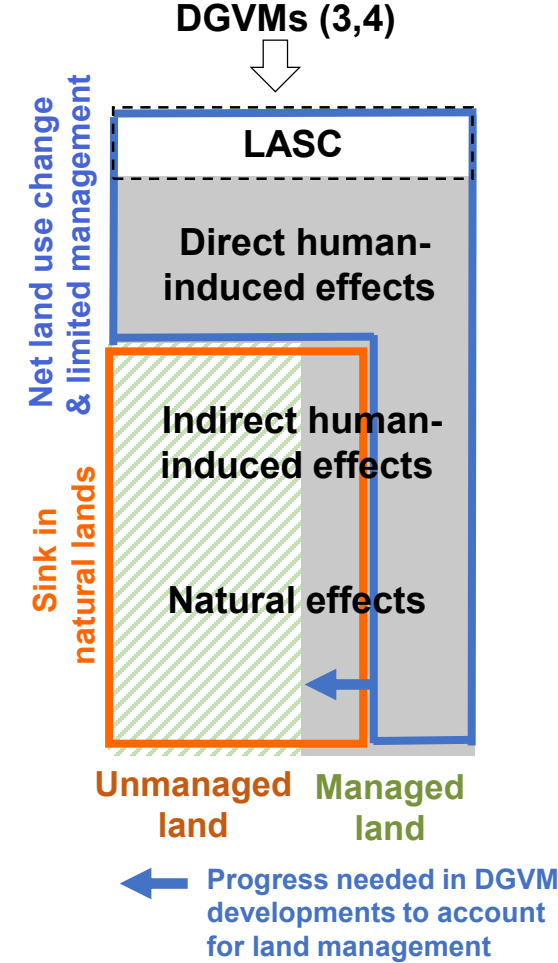**(a) Effects of various factors on the forest CO_2 fluxes**
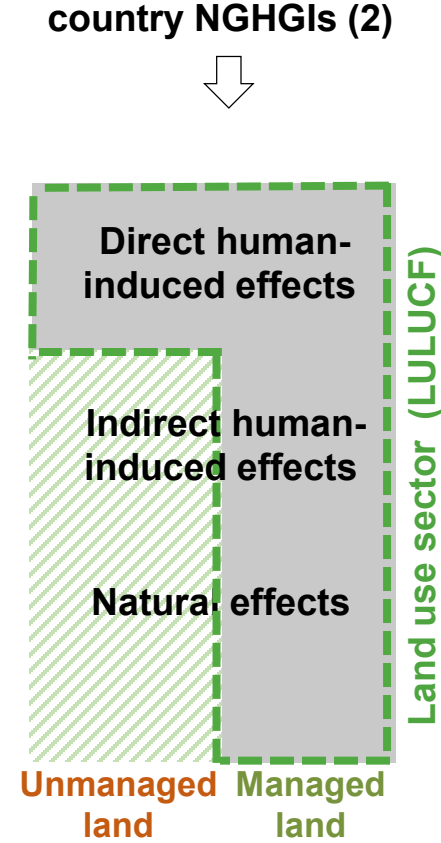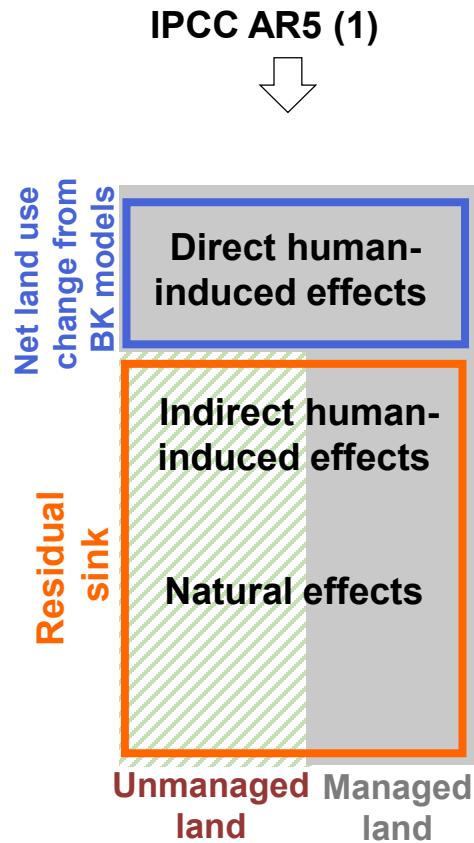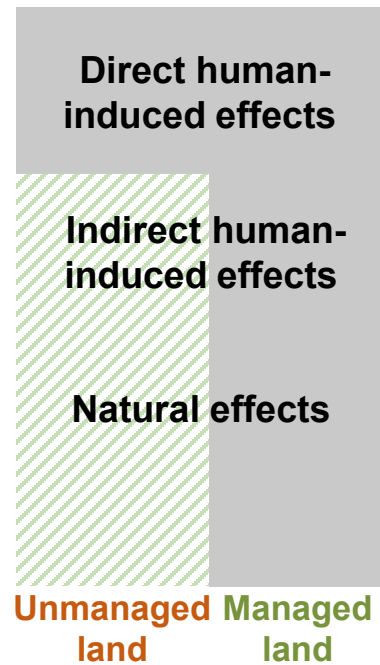
(b) Where these effects occur

(c) How these effects are captured in

IPCC AR5 (1)

country NGHGIs (2)

DGVMs (3,4)

Direct human-induced effects
- Land use change
- Forestry management
- Cropland and pasture management
- Conservation / restoration management

Indirect human-induced effects
- Climate-change-induced change in T°, precipitation, length of growing season
- Atmospheric CO_2 fertilisation and N deposition, impact of air pollution
- Changes in natural disturbances regime

Natural effects
- Natural interannual climate variability
- Natural disturbances

Direct human-induced effects

Indirect human-induced effects

Natural effects

Unmanaged land   Managed land

Net land use change from BK models

Residual sink

Direct human-induced effects

Indirect human-induced effects

Natural effects

Unmanaged land   Managed land

Land use sector (LULUCF)

Direct human-induced effects

Indirect human-induced effects

Natural effects

Unmanaged land   Managed land

LASC

Net land use change & limited management

Sink in natural lands

Direct human-induced effects

Indirect human-induced effects

Natural effects

Unmanaged land   Managed land

Progress needed in DGVM developments to account for land management

(1) In IPCC AR5, the residual sink is inferred as a difference between FF emissions + net land use – growth rate – ocean uptake, and thus matches the observed CO_2 growth rate by construction. In this method, a bias on net land use change is transferred to the inferred residual sink.

(2) In NGHGI, the LULUCF C balance only covers direct management actions and does not match the CO_2 growth rate. Any difference with the CO_2 growth rate can be attributed to errors in NGHGI estimates and / or fluxes on unmanaged lands.

(3) In DGVMs, net land use change includes a source corresponding to the loss of additional sink capacity (LASC). Some models include limited land management (wood harvest, crop harvest). Nonmodeled management from forestry, cropland and pasture management, conservation / restoration management, being in the grey area part of the orange box.

(4) DGVMs have parameterizations and structural uncertainties, and their net land flux does not match the global CO_2 growth rate, leading to a global BIM (budget imbalance).