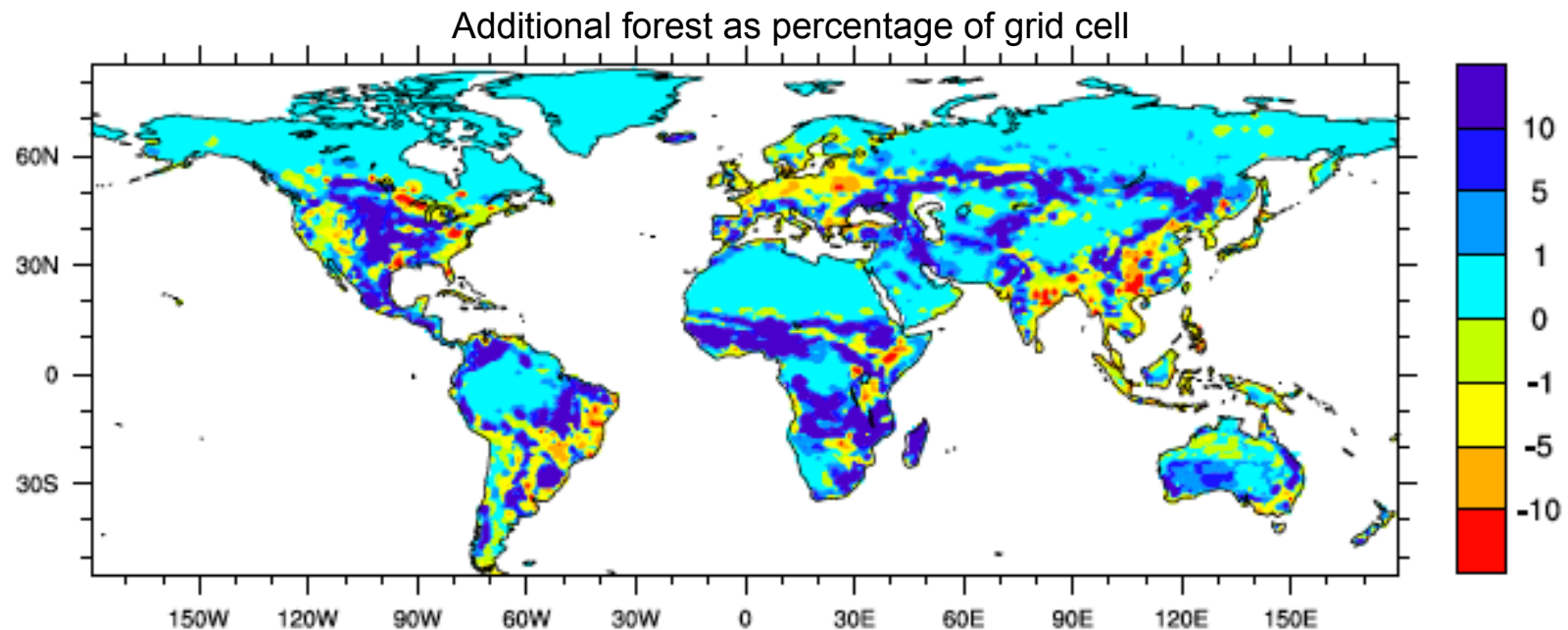


From land use to land cover: Restoring the afforestation signal from GCAM to CESM and the implications for CMIP5 RCP simulations



Alan Di Vittorio, Louise Chini, Ben Bond-Lamberty, Jiafu Mao, Xiaoying Shi, John Truesdale, et al.



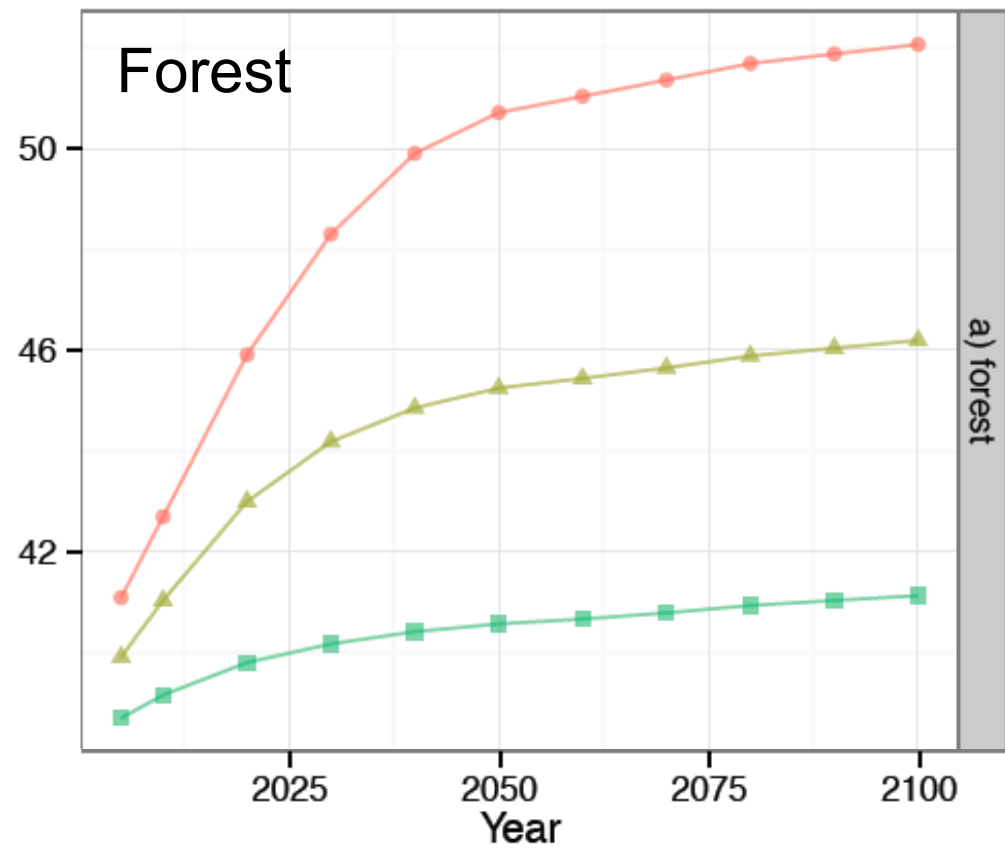
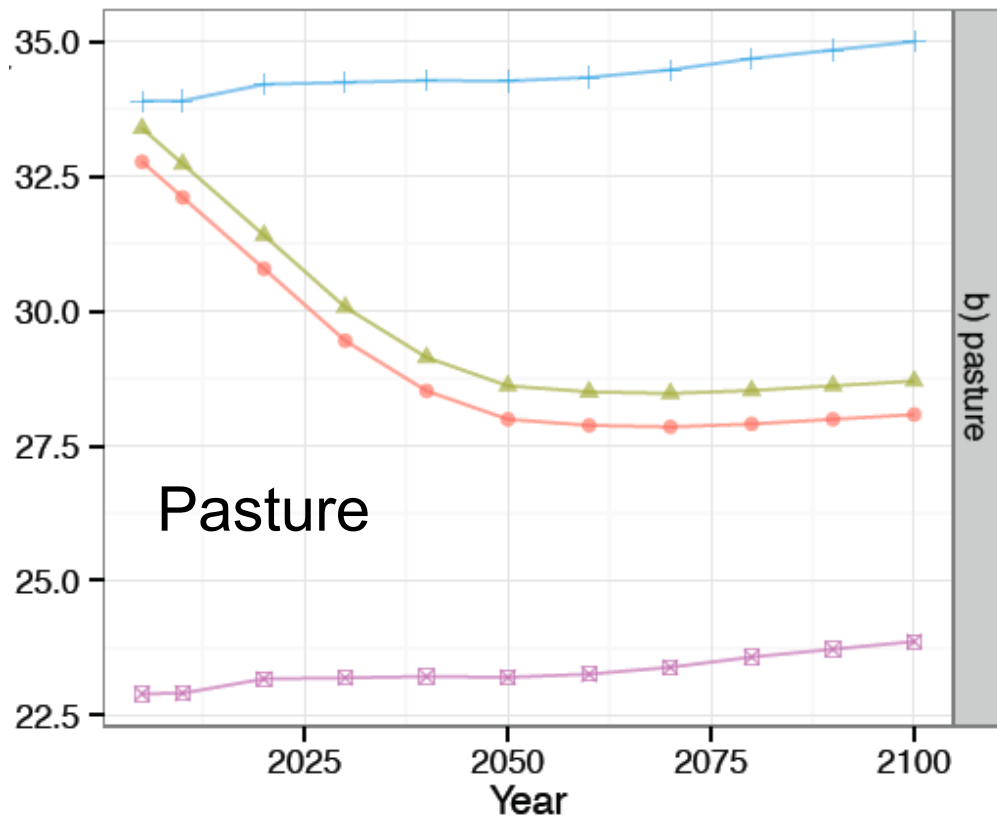
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26 February 2014



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CMIP5 RCP4.5 global area (million km²)



Legend

- RCP4.5
- ▲ GLM
- CLM forest PFTs
- + CLM shrub and grass PFTs
- ◻ CLM grass PFTs

In the context of the integrated Earth System Model (iESM)

To what extent can we restore the RCP4.5 afforestation solely within CLM/CESM?



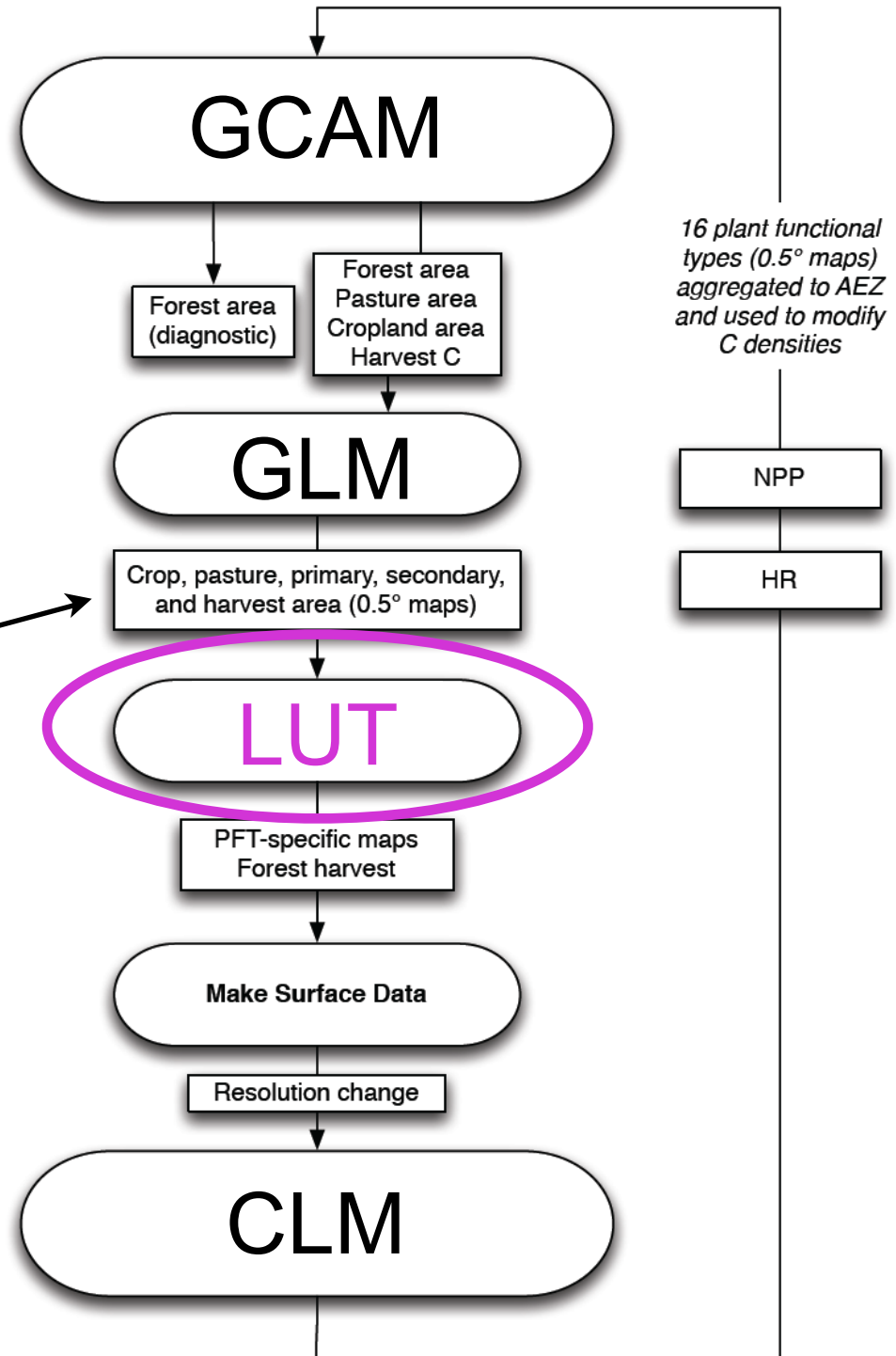
```
Debug | x86_64
updateannuallanduse.c
3205 // setavailtreefracrem = 1 is proportional removal to available potential
3206 // setavailtreefracrem = 0 is add tree first (maximize forest)
3207 // Ranges from 1 to 2 for minimizing forest (maximize herbaceous+bare)
3208 // setavailtreefracrem = 1 is proportional removal to available potential
3209 // setavailtreefracrem = 2 is add herb+bare first (minimize forest)
3210 // (setavailtreefracrem = 0.0 is setavailtreefracrem = 1.0)
3211 // setavailtreefracrem = min(availtreefracrem + (propavailtreefracrem -
3212 // min(availtreefracrem));
3213 } else if (setavailtreefracrem < 0.0) {
3214 // setavailtreefracrem = setavailtreefracrem - 1.0;
3215 // availtreefracrem = propavailtreefracrem + setavailtreefracrem +
3216 // propavailtreefracrem);
3217 } else {
3218 // Error: setavailtreefracrem is not within input range of 0 to 2 in sethurtpftval, setavailtreefracrem
3219 }
3220 }
3221 // if (availpotveggherbarepftsum > 0.0) {
3222 //     availherbarefracrem =
3223 //     ((1.0 - availtreefracrem) * availpotveggtreepftsum / availpotveggherbarepftsum -
3224 //     (adpftsum / availpotveggherbarepftsum) + 1.0);
3225 // } else {
3226 //     availherbarefracrem = 1.0;
3227 // }
3228 // ensure that the fractions are between 0.0 and 1.0
3229 if (availherbarefracrem < 0.0) { availherbarefracrem = 0.0; }
3230 if (availherbarefracrem > 1.0) { availherbarefracrem = 1.0; }
3231 if (availtreefracrem < 0.0) { availtreefracrem = 0.0; }
3232 if (availtreefracrem > 1.0) { availtreefracrem = 1.0; }
3233
3234 printf("availtreefracrem: %f\n", availtreefracrem);
3235 printf("availherbarefracrem: %f\n", availherbarefracrem);
3236 // add tree pfts by potential proportions
3237 // if there is no potential tree veg then these authortpftvals do not change
3238 outavailpotveggtreepftsum = availpotveggtreepftsum;
3239 // (potveggtreepftsum = 0.0)
3240 for (outpft = 0; outpft <= 0; outpft++) {
3241 // authortpftval[outpft][outgrid] =
3242 // round(authortpftval[outpft][outgrid] * inpotveggtreepftsum / potveggtreepftsum);
3243 // outavailpotveggtreepftsum = outavailpotveggtreepftsum -
3244 // round(inpotveggtreepftsum[outpft][outgrid] *
3245 // (availpotveggtreepftsum - (1.0 - availtreefracrem)) / potveggtreepftsum);
3246 }
3247 }
3248 // add herbaceous+bare by potential proportions
3249 // if there is no potential herb+bare veg then these authortpftvals do not change here
3250 // the bare soil is changed above if needed
3251 outavailpotveggherbarepftsum = availpotveggherbarepftsum;
3252 // (potveggherbarepftsum = 0.0)
3253 for (outpft = 0; outpft <= 0; outpft++) {
3254 // authortpftval[outpft][outgrid] = round(authortpftval[outpft][outgrid] *
3255 // inpotveggherbarepftsum /
3256 // (availpotveggherbarepftsum + (1.0 - availherbarefracrem)));
3257 // potveggherbarepftsum = inpotveggherbarepftsum -
3258 // round(authortpftval[outpft][outgrid] *
3259 // (availpotveggherbarepftsum - (1.0 - availherbarefracrem)) /
3260 // (potveggherbarepftsum + inpotveggherbarepftsum));
3261 // authortpftval[0][outgrid] = round(authortpftval[0][outgrid] * inpotveggtreepftsum /
3262 // (availpotveggherbarepftsum + (1.0 - availherbarefracrem)));
3263 // outavailpotveggherbarepftsum = outavailpotveggherbarepftsum +
3264 // round(authortpftval[0][outgrid] *
3265 // (availpotveggherbarepftsum - (1.0 - availherbarefracrem)) /
3266 // (potveggherbarepftsum + inpotveggtreepftsum));
3267 }
3268 }
3269 // check forest maximization
3270 // this check takes into account rounding error up to 1 unit (percent) of veg land unit
3271 if (setavailtreefracrem < 0.0 && adpftsum = availpotveggtreepftsum &&
3272 (outavailpotveggtreepftsum < -1.0 || outavailpotveggtreepftsum > 1.0)) {
```

How does restored afforestation affect the carbon cycle and climate?

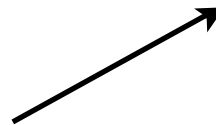
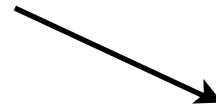
iESM coupling framework

No land cover info!
Only crop, pasture,
primary, secondary

Modify the Land
Use Translator
(LUT)



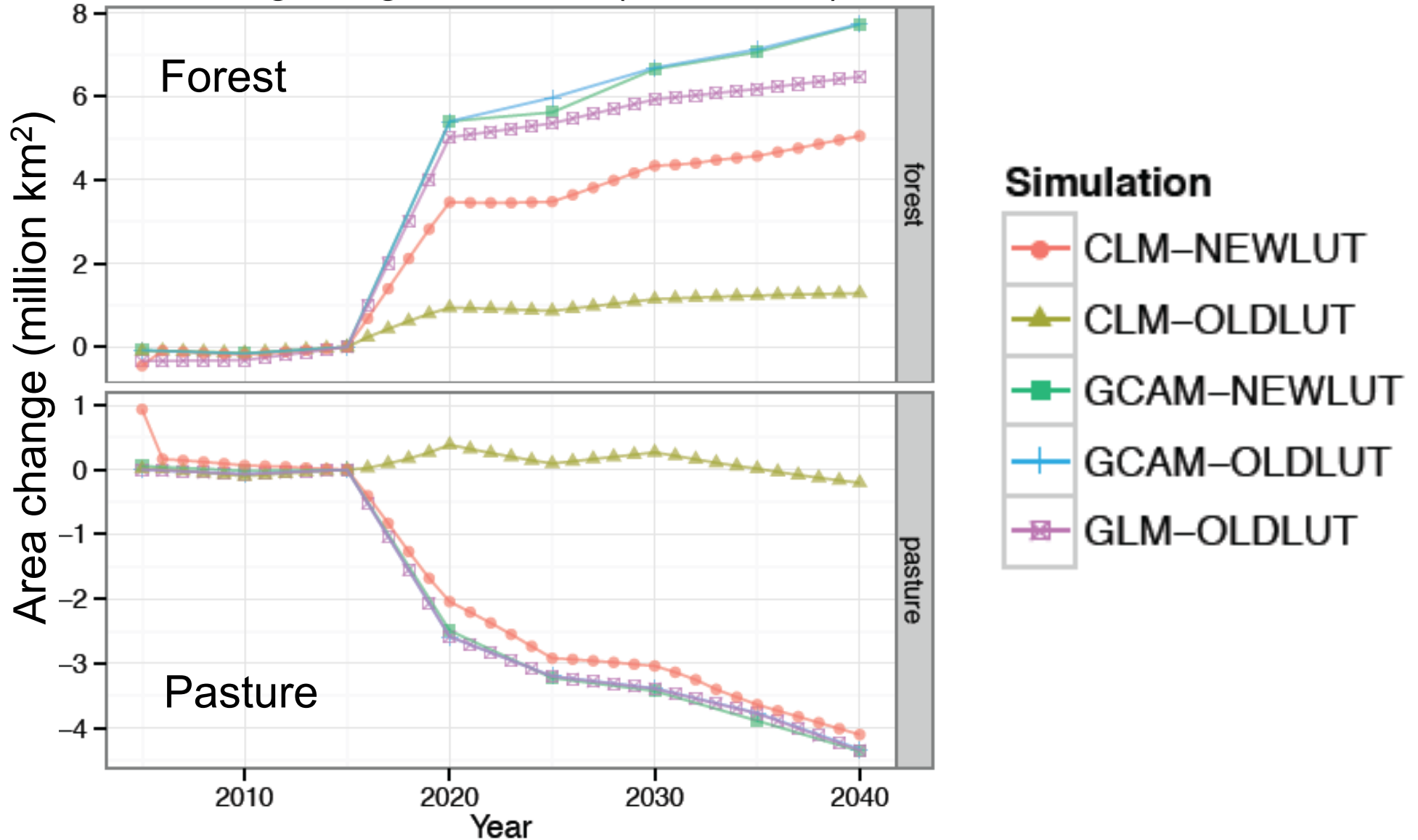
Add trees when cropland and pasture areas are reduced



6

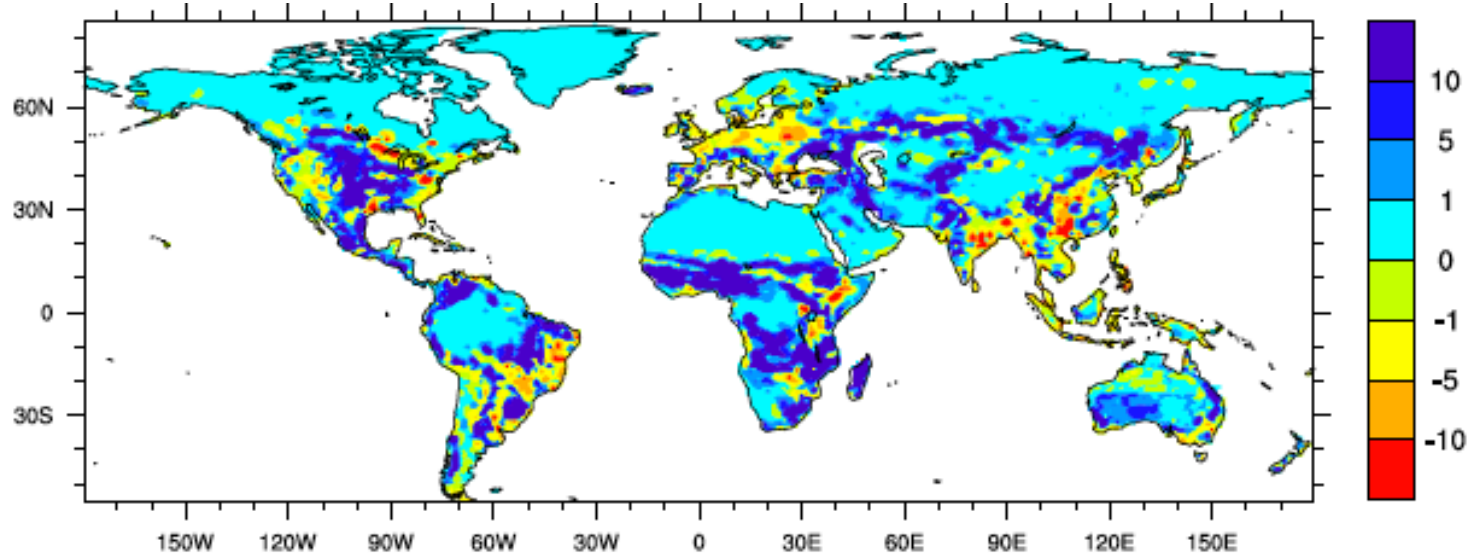
This method transmits 66% of the afforestation to CLM

Change in global area (from 2015)



Most new trees replace shrubs and grass

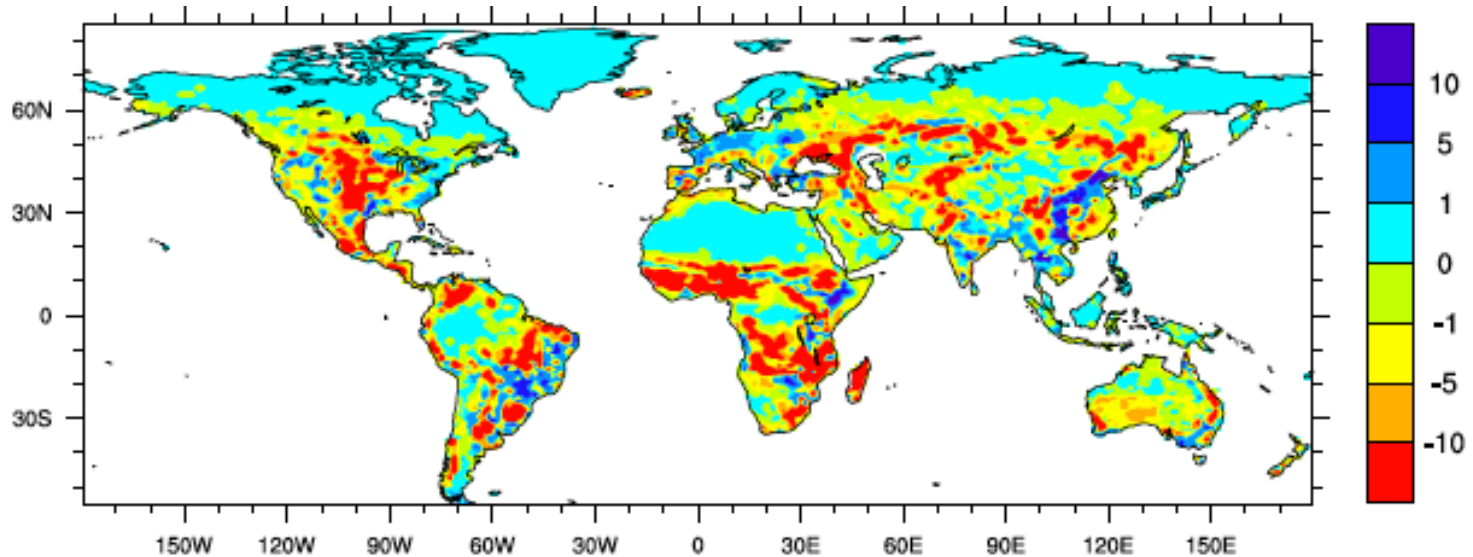
Difference in tree PFT area (2040)



NEWLUT -
OLDLUT

Difference
as
Percent of
grid cell

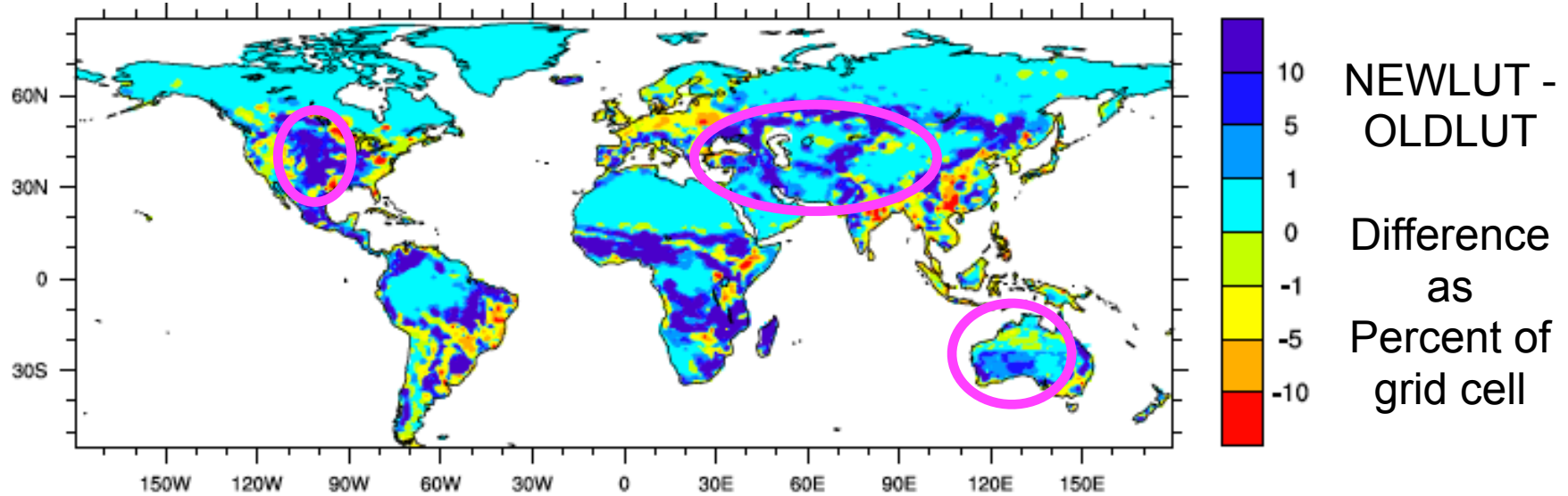
Difference in shrub and grass PFT area (2040)



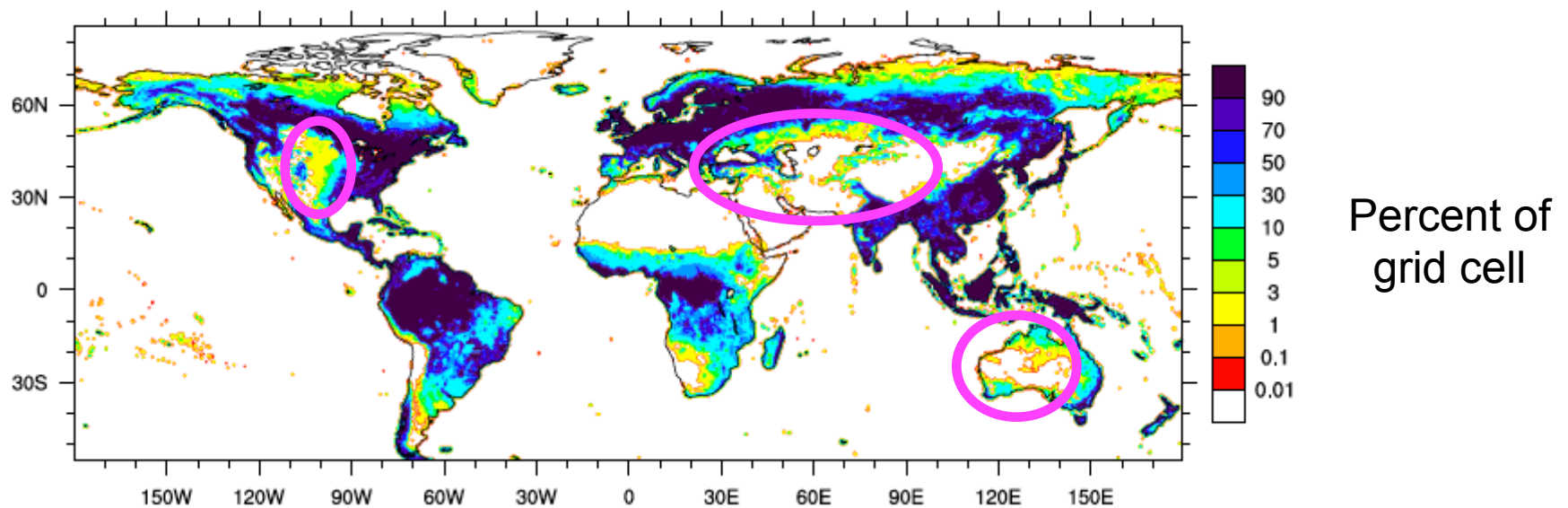
8

Not always coincident with potential forest

Difference in tree PFT area (2040)

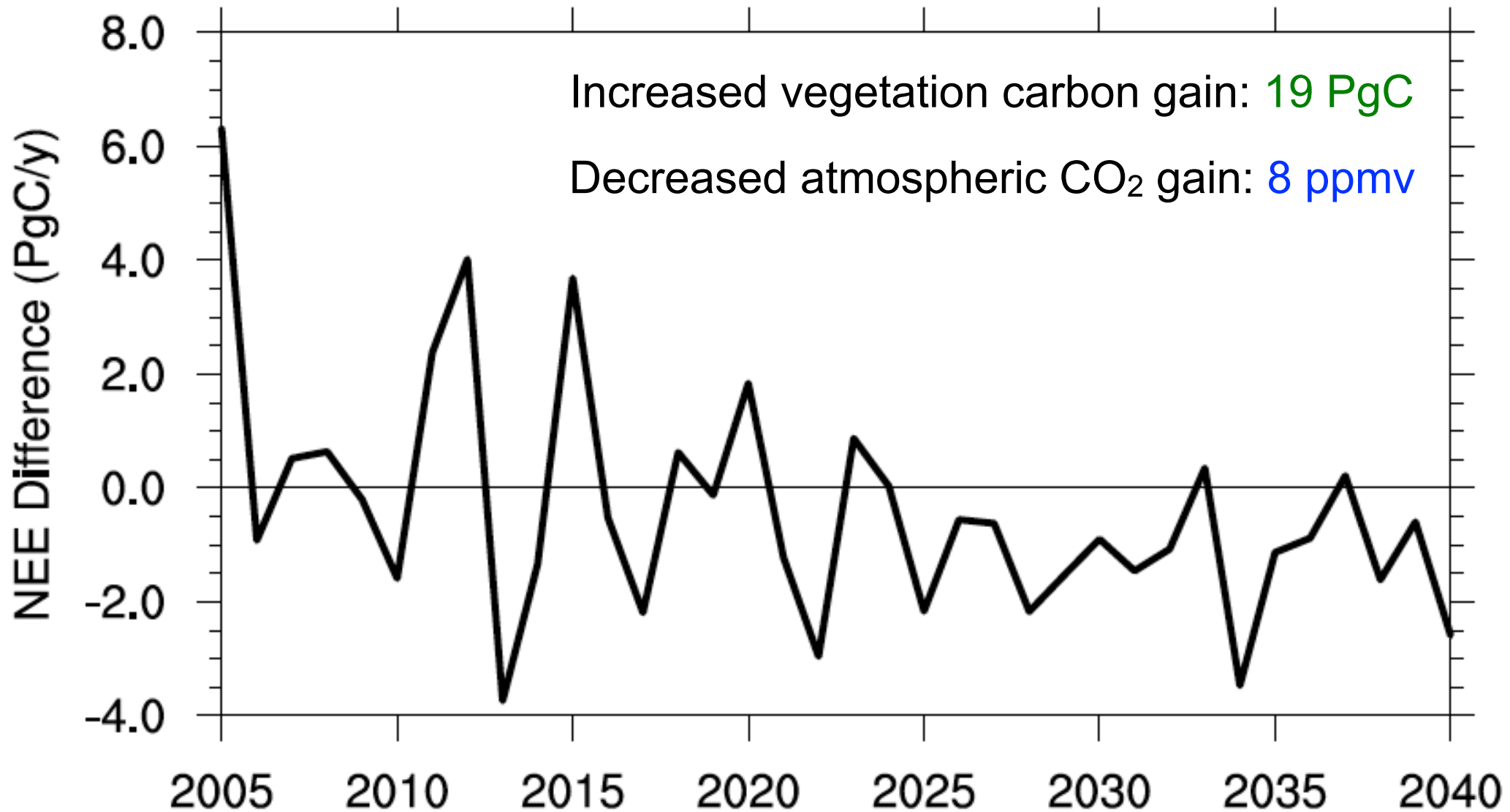


Potential forest area



Additional land C uptake due to afforestation

Global NEE: NEWLUT minus OLDLUT



Summary

- Identified major gap in CMIP5 land coupling
 - No land cover type info passed to ESMs
- CESM-only modification helps, but not sufficient
 - approx. -0.3 out of -0.5 W m^{-2} by end of century
- GCAM may overestimate potential afforestation
- Effects on other ESMs will be model-specific
 - Not necessarily limited to RCP4.5

Thank you!

Who is *et al.*, anyway?

Marcia Branstetter, Kate Calvin,
Bill Collins, Tony Craig, Enhao Du,
Jae Edmonds, Jennifer Holm,
George Hurtt, Andy Jones, Pralit Patel,
Allison Thomson, Peter Thornton

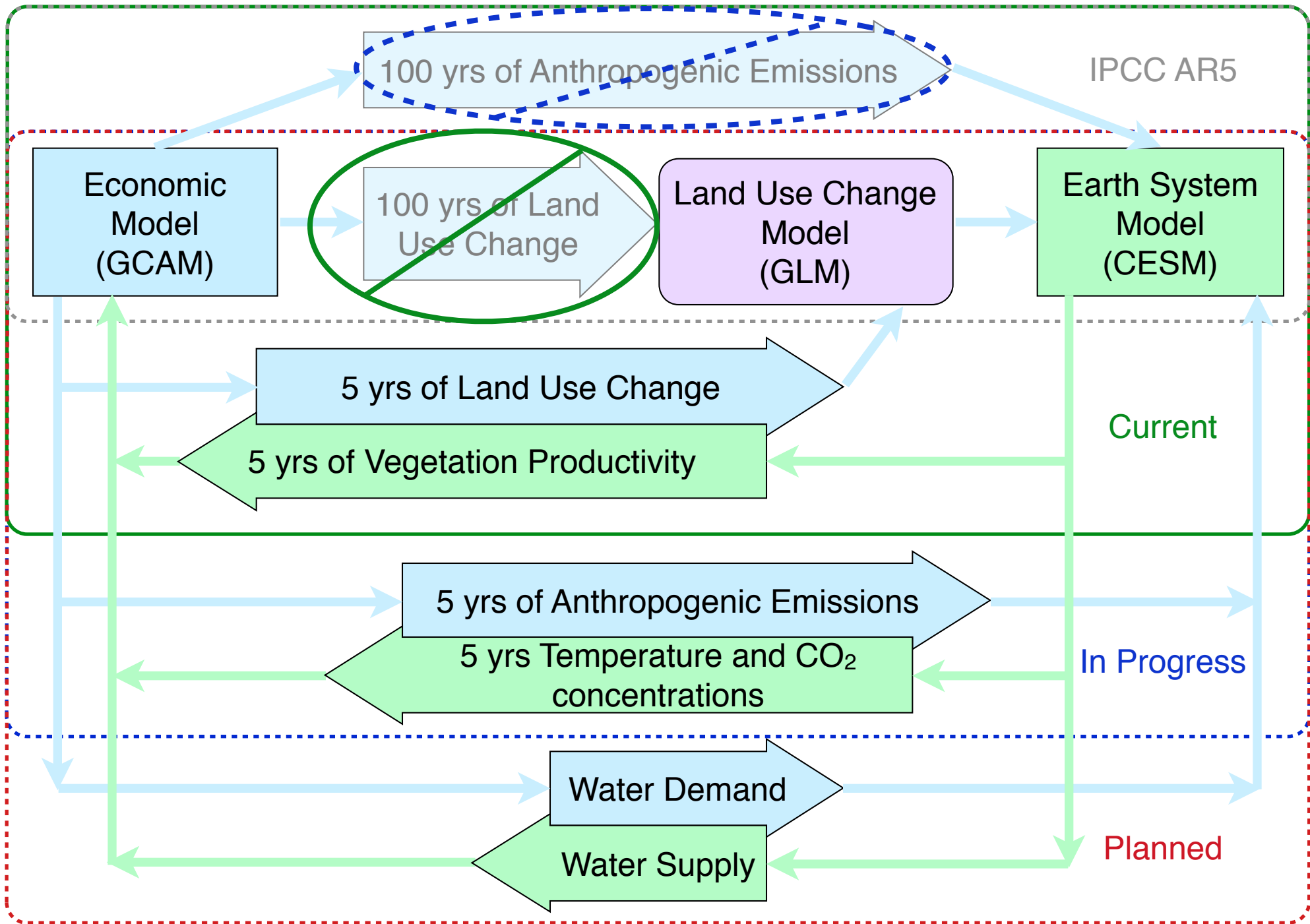


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Absolute area

