómo las capturas globales de pesca marina han ido descendiendo desde mediados los 1990s mientras que, simultáneamente, los esfuerzos pesqueros han aumentado de manera constante (ver tabla suplementaria S1). El indicador de abundancia de vertebrados mostrado en (f), aunque ha sido ajustado por sesgos de tipo geográfico y taxonómico, incorpora relativamente pocos datos de los países en desarrollo, donde hay menos estudios; entre 1970 y 2012, el número de especies de vertebrados se redujo un 58%, con poblaciones que se redujeron en el 81% las especies de agua dulce, 36% las especies marinas y 35% las especies terrestres (ver tabla suplementaria S1). En (h) se muestran los cambios en la temperatura superficial, tomando medias de 5 años. En (i) se muestra la evolución de la población humana en miles de millones y de ganado rumiante, que incluye vacas, ovejas, cabras y búfalos. Noten que los ejes Y de las gráficas no empiezan en cero y que hay que analizar los rangos de datos para interpretar cada gráfica. Los cambios en porcentaje, desde 1992, para las variables de cada panel, incluyen (a) -68.1%, (b) -26.1%, (c) -6.4%, (d) +75.3%, (e) -2.8%, (f) -28.9%, (g) +62.1%, (h) +167.6%, (i) humanos: +35.5%; ganado rumiante: +20.5%. Descripciones adicionales de las variables y tendencias, así como las fuentes de datos de esta Figura 1, se incluyen en la Tabla suplementaria S1.